Regional Environmental Change (2021) 21: 107
https://doi.org/10.1007/s10113-021-01810-1

REVIEW

Climate change and its impacts in the Balearic Islands: a guide for policy design in Mediterranean regions

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Received: 19 February 2021 / Accepted: 9 July 2021 / Published online: 23 October 2021 / Published online: 23 October 2021

Abstract

Understanding the local effects of global warming-derived impacts is important to island systems due to their fragile environmental conditions. This is especially true when it comes to Mediterranean insular regions as they are climate change (CC) hotspots where adaptation and mitigation policy design is an urgent matter. Looking at 2030 as a time horizon for climate action and focusing on the Balearic Islands, this paper reviews the physical changes projected for the coming decades as a result of CC and analyses their impacts on regional environmental, economic and social variables. Mitigation and adaptation measures are also proposed based on the identified priority impacts. The fact the Balearics are a top world holiday destination allows the analysis to serve as a guide to other Mediterranean islands with tourism-based economies facing similar CC scenarios. Results show the projected rise of temperature and sea level; the reduction of the average precipitation and increase in evapotranspiration, the droughts and the increase in ocean acidification and deoxygenation are the main threats faced by the Balearics, this putting their economy at risk due to the high tourism's vulnerability to CC. Mitigation and adaptation action on terrestrial and marine ecosystems, water resources, energy, infrastructure and urban planning, human health, economy, law and education is recommended. Sustainable mobility and waste managing are also viewed as important fields for mitigation action. Conclusions show that diversifying the current socioeconomic model is needed to increase the community and territory resilience.

Keywords Climate change · Mediterranean islands · Impacts · Mitigation · Adaptation

Introduction

Since the beginning of the twentieth century, the increase in human-induced concentrations of greenhouse gases (GHG) in the atmosphere has raised the planet's mean temperature (IPCC 2018). In this context, understanding the local effects of global warming-derived impacts is especially important to islands due to their fragile environment. This is particularly true in the Mediterranean Basin as it is a climate change (CC) hotspot (Giorgi 2006; MedECC 2020). Accordingly, both the review of CC-related current and projected physical changes and the analysis of their derived impacts on environmental, economic and social variables represent the starting point for developing adequate policies in insular territories. Though these changes will be most noticeable in the second half of the twenty-first century (Klausmeyer and Shaw 2009; Lelieveld et al. 2012; Cramer et al. 2018; Kaniewskia et al. 2020), designing measures to mitigate and adapt to CC becomes today an urgent task since the islands especially need preparedness given their vulnerabilities.

In 2018, responding to the interest of the regional government to assess the economic, social and environmental prospects for the Balearic Islands by 2030, the Economic and Social Council (ESC) requested to the Interdisciplinary Lab on Climate Change of the University of the Balearic Islands (LINCC UIB) a study about climate change (CC). In particular, the ESC commissioned the LINCC UIB to evaluate the CC impacts on the insular territory and give guidance on the implementation of mitigation and adaptation policies to address them. This resulted in chapter 5 of the 'Study on the Economic, Social and Environmental Prospects for the Balearic Islands for the 2030 Horizon' report. This chapter

Communicated by James Ford

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attempted to assist the government in the identification of all the relevant CC-related issues to be included in mitigation and adaptation plans before 2030 (De Vílchez et al. 2019). This paper upgrades and extends the research undertaken in such a report. However, for space limitations, it only presents the CC impacts considered of priority for the Balearic Islands[1] and briefly discusses the importance of designing mitigation and adaptation measures. The fact the Balearics are a world top holiday destination makes relevant this discussion as it can serve to give guidance to other Mediterranean territories with tourism-based economies facing similar CC threats. The high vulnerability of tourism to CC (Simpson et al. 2008; Bujosa et al. 2015; Factor CO_2 Ideas 2015; Lee et al. 2018; González et al. 2019; Arabadzhyan et al. 2020) makes these regions even more fragile thus calling for an urgent change of their socioeconomic model. The analysis presented here also wants to serve as a wake-up call for initiating such a change.

The paper is structured as follows. The next section describes the methodology used to evaluate the CC-related physical changes and their derived impacts, which is based on an ad hoc expert opinion elicitation procedure. "Physical changes" and "From physical changes to impacts on ecosystems" discuss the priority physical changes and expected impacts on ecosystems, respectively, while "From physical changes to impacts on human systems" revolves around the priority impacts on human systems. "Climate policy for the Balearic Islands" comments on the importance of mitigation and adaptation and recommends a series of policies within each field. A "Conclusions" section ends the paper.

Methodology

To evaluate the CC-related physical changes and impacts (both referred to as hazards from now on) in the Balearic Islands, a LINCC dedicated working group was created including nine experts from different academic disciplines such as physics, engineering, biology, oceanography, economics and law. Based on their expertise, they reviewed existing research on hazards in both the Balearics Islands and other Mediterranean regions sharing similar environmental and/or socioeconomic characteristics, thus facing analogous CC threats. In cases where information on hazards was scarce for the region of interest, the experts reviewed related research focusing on other places elsewhere.[2] Regarding the identified impacts, they were classified into two groups: (i) impacts on ecosystems, divided into the categories 'terrestrial' and 'aquatic' and (ii) impacts on human systems, divided into the categories 'water resources, energy and infrastructure', 'human health', 'economy' and 'human rights, society and the political system'. Impacts on terrestrial ecosystems were further divided into 'natural' and 'agricultural and livestock' systems, and those on aquatic ecosystems were classified into 'marine' and 'freshwater'. Likewise, economic impacts distinguished between 'general impacts' and 'sectoral impacts' (including tourism, agriculture, livestock, fishing, construction, real estate and public sector).

An expert opinion-based assessment was conducted according to an ad hoc methodology based on a qualitative informal knowledge elicitation (Gavrilova and Andreeva 2012; O'Hagan 2019).[3] Considering the nature of and the available time for the exercise, a round table–focused collective knowledge elicitation was carried on where all of the experts had equal rights to answer. A consensus combination of collective elicited judgements was adopted after a facilitated discussion among experts during a series of meetings to determine the relevance of each identified hazard and the available documented evidences. For each hazard, the experts were asked to answer the following questions: (1) 'Is there any chance the hazard will occur in the Balearic Islands during the 2050–2100 period?' and, if so (2) 'Which is the expected variation in its magnitude and the associated probability of occurrence for this period?' Such a time frame was chosen because changes due to CC were expected to be exacerbated in the second half of the twenty-first century and hence easily distinguishable from changes related to the natural (in case of physical changes and ecosystem impacts) or usual (in case of human system impacts) variability. Three different levels of magnitude variation were defined according to the comparison between the expected change in the intensity, duration and/or frequency of the hazard due to CC and the variation registered during the last 30 years. So, if the CC-related expected change in magnitude was much larger or larger than the variation occurring due to natural/usual variability, it was assigned the levels high or medium, respectively. In contrast, if the expected magnitude change was slightly above the natural/usual variation, it was considered low. The probability of occurrence (i.e. the confidence on the projection) was also assigned the levels low, medium or high depending on the extent to which the expected magnitude variation was likely to happen.[4]

[1] All the identified CC impacts are reported in the Table I provided as Supplementary Material (Online Resource 1).

[2] This was especially true for some expected impacts on human systems.

[3] Expert opinion elicitation has been frequently used to predict the effect of CC on ecosystems, technology or management, among others (Barons et al. 2018; Dessai et al. 2018; Few et al. 2018; Verdolini et al. 2018; Wilcox et al. 2018; Reside et al. 2019; Abad et al. 2020).

[4] The level was assigned depending on the robustness of the projections.

Table 1 Categories of climate change-related hazards being likely to happen in the Balearic Islands according to their expected magnitude variation and its probability of occurrence

Probability of occurrence	Expected magnitude variation		
	Low	Medium	High
Low	Of no concern	Of no priority	Of no priority
Medium	Of no priority	Of priority	Of priority
High	Of no priority	Of priority	Of priority

To evaluate the expected magnitude and associated probability of occurrence for each hazard, the experts reviewed literature published from 2003 onwards and considered different criteria depending on whether they were assessing a physical change, an ecosystem impact or a human system impact. Thus, to determine the expected variation in the magnitude of a physical change and its probability of occurrence, they considered information on the observed and projected climate at regional scale. For the impacts on natural and human systems, they took into consideration the expected magnitude variation of physical changes and its probability of occurrence, the environmental and socioeconomic conditions of the islands and their expert knowledge on both the system and its resilience in terms of vulnerability.[5] For the human system impacts, they also considered the expected magnitude variation of ecosystem impacts and its probability of occurrence.

As a final step for the elicitation, the experts defined different categories for the hazards being likely to happen in the Balearic Islands. Hazards were considered of priority when both their expected magnitude variation and its probability of occurrence were medium or high. In contrast, they were considered of no priority when either (i) their expected magnitude variation was low and its probability of occurrence was medium/high or (ii) their expected magnitude variation was medium/high and its probability of occurrence was low. When both the expected magnitude variation and its probability of occurrence were low, the hazards were assumed to be of no concern for the islands (Table 1).[6]

When the existing research was not enough to draw conclusions about whether the hazard would occur or not due to CC, it was classified into a 'not enough information' category. This category was also applied to hazards being likely to happen but whose expected variation in its magnitude and/or its probability of occurrence were difficult to determine according to existing data (e.g. decrease of the market value of coastal properties due to a loss of aesthetics caused by beach erosion).[7]

Once the different types of hazards being likely to happen in the Balearic Islands had been identified, the experts proposed a series of mitigation and adaptation measures which could be implemented.

Physical changes

From 1975 to 2015, maximum and minimum air temperatures have risen at a rate of 0.44 and 0.37 ºC/decade, respectively (Herrera et al. 2016). The winter-summer transition has become more abrupt (0.86 ºC/decade) due the spring warming (Jansà et al. 2017). Since 1970, the Western Mediterranean sea temperatures have also increased at a rate of 0.25 ºC/decade in the upper 80 m of the water column (Vargas et al. 2008). Sea level records also show an upward trend of 1.3 cm/decade for the twentieth century (similar to the global one).

Climate projections suggest temperatures will increase by 3–5 ºC by the end of the twenty-first century compared to 2010 if GHG emissions follow current trends (Adaptecca 2018), and by 1.75–2 ºC under a moderate scenario. This will lead to longer and more intense heat waves. Mean precipitation will decrease by 20% in 2100 under a pessimistic GHG emissions scenario and by 10% under a moderate one, and the severity of droughts will be enhanced. There are some results projecting a slight increase of extreme precipitation, but there is little consensus among models. Also, wind intensity and the number of cyclones will likely decrease on average, while the intensity of the intense events could slightly increase.

Depending on the GHG scenario, the mean sea level will increase between 37 and 90 cm (MedECC 2020). The intensity and frequency of marine storms will slightly decrease, although their impact will increase due to the rise of the mean sea level. The sea temperature will also rise between 2 and 4 ºC in the upper layers (Soto-Navarro et al. 2020), leading to stronger marine heat waves. Also, the vertical stratification will be enhanced and the available dissolved oxygen reduced, thus diminishing the ventilation of intermediate and deep layers. Though there are not robust estimates for this yet, more atmospheric CO_2 might provoke higher ocean CO_2 absorption and ocean acidification.

[5] Vulnerability was related to the sensitiveness and capacity of the system to cope with CC as well as its dependency on other systems.

[6] The values of the expected magnitude variation and its probability of occurrence for all the identified hazards are reported in Table I provided as Supplementary Material (Online Resource 1).

[7] The very few impacts classified into these categories are reported in Table I provided as Supplementary Material (Online Resource 1).

From physical changes to impacts on ecosystems

Impacts on plant and animal biodiversity

Terrestrial ecosystems are suffering from rising temperatures and reduced rainfall-derived impacts. Both factors combined will lead to an increase in evapotranspiration that will reduce the area occupied by forests of *Quercus ilex* (holm oaks), which will not be able to subsist in the spaces that currently represent their climatic limit. In turn, there will be an increase in the forests and maquis of *Olea europea* var. *sylvestris* (olive tree) and *Pinus halepensis* (pine tree). On the other hand, forest fire risk will be higher due to a greater number of days with high temperatures and low humidity. All these factors combined can lead to forest decline and make them more sensitive to pests and pathogens. Consequently, their capacity to sequester carbon will be reduced.

It is also expected that some threatened plant species may become extinct when their habitat disappears such as plants living in fountains, torrents or simply wet soils. *Naufraga balearica*, a critically threatened endemic monotypic plant genus, is paradigmatic in this sense (Cursach et al. 2018). In contrast, some exotic species are becoming dangerous invaders by finding a more favourable climate, such as some cultivated plants natives from dry tropical zones (*Lantana camara*, *Opuntia* spp., *Agave* spp., etc.). Finally, changes in phenology of flowering and fruiting could result in ruptures of mutualisms, for instance with their pollinator and dispersant animals. On the other hand, sea level rise and extreme meteorological events will have an important impact as well, since beaches and coastal dunes will reduce its extension, and in some places, they may disappear. Likely some rare psammophilous plants and animals could be extinct at the local level. Also, coastal wetlands will suffer salinization, with dramatic changes in these ecosystems. It is also expected that temporary ponds and torrents will reduce the time they are flooded; even some could disappear. It could also threaten some plants and animals which live in this habitat, for instance, the endemic and endangered amphibian *Alytes muletensis* or the very rare fern *Marsilea strigosa*.

Even if there are not specific studies in the Balearic Islands about the CC effect on animals, it is expected that animal biodiversity and populations are also affected by alteration of distribution, seasonality, growth, reproduction, migration and synchrony of life cycles among animals and/or plants. Temperature increase is currently changing distribution of birds, insects and mammals to northern latitudes (Feehan et al. 2009) as well as contributing to the extinction of some species of mammals (Thomas et al. 2004). CC effects are expected to be more severe on those species with a restricted distribution, such as the endemic ones (i.e. *A. muletensis* in the Balearic Islands). On the contrary, invasive species (i.e. insects such as *Aedes albopictus* and *Rhynchophorus ferrugineus*) will be favoured by higher temperatures thus increasing its distribution. There are also evidences of global insect decline due to CC (Habel et al. 2019; Harris et al. 2019; Powney et al. 2019). Indeed, indicators of decline in lepidoptera populations were found in Menorca and attributed to changes in the phenology of host plants (Colom et al. 2019).

Impacts on wild plant and animal health

CC is expected to cause a weakening of trees and a reduction of their defences against phytophagous insects and pathogens that will experience favourable periods for proliferation. Currently, severe outbreaks of bark beetle species (*Tomicus destruens* and *Orthotomicus erosus*) and pine processionary (*Thaumetopoea pityocampa*) on the populations of *P. halepensis* have been observed in the Mediterranean region (Spathelf et al. 2014). Meanwhile, *Q. ilex* forests are increasingly affected by high abundance of the lepidopteran pest *Lymantria* dispar. Thus, holm oaks weakened by insects or unfavourable weather are more vulnerable to the spread of pathogenic fungi, such as *Botryosphaeria corticola* and *Biscogniauxia mediterranea* (Moralejo 2010, unpublished work).

Recent emerging plant vector borne diseases such as the bacterium *Xylella fastidiosa* found in the Balearics in 2016 (Olmo et al. 2017) will increase its distribution in Europe because of the temperature rise according to model scenarios for 2050 and 2100 (Bosso et al. 2016). CC will also affect the wild animals' health by favouring reproduction and distribution of parasites (i.e. gastrointestinal nematodes) and increasing the presence of emerging diseases (Altizer et al. 2013). In the Balearics, some introduced parasites are affecting key endemic species (i.e. chrytidiomycosis in *A. muletensis*) (Fisher et al. 2012). The effect of tropical parasites species (e.g. Angiostrongilasis in the hedgehodge *Atelerix algirus*) on some vertebrates is also an example (Paredes-Esquivel et al. 2019). Pollinators (bees) are a key group of animals affected by CC. Indeed, it directly impacts their life cycles and indirectly affects them via diseases and parasites such as fungi *Nosema* spp., the mite *Varroa destructor* and the coleopteran *Aethina tumida* (EFSA 2015).

Impacts on marine ecosystems

Global warming has multiple effects on marine ecosystems, including biodiversity loss, changes in ecosystem functioning and proliferation of invasive species.

The coastal ecosystems of the Balearic Islands are dominated by the endemic seagrass *Posidonia oceanica*, which is a key species providing multiple services thanks to its high productivity: it increases water transparency and biodiversity; produces oxygen and acts as an important carbon sink, absorbing 7% of carbon emissions of the islands (Marbà, personal communication). However, these meadows are very sensitive to global warming as it produces physiological stress, stimulates bacterial activity, changes ecosystem biodiversity and increases flowering events and plant mortality (Marba and Duarte 2010). As a result, both the seagrass and its services could disappear by 2040–2060 in the shallowest areas (Jorda et al. 2012), this shaping the future of Mediterranean coastal ecosystems.

Benthic filters are another Mediterranean sensitive community to global warming. During summer, high temperatures enhance stratification, reducing food-supply to bottom waters, and benthic filtering communities die of starvation. This phenomenon has already caused mass mortality events of different invertebrate groups, such as gorgonians and corals (Garrabou et al. 2019).

Migration and distribution of fish communities can also suffer from CC impacts. Since 1960, global warming produced a migration of ocean isotherms of 50 km/decade in the Mediterranean Sea (Burrows et al. 2011) altering distribution of fish species, with some species migrating northwards seeking for refugee in colder waters.

The proliferation of tropical species is leading to the Mediterranean tropicalization (Bianchi and Morri 2003). Some invasive species will benefit from warmer waters (Raitsos et al. 2010). The invasive macroalgae *Halimeda incrassata* has rapidly colonized sandy habitats since 2011 (Alós et al. 2016) leading to changes in abundances and distribution of fishes (Vivo-Pons et al. 2020). Another invasive species that could benefit from CC are the rabbitfish (*Siganus luridus* and *S. rivulatus*). These species negatively affect rocky ecosystems leading to deforestation, due to their highly herbivore rates (Vergés et al. 2014a). At the moment, thermic tolerance of these species limits their distribution to the Eastern Mediterranean, but CC might allow to broad its distribution western-wards with isotherm migration (Vergés et al. 2014b).

CC can also alter trophic interactions as a consequence of the presence of new species with warmer thermal windows and due to changes in the nature or strength of existing interactions due to warming responses. Species interactions can dramatically alter species responses to CC. The exact consequences for focal species are unknown and dependent on multiple interacting factors (Gilman et al. 2010; Zarnetske et al. 2012).

CC also impacts marine biogeochemical cycles and organisms' metabolic rates. Temperature raises both respiration (oxygen consumption) and photosynthetic (oxygen production) rates although respiration increases faster than primary production (Brown et al. 2004; Vaquer-Sunyer and Duarte 2013). This could lead to a decrease in oxygen content in coastal waters with negative consequences for marine benthic communities, very sensitive to deoxygenation (Díaz and Rosenberg 2008; Vaquer-Sunyer and Duarte 2008). This situation has been already reported for a Balearic enclosed bay (Vaquer-Sunyer et al. 2012). CC will also aggravate negative effects of deoxygenation as organisms increase their oxygen requirements at warmer waters at the time that warming accelerates oxygen depletion (Vaquer-Sunyer and Duarte 2011).

Ocean acidification decreases survival, calcification, growth, development and abundance of a broad range of marine organisms. However, the magnitude of these responses varies among taxonomic groups. Molluscs larvae are specially sensitive to acidification, whereas in other taxonomic groups, it is not clear that early stages are more sensitive than adults. The variability in the species' responses is enhanced when multi-species assemblages are assessed. Elevated water temperature enhances organisms' sensitivity to acidification (Kroeker et al. 2013).

Impacts on agricultural and livestock systems

Climate prediction models indicate warming will cause substantial changes in global agriculture (IPCC 2014) which will be of particular importance in Mediterranean regions (del Pozo et al. 2019; Santillán et al. 2020; Varotsos et al. 2021). Temperature increase, changes in precipitation distribution and more intense and frequent extreme events (e.g. severe drought periods, heat waves) can cause important quantifiable impacts on agriculture. On the one hand, crop productivity can be reduced due to prolonged drought (Fraga et al. 2019). Evaporative demand and plant transpiration rates can also raise this leading to greater direct evaporation of soil water and reduction of availability of water for crops, respectively (López-Urrea et al. 2012). In addition, modification of phenology of cultivated species (advance of budburst, lengthening of phenologic cycles, delays in dormancy of buds) can happen (Ramos 2017; Lorite et al. 2020), and a reduction of chill hours can affect physiology, such as flowering (Ashebir et al. 2010), dormancy and latent periods. The severity and frequency of heat waves will also influence the physiology of plants causing a loss of production (DaMatta et al. 2010). Changes in chemical composition of crop products and its derivatives due to light spectrum modification (greenhouse effect), and high temperatures will be another CC impact on agriculture. Such changes will have negative effects on products' taste and nutritional properties (Lorite et al. 2018; del Pozo et al 2019). Finally, new pests might cause significant economic costs, and even the infeasibility of certain crops. Milder winter periods will also intensify local pest–derived impacts due to more annual generations and favour the emergence of new invasive plant pest and diseases (Civantos et al. 2012).

Extreme heat waves are considered the most important CC direct impact on livestock production (Thornton et al. 2009), while the loss in the quality of pastures due to rainfall reduction would be the main indirect impact. New vector borne diseases are also expected as shown by those having occurred in Europe in recent years such as Lumpky Skin Disease in Greece and East Europe. Diseases transmitted by *Culicoides* spp., such as bluetongue (Miranda et al. 2003), have also occurred in Spain and the Balearics Islands. Though bluetongue was initially considered to be restricted to southern latitudes, it has surprisingly reached North European countries, such as Germany, Deutschland and UK. This is viewed as an example of the global warming–derived effect on the insect vector competence (Purse et al. 2015) (Table 2).

From physical changes to impacts on human systems

Impacts on water resources, energy and infrastructures

CC is expected to reduce the fresh water resources due to a reduction of precipitation and an increase in evapotranspiration. Specifically, the more pessimistic emission scenarios show reductions greater than 55% (Pulido-Velazquez et al. 2015). In addition, a significant increase of water demand by the residential, service and industrial sectors (Milano et al. 2013) would lead to future lower water availability. The Balearic Islands' water reservoirs get their minimum levels during summer, in particular in August due to the

Table 2 Priority impacts on ecosystems derived from priority climate change-related physical changes expected for the Balearic Islands during the 2050–2100 period

Priority physical changes	Types of ecosystems				
	Terrestrial ecosystems			Aquatic ecosystems	
	Natural systems		Agricultural and livestock systems	Marine ecosystems	Freshwater ecosystems
Sea level rise	• Beach surface decrease, dune system loss and increase in coastal erosion • Decrease in population and local extinction of rare psammophilous species				• Increase in the salinization of aquifer and coastal wetlands
Air and sea temperature increase Increase in the number, length and frequency of atmospheric and marine heat waves	• Emergence and spread of invasive plants and animals	• Changes in the distribution of the main forest communities • Increase in wildfires • Increase in forest pests and pathogens due to the weakening of the main tree species • Decay and defoliation of forests • Reduction of forest carbon sink capacity • Insect decline	• Changes in plant physiology due to heat waves • Changes on chemical composition of fruit and by-products • Increase in morbidity and mortality of animals caused by heat waves • Emergence of vector borne diseases	• Loss of *Posidonia oceanica* meadows and the services provided by the plant[a] • Increase in organisms migration • Increase in the abundance and number of invasive species of tropical origin • Trophic interactions disruption • Increase in mass mortality events (i.e. benthic filters)[a]	
Reduction of average precipitation and increase in evapotranspiration Increase in the number, duration and intensity of droughts			• Reduction of crop yields		• Increase in the salinization of aquifer and coastal wetlands • Local extinction of plant and animal species from seasonal aquatic environments

[a]Coastal protection, wave's velocity and intensity reduction, water transparency, carbon sinks, oxygen sources, biodiversity hotspots and sand sources are examples of services provided by the plant

tourism activity, which is one of the biggest contributors to local water demand (Garcia and Servera 2003). The monthly mean water demand by the region's population is 1.7 hm^3, which almost doubles during the peak season when an increase between 0.9 and 1.4 hm^3 is produced. This will undoubtedly impact water distribution and collection systems (Loftus et al. 2011). Increased water demand will also contribute to raise the pollutant concentrations in the water reservoirs and aquifers' salinity (Fader et al. 2020).

Such a water scarcity scenario will also lead to raise the demand for desalination which will increase energy consumption. The Balearic Islands have 8 desalination plants (3 in Mallorca, 3 in Eivissa, 1 in Menorca and 1 in Formentera) based on reverse osmosis. Although this is said to be an efficient technology, it requires at least 5 kWh to desalt 1 m^3 of sea water (Shemer and Semiat 2017). Energy consumption from water desalination rose by 37.4% during the 1999–2017 period (GOIB 2016; ABAQUA 2019; Vaquer-Sunyer et al. 2021).[8]

As water demand, energy demand will be higher in summer (Valor et al. 2001), especially at nights (Papakostas and Slini 2017), while it is expected to be lower in winter (Giannakopoulos et al. 2009). Thus, the annual average demand might remain unchanged at current energy consumption levels. However, as peaks of summer demand will be higher due to cooling systems, polices oriented to either increase the power generation capacity or implement energy saving will have to be undertaken, which will involve higher generation costs (Elimelech and Phillip 2011).

Action on infrastructures will also be needed in the face of global warming. Higher temperatures might also deteriorate the infrastructures due to dilatations/thermal contractions and induce acceleration of corrosion processes. More CO_2 concentration involves a higher carbonation rate, this deteriorating existing concrete infrastructures (Stewart et al. 2011; Ekolu 2020). Although corrosion might be viewed as a minor issue, current estimates indicate that the global cost of corrosion represents the 3–4% of the GDP in industrialized countries, or equivalently $US1.8 trillion (Schmitt 2009). The huge magnitude of the direct and indirect corrosion costs allows anticipating that a slight CC-derived acceleration of this process could lead to important global economic costs.

On the other side, the expected rise in the sea level will reduce the height of the coronation level of the breakwaters in harbours and other maritime infrastructures, increasing the risk of failure under the occurrence of potential high waves. In addition, extreme rainfall episodes may increase which would lead to more floods, and therefore, larger drainage requirements such as slopes, elements of transverse drainage on roads or bridges, among others, may be needed locally to avoid aggravating the flooding effect at certain points (CEDEX 2013; Cramer et al. 2018).

Impacts on human health and the economy

Although at the global level it is expected CC will cause deaths due to heat stress, poor nutrition and malaria between 2030 and 2050 (WHO 2014), heat waves will represent the major direct CC human health impact in Western societies. The one occurring in Europe in 2003 was estimated to increase the probability of death between 20 and 70% in large cities (Mitchell et al. 2016). In the Balearic Islands, elders suffering from cardiovascular or respiratory diseases as well as outdoor workers are expected to be the most vulnerable population segments. On the other side, the most important indirect CC human health impacts will be vector-borne diseases and the rise of allergy episodes. Invasive species of vectors (i.e. *Aedes albopictus*) and imported diseases (i.e. dengue) will also increase the transmission risk, as already confirmed in Spain in 2018 (ECDC 2018). In addition, higher temperatures may modify the transmission capacity of autochthonous vectors, such as *Culex pipiens* and West Nile virus, as confirmed in the recent epidemic in Andalusia (ECDC 2020). Higher pollen concentrations will also provoke allergy-related respiratory problems.

CC is also expected to substantially affect the economy, thus leading to a decrease in social welfare (IPCC 2014). On the one side, production costs of all sectors will be affected by some physical changes. Indeed, higher temperatures and more frequent heat wave episodes will lead to a lower labour productivity mainly affecting the most vulnerable people and the employees' mental and physical health (Kjellstrom et al. 2016). In addition, the capacity of facilities and infrastructures can also be reduced by increased temperatures, which can lead to a growing risk of fires affecting infrastructures' logistics. The electricity generation and/or distribution systems will also experience more pressure due to the potential rise in summer energy demand. Utilities of provision and treatment of water for consumption can suffer from overload not only due to higher water demand but also due to lower precipitation. Some facilities might also have to be repaired or forced to close due to the sea level rise (Linnenluecke et al. 2011; Factor CO_2 Ideas 2015).[9] Production costs will further increase because of a potential rise in water prices due to both the increase in the demand of water and its use

[8] As an example, this consumption represented the 2.6% of the archipelago's annual electricity demand during the last drought period experienced by the region in 2016.

[9] Fossil fuel burning emissions are also expected to reduce both labour productivity and the facilities and infrastructures' capacity due to health impacts and the acceleration of corrosion processes, respectively.

rivalry between sectors (e.g. tourism, agriculture, industry). The agro-product prices might also increase due to a reduction of agro-systems productivity which, together with insularity costs, can increase imports of agro-products and their price (MedECC 2020). A higher energy demand can also lead to a rise in the energy prices which could be further exacerbated due to the peak oil, gas and coal phenomena.

On the other side, CC will also impact ecosystems' capacity to provide goods and services (Torres and Hanley 2017) especially affecting tourism, livestock and agriculture sectors. Warming and frequent heat waves are expected to affect the Balearic Islands' attractiveness (Bujosa et al. 2018) leading to a seasonal and geographical redistribution of tourists' flows, which will look for higher latitude, cooler regions (Bujosa et al. 2015). They are also expected to cause a loss of environmental quality, this making the islands even less attractive. Indeed, higher temperatures will increase the risk of fires (Fernández-González et al. 2005) and provoke the loss of seagrass *Posidonia oceanica* (Marba and Duarte 2010) affecting two recreational services provided by this plant: (i) the quality and transparency of coastal waters (Torres et al. 2009) and (ii) the recreational fishing of species which the plant serves as habitat to.[10] Warming can also lead to a higher frequency of jellyfish outbreaks (Canepa et al. 2014) and a loss of landscape values due to the further spread of the plant pathogen *Xylella fastidiosa*. New pathogens could also affect the destination attractiveness through vector-borne diseases or pandemics caused by other types of viruses like Covid-19.[11] On the other side, the sea level rise will also affect the environmental quality through the reduction of beaches' width (Enríquez and Bujosa 2020). Warming and lower precipitation will also impact the livestock and agricultural sectors' benefits (Factor CO_2 Ideas 2015; Institut d'Estudis Catalans and Generalitat de Catalunya 2016) as they will lead to a lower availability of fodder and grasses, this causing a reduction in milk and cheese production, lower yields and increased irrigation costs.

As a result of general and sectoral impacts, a rise in governments' budget deficit is expected due to the potential growth in public spending associated to energy and health systems, fighting against pests, port infrastructures and water collecting and distribution utilities.[12] The expected economic losses will also lead to an income reduction and hence less public revenues, this further contributing to raising the deficit.

Impacts on human rights and socio-political systems

CC can also lead to serious consequences upon citizens, society and the democratic institutions. Even from a legal perspective, the interdependence between nature and human beings is becoming increasingly clear. Since the 1972 Stockholm Declaration on the Human Environment, there has been a growing awareness that a clean and healthy environment is indispensable to the enjoyment of human rights. This has been clearly stated by the most recent reports of David R. Boyd, the current Special Rapporteur on Human Rights and the Environment,[13] and recognized by an increasing number of courts, both at the domestic[14] and international level.[15]

Accordingly, it is expected that CC will affect the human right to life, health, private and family life, property, food, water and housing, which have been established in several international instruments to which Spain is Party[16] and according to which Spain is obliged to interpret the fundamental rights set forth in its own Constitution.[17] This is especially true when it comes to consider the CC impacts on the most vulnerable, lower-income and marginalized sectors of society which are expected to be the most affected ones (O'Brien and Leichenko 2000; MedECC 2020). The encroachment of legally established human rights is likely to produce a surge in legal actions directed either against public authorities or private actors contributing to global warming, as is already happening in many countries (UNEP 2020).

Moreover, the dire CC impacts, together with a probable increase in the flux of migrants from Northern Africa

[10] It is worth noting the economic value of recreational fishing is five times higher than that of commercial fishing in Mallorca (Morales-Nin et al. 2015).

[11] Together with CC, the Covid-19 pandemic represents another global environmental effect from the expansion of human activities (Perkins et al. 2020).

[12] Impacts on health and port infrastructures due to more atmospheric CO_2 can also increase public expenditure.

[13] See, for instance, the 2019 Report on a safe climate, A/74/161 and the pioneering report on Human Rights and the Environment submitted by Fatma Zohra Ksentini to the Commission on Human Rights in 1994, UN Doc E/CN.4/Sub.2/1994/9.

[14] See the ruling by the Supreme Court of the Philippines in the Minors Oposa case, in 1993 (G.R. No. 101083 July 30, 1993). More recently, Juliana et al. v The United States of America et al., Opinion and Order, 10 November 2016, p. 32., or Friends of the Irish Environment et al. v. Fingal County Council et al., High Court of Ireland, Judgment, 2017 No. 201 JR, 21 November 2017, §264.

[15] See, among others, Taskin c. Turquie, 46,117/99, [2004] ECHR 621, and Corte Interamericana de Derechos Humanos, Opinión Consultiva OC-23/17 de 15 de noviembre de 2017.

[16] Among others, the 1948 Universal Declaration of Human Rights, the 1966 Covenant on Civil and Political Rights, the 1989 Convention on the Rights of the Child or the 1950 European Convention on Human Rights.

[17] As established by Article 10.2 of the 1978 Spanish Constitution.

(Cramer et al. 2019), will also likely deteriorate social stability and increase an already growing disaffection towards the democratic institutions that has fuelled the surge of a xenophobic and extreme-right party in the 2019 local, regional and nation-wide elections (Tables 3 and 4).[18]

Climate policy for the Balearic Islands

Given CC cannot be avoided, prevention is not seen as a policy option, and climate policy usually revolves around two types of action: mitigation and adaptation. While adaptation is oriented to enhance the resilience of the ecosystem and society for them to better cope with the expected CC impacts, mitigation pursues to diminish GHG concentrations in the atmosphere to reduce the global temperature increase and hence its derived impacts. The IPCC strongly recommends reaching net zero emissions by 2050 to limit the temperature increase to 1.5 ºC (IPCC 2018). On the other side, the EU has reached an agreement on the European Commission's proposal for the first European Climate Law, which aims to write into law the goals of the European Green Deal, establishing a GHG emissions reduction target of at least 55% by 2030. This is consistent not only with the Paris Agreement's recommendation to reach net zero emissions by 2050 but also with some studies pointing to the need to raise the ambition level up to a 55–65% reduction in an attempt to ensure the net zero emissions objective (ECF 2018).

Mitigation is urgently needed to avoid the further exacerbation of the economic and social costs linked to emissions reduction within a shorter time period. Starting mitigation now can also avoid a reduction of both the set of feasible emissions reduction options and the social capacity for response.

Mitigation policy recommendations

Mitigation policies can be viewed as an opportunity to diversify the Balearic Islands economy as they can lead to create new job opportunities in high value-added technological sectors requiring skilled labour and being hard to delocalize. Mitigation can also help to strengthen local economic sectors such as agriculture, fishing, arts and crafts and natural resource management. In a CC context, diversification becomes a necessity for a tourism-based economy due to the intensive use of fossil fuel energy and materials by the tourism sector which converts it into a big contributor to CC (Simpson et al. 2008; Torres and Moranta 2021). Indeed, tourism carbon footprint rose from 3.9 to 4.5 $GtCO_2e$ at the planetary level between 2009 and 2013 accounting for the 8% of global emissions (Lenzen et al. 2018). As stated by Cadarso et al. (2015, 2016), tourism is responsible not only for direct, indirect and imported emissions but also for emissions associated with the capital investments required to supply tourism goods and services, which are mostly linked to the construction sector (e.g. hotels, restaurants, transport infrastructures).

Accordingly, it is highly recommendable to design a Plan for Mitigation to reach by 2030 the emissions reduction targets set by the Climate Change and Energy Transition Law launched by the Balearic Islands Government at the beginning of 2019[19] in accordance with EU goals. Although mitigation in a broad set of areas is required, it is worth noting the importance of acting on the energy and transport sectors as they represent almost 80% of total direct emissions in the territory (40% and 37%, respectively, in 2016). Implicitly, this involves reducing the mass tourism–induced human pressure which an economy's diversification built on promoting activities having a lower carbon footprint will undoubtedly contribute to. Within a framework of a more diversified economy, the tourism sector's strategies aimed at reducing its emissions are also necessary. In this sense, some airlines, cruise liners and establishments are already committed to achieve carbon neutrality by putting emphasis on reducing energy consumption through efficiency improvements and a rise in renewable energy use. The case of Artiem Hotels in Menorca is outstanding in this regard. This family enterprise has reduced by 14% the CO_2 emissions of all its establishments in 5 years and pursues to reduce them by 80% in an 8-year time period.[20] However, technological innovation will not be sufficient to effectively decarbonise tourism as behavioural and structural changes at a large scale are required (Simpson et al. 2008; Becken 2019). In line with this, latest debates on tourism, which have been intensified by the Covid-19 pandemic, interestingly advocate for relocating tourism in search of other alternatives involving

[18] The extreme right party Vox obtained 11.30% of the ballots in April 2019 and rose to 17.08% in November 2019, up from 1.53% in the 2014 European elections. Source: http://www.infoelectoral.mir.es/.

[19] 10/2019 Law of Climate Change and Energy Transition, 22nd February (https://www.caib.es/sites/institutestudisautonomics/ca/n/llei_102019_de_22_de_febrer_de_canvi_climatic_i_transicio_energetica/).

[20] Artiem Hotels presented both its mitigation strategy and its Sustainability Artiem 8/80 project at the 2018 First Conference on CC in the Balearic Islands organized by the LINCC UIB. It also showed the case of the Hotel Artiem Audax which has reduced its emissions by 44% since 1999 (http://lincc.uib.eu/conferencies-jornades/primeres-jornades-sobre-canvi-climatic-a-les-illes-balears/resum-i-conclusions-de-les-jornades/#section4. Accessed 13 May 2021).

Table 3 Priority impacts on water resources, energy, infrastructures and human health derived from priority climate change–related physical changes expected for the Balearic Islands during the 2050–2100 period

Priority physical changes	Types of human systems			
	Water resources, energy and infrastructures[a]			Human health
Sea level rise	• Impacts on port infrastructures		• Increase in the penetration of salt water into aquifers leading to a reduction of the quality of water supply	
Air and sea temperature increase Increase in the number, length and frequency of atmospheric and marine heat waves Reduction of average precipitation and increase in evapotranspiration Increase in the number, duration and intensity of droughts	• Increase in infrastructure deterioration due to thermal deformations	• Decrease in water availability • Increase in seasonal demand for water resources • Increase in the interconnections of the water distribution infrastructures to deal with droughts • Reduction in the replacement flow and increase in the concentrations of pollution in the aquifers • Increase in summer energy demand peaks •Increase in the base power generation to meet the peak demand, due to the HVAC in summer period • Increase in the energy demand linked to desalination • Increase of the risk of wildfires and other types of fires linked to construction or exploitation of infrastructures		• Increased morbidity and mortality • Increase of vector-borne diseases

[a]It is worth noting that the rise in atmospheric CO_2 concentration will also accelerate corrosion processes in concrete and steel structures, an impact on infrastructures which is also exacerbated by the increase in the air temperature

a reduction of the ecological and social conflicts associated with the exponential growth of the sector (Cañada 2014). Labelled as 'proximity', 'low-carbon' or 'slow' tourism, such alternatives aim to rethink tourism to make it more sustainable (Becken 2017; Lee et al. 2018; Gössling and Higham 2020; Romagosa 2020).

Table 4 Priority impacts on the economy, human rights, society and the political system derived from priority climate change–related physical changes expected for the Balearic Islands during the 2050–2100 period

Priority physical changes	Types of human systems							
	Economy				Human rights, society and the political system			
Sea level rise	• Impacts on public sector (expenditure on infrastructures)	• Impacts on tourism sector		• Increase in production costs due to decreased capacity of facilities and infrastructures	• Right to property	• Right to private and family life and housing		• Right to water • Increase in the number of legal actions against public administrations and private corporations • Impacts on the insurance sector and existing contracts • Growing social unrest and lack of confidence on the political system
Air and sea temperature increase Increase in the number, length and frequency of atmospheric and marine heat waves	• Decreased labour productivity • Impacts on public sector (expenditure on energy, health and fight against pests)		• Increase in prices of water, energy[a] and agro-products • Impacts on agriculture and livestock sectors		• Right to life and health		• Right to food	
Reduction of average precipitation and increase in evapotranspiration Increase in the number, duration and intensity of droughts	• Impacts on public sector (expenditure on energy and water collecting and distribution systems)							

[a]It is to say energy prices are also expected to rise due to the peak oil, coal and gas phenomenon, this further increasing the production costs of all the sectors

Table 5 Recommended mitigation measures to address the identified priority climate change impacts to be included in mitigation plans before 2030

Policy area	Mitigation measures
Terrestrial and marine ecosystems	• Protect and promote the increase of natural areas such as forests and *Posidonia oceanica* seagrasses[a] • Calculate emissions associated to different land uses to complete the information of the Balearic Islands emissions inventories • Regulate biomass forest extractions to reduce the associated emissions • Implement an agricultural land and grazing management plan to reduce emissions • Promote soil uses and crops which better act as carbon sinks and preserve them through adequate waste management
Water resources	• Increase efficiency in water collection, distribution and consumption to reduce the need for desalinization as well as energy consumption
Energy	• Reduce energy demand in end-use sectors, especially in services and residential sectors, mostly through increasing buildings' energy efficiency[b] • Generate renewable energy together with both an adequate territorial planning and environmental impact assessments[c] • Promote changes in consumption patterns • Give up oil/gas exploratory drillings • Promote decentralized electricity generation • Define areas with a higher potential to facilitate access to electricity systems, thus being more suitable to allow for installation of renewable energy infrastructures • Use of smart-grid electricity techniques to allow for distribution of renewable energy generation • Promote district-heating networks in tourist coastal areas
Infrastructure and urban planning	• Promote urban planning which makes unnecessary or less necessary the use of private vehicles, thus reducing the pressure on the current transportation network as well as emissions and land consumption • Ensure compulsory sustainable parameters are established such as energy and water consumption and climate control systems in the construction sector • Implement plans for building restoration aimed at extending the useful life of buildings to avoid energy losses • Make urban areas greener through tree planting and green roofs to reduce the temperature and absorb CO_2 as well as maintain them through a more sustainable water use
Sustainable Mobility	• Establish a public transport network with affordable prices, not based on fossil fuels and adapted to each island avoiding the use of private vehicles • Promote foot and bicycle mobility within urban areas by making easy and safe the use of the public space • Promote shared mobility mechanisms and small electric vehicles • Initiate debate with national and local institutions about the need to reduce substantially emissions of flights, prioritizing their public service character, and evaluate the need of designing emission compensation mechanisms[d]
Human health	• Promote consumption of local products as they have a lower carbon footprint • Promote more sustainable mobility systems (foot and bicycle mobility)
Economy	• Promote disinvestment in fossil fuel and high carbon activities • Apply the Polluter Pays Principle and introduce a carbon tax as well as incentives to reduce emissions • Support those companies which want to develop a low carbon activity • Promote the development of a proximity economy specifically through regulation of the hotel and restaurant sectors as well as sustainable public purchases • Implement a circular economy system and reduce production and consumption of goods • Develop alternative types of tourism such as 'proximity', 'slow' or 'low-carbon' tourism[e]
Waste	• Reduce waste generation especially that concerning food, packaging and textile • Extend the useful life of goods and facilitate their repair and exchange (eliminate planned obsolescence) • Promote circular economy in such a way waste can be converted into resources to be used in production processes • Increase recycling rates • Use of compost to reduce the emissions associated to its discharge and to increase the carbon amount in soils
Law	• Promote initiatives aimed at changing the Spanish state regulation of high carbon activities in which the Balearic Islands don't have any (or have a partial) power such as those related to energy, ports, airports, waste and construction

Table 5 (continued)

Policy area	Mitigation measures
Education	• Incorporate into formal education curricula new contents relating to climate change issues • Identify jobs/sectors which need to be trained more urgently in relation to climate change and design specific education programmes for them • Establish a team work with the General Direction of Environmental Education, Environmental Quality and Waste, the Education Department of the Balearic Islands Government and the University of the Balearic Islands to deal with educational issues relating to climate change

[a]In 2017, terrestrial ecosystems captured a CO_2eq amount equal to 11% of the annual GHG emissions of Spain. It is estimated the Balearic Islands forests could store up to at least 5% of the annual islands emissions. On the other side, it is expected that *Posidonia oceanica* seagrasses, currently excluded from national emissions inventories, can store up to a 10% of the annual islands emissions. They could retain in their sediments an amount of CO_2eq corresponding to 100 years of emissions

[b]The efficiency increase should be at least equal to 27% according to EU goals set in 2014 for the 2030 Climate and Energy Framework. This target was raised to 32.5% in June 2018. It is possible that it will be updated again in June 2021

[c]A target of at least a 35% share of renewable energy by 2030 would be necessary, in line with the goals set by the EU 2030 Climate and Energy Framework (32% by 2030). It is highly possible that the EU target will be raised in June 2021, with speculation that it could reach between 38 and 40%

[d]Air transport's energy consumption represents about 30% of total energy consumption by transport. All these mitigation measures should also be adapted and applied to the maritime sector

[e]These types of tourism have to be understood within a framework of economy's diversification based on promoting activities with a lower carbon footprint

In this context, both designing an R&D&I Plan oriented to acquire knowledge on potential mitigation strategies and developing a system to measure emissions also become essential to achieve mitigation targets.

Table 5 reports the mitigation policies which are recommended to effectively address all the impacts considered of concern:

Adaptation policy recommendations

Adaptation policies should serve to make more resilient the ecosystems, the economy and the society of the Balearic Islands as well as to acquire knowledge oriented to keep or even increase social welfare. Such policies have to be adequate to cope with the expected priority CC impacts by 2030. So, the design of a Plan for Adaptation based on specialized research on both the CC effects on natural and human systems and the vulnerability of the different socio-economic sectors is highly recommendable. The plan should be focused on the impacts requiring most urgent action such as temperature increase, sea level rise, threats to biodiversity, human health, water resources and risks related to infrastructures, and be built on an in-depth analysis about which activities can better adapt to CC.

In this sense, the high vulnerability of tourism to global warming emerges as another argument in favour of the economy's diversification. Put it another way, diversifying the economy also represents a necessary adaptation strategy for the Balearic Islands to become more resilient. Even more, basing diversification on the promotion of activities with a lower carbon footprint (as explained in "Mitigation policy recommendations") can further increase the destination's resilience. In parallel with such a diversification process, it is also recommendable the different sectors engage in adaptation strategies to better cope with CC. And tourism is not an exception. Accordingly, retreat measures or relocating coastal firms, infrastructures and facilities and even residential populations from one area to another one are examples of adaptive responses to CC (Wall and Badke 1994; Linnenluecke et al. 2011; Mycoo 2013; Fatorić et al. 2017) which become interesting strategies to follow in 'sun and beach' tourism destinations. Creating shadow areas to counteract the expected tourists' thermal discomfort due to the increase in the temperature (e.g. designing green environments surrounding the buildings) or diversifying the tourism product in favour of less climate-dependent activities (e.g. conservation strategies of natural assets or improvement of the cultural offer) are other examples of adaptation strategies which could also be undertaken (Bujosa et al. 2018).

Undoubtedly, creating an Observatory of CC Impacts to better forecast the expected impacts and closely monitor the actual ones upon all relevant sectors would be very helpful. Such an Observatory would provide essential data to devise efficient policies to prevent and address the deleterious CC effects. Designing an R&D&I Plan allowing for the development of adaptation policies being suitable for the Balearic Islands would also be recommendable.

The adaptation policies recommended to cope with CC are reported in Table 6:

Table 6 Recommended adaptation measures to address the identified priority climate change impacts to be included in adaptation plans before 2030

Policy area	Adaptation measures
Terrestrial and marine ecosystems	• Strengthen forest fire prevention systems and regulate biomass extractions both to prevent fires and to ensure carbon capture and storage by forests • Identify threatened species and design strategies for their conservation • Design a biosecurity strategy, adapt the existing laws to it and generate an alert system to manage the introduction of alien, potentially invasive species • Generate management systems for beaches allowing for their conservation and recreational use • Implement *Posidonia oceanica* seagrasses protection measures • Design plans for adaptation taking into consideration key threats such as water resources deficit and pollution, soil mineralization reduction and vulnerability of certain crops to climate change • Increase efficiency in the water use both in irrigated and non-irrigated lands • Implement a fishing plan aimed at dealing with fish species being most vulnerable to climate change • Design plans for adaptation of livestock to climate change, including adaptation of facilities and management (i.e. foraging alternatives)
Water resources	• Manage water demand in an integrated way to adapt it to water availability through saving mechanisms, use of alternative local drinking fountains and especially reuse of regenerated waters whenever is possible in agricultural and tourism activities • Revise and adapt water collection and distribution systems to optimize the volume of 'recuperated water' and reduce water losses • Protect aquifers from overexploitation and prevent the coastal ones from salinization derived from sea level rise • Elaborate a plan to identify nitrate pollution sources of aquifers and implement policies to restore the polluted ones • Promote housing water reuse systems • Promote housing water efficiency consumption • Educate and increase social awareness about water as a scarce resource • Revisit and adapt water treatments
Infrastructure and urban planning	• Analyse infrastructure vulnerability and adapt current and planned infrastructure to temperature rises (in case of terrestrial infrastructures) and sea level rise (in case of maritime infrastructures) • Redesign urban planning by creating shadow areas and green passages (trees, green roofs, vegetation) to reduce urban heat island effects • Incorporate climate variables into infrastructure design • Consider bioclimatic issues in urban planning • Promote the energy efficiency in buildings to reduce the need of climate control systems
Energy	• Assess vulnerability and use potentiality of electricity systems
Human health	• Improve prediction systems and provide knowledge about CC risks especially those related to heat waves and vector borne diseases • Design and strengthen prevention programs for the most vulnerable people • Increase capability of healthcare workers and adapt the health system to identify and address CC human health risks
Economy	• Reduce the need to import goods and services • Diversify the economy
Education	• Incorporate into formal education curricula new contents relating to climate change issues • Identify jobs/sectors which need to be trained more urgently in relation to climate change and design specific education programmes for them • Establish a team work with the General Direction of Environmental Education, Environmental Quality and Waste, the Education Department of the Balearic Islands Government and the University of the Balearic Islands to deal with educational issues relating to climate change

Conclusions

For the Balearic Islands, this paper discusses the observed and projected changes in the most relevant atmospheric and marine variables due to the higher GHG emissions concentrations in the atmosphere. It also analyses the derived priority impacts on natural and agricultural and livestock systems, water resources, energy and infrastructures, as well as on human health, the economy, human rights and the socio-political system. Though all these hazards are expected to be more intense in the second half of the twenty-first century, it is argued a fragile territory such as the islands should design mitigation and adaptation plans before 2030 on the basis of the priority impacts identified in this paper for them to better cope with CC.

The analysis presented here shows higher temperatures, heat waves, the reduction of the average precipitation, the increase in evapotranspiration, the droughts, the sea level rise and the increase in ocean acidification and marine deoxygenation as the main CC-associated threats. The high vulnerability of the islands' ecosystems and the human systems depending on them calls for an urgent set up of CC policies if welfare of current and future generations is to be ensured. We identify important threats for the insular economy as it strongly depends on mass tourism, which is not only highly vulnerable to CC and pandemics but also a big contributor to the planetary environmental problems due to its high ecological footprint. This can put into risk the islanders' wellbeing if the economy is not diversified in an attempt to make it more resilient and lesser emitter of GHGs. CC will have an important impact on biodiversity and the supply of services by terrestrial and marine ecosystems which importantly contribute to the current sun and beach tourism model of the Balearic Islands (e.g. landscapes, forests, sandy beaches, *Posidonia oceanica* meadows).

Under recognition that ecosystems provide the society with goods and services that are not only economically valuable but especially crucial for life reproduction, the economy's diversification should be oriented to promoting an economic system which is environmentally friendly and protects the islands' heritage and idiosyncrasy. Diversification of the current socioeconomic model will facilitate the implementation of the needed adaptation and mitigation measures. In this sense, we identify ten areas which should be object of mitigation action related to terrestrial and marine ecosystems, water resources, energy, infrastructure and urban planning, sustainable mobility, human health, economy, waste, law and education. Terrestrial and marine ecosystems, infrastructure and urban planning, energy, human health, economy and education have also been identified as major areas for adaptation action.

Though the analysis has been focused on the Balearic Islands, their Mediterranean environmental conditions, and hence the particular CC threats they face, also make it interesting to other Mediterranean insular regions, and in particular, to those that also have a mass tourism–based economy. So, the conclusions drawn here can serve as a guide for them when it comes to design CC mitigation and adaptation policies.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10113-021-01810-1.

Acknowledgements We acknowledge Gabriel Moyà, Ignacio Catalan, Josep Alós, Jaume Sureda, Aina Calvo, Olaya Álvarez, Iris E. Hendriks, Júlia Santana and Ferran Rosa for their comments and suggestions on different sections of the manuscript.

Funding This work was supported by the Economic and Social Council of the Balearic Islands (Consell Econonòmic i Social de les Illes Balears).

Declarations

Conflict of interest The authors declare no competing interests.

References

Abad J, Booth L, Baills A, Fleming K, Leone M et al (2020) Assessing policy preferences amongst climate change adaptation and disaster risk reduction stakeholders using serious gaming. Int J Disaster Risk Reduct 51:101782. https://doi.org/10.1016/j.ijdrr.2020.101782

ABAQUA (2019) Memòria anual 2019. Conselleria de Medi Ambient i Territori. Agència Balear de l'Aigua i la Qualitat Ambiental (ABAQUA). https://www.lagencia.cat/wp-content/uploads/2020/10/MEMORIA_ANUAL_ABAQUA_2019_Castellano.pdf. Accessed 26 May 2021

Adaptecca (2018) Visor de Escenarios Climáticos. http://escenarios.adaptecca.es. Accessed 1 April 2018

Alós J, Tomas F, Terrados J, Verbruggen H, Ballesteros E (2016) Fast-spreading green beds of recently introduced *Halimeda incrassata* invade Mallorca island (NW Mediterranean Sea). Mar Ecol Prog Ser 558:153–158. https://doi.org/10.3354/meps11869

Altizer S, Ostfeld RS, Johnson PTJ, Kutz S, Harvell CD (2013) Climate change and infectious diseases: from evidence to a predictive framework. Science 341:514–519. https://doi.org/10.1126/science.1239401

Arabadzhyan A, Figini P, García C, González MM, Lam-González YE et al (2020) Climate change, coastal tourism, and impact chains – a literature review. Curr Issues Tour 1–36. https://doi.org/10.1080/13683500.2020.1825351

Ashebir D, Deckers T, Nyssen J, Bihon W, Tsegay A et al (2010) Growing apple (*Malus domestica*) under tropical mountain climate conditions in northern Ethiopia. Exp Agric 46:53–65. https://doi.org/10.1017/S0014479709990470

Barons MJ, Hanea AM, Wright SK, Baldock KC, Wilfert L et al (2018) Assessment of the response of pollinator abundance to environmental pressures using structured expert elicitation. J Apic Res 57(5):593–604. https://doi.org/10.1080/00218839.2018.1494891

Becken S (2017) Evidence of a low-carbon tourism paradigm? J Sustain Tour 25(6):832–850. https://doi.org/10.1080/09669582.2016.1251446

Becken S (2019) Decarbonising tourism: mission impossible? Tour Recreat Res 44(4):419–433. https://doi.org/10.1080/02508281.2019.1598042

Bianchi CM, Morri C (2003) Global sea warming and "tropicalization" of the Mediterranean Sea: Biogeographic and ecological aspects. Biogeographia 24:319–327. https://doi.org/10.21426/B6110129

Bosso L, Di Febbraro M, Cristinzio G, Zoina A, Russo D (2016) Shedding light on the effects of climate change on the potential distribution of *Xylella fastidiosa* in the Mediterranean basin. Biol Invasions 18:1759–1768. https://doi.org/10.1007/s10530-016-1118-1

Brown JH, Gillooly JF, Allen AP, Savage VM, West GB (2004) Toward a metabolic theory of ecology. Ecology 85:1771–1789. https://doi.org/10.1890/03-9000

Bujosa A, Riera A, Torres CM (2015) Valuing tourism demand attributes to guide climate change adaptation measures efficiently: the case of the Spanish domestic travel market. Tour Manag 47:233–239. https://doi.org/10.1016/j.tourman.2014.09.023

Bujosa, Torres CM, Riera A (2018) Framing decisions in uncertain scenarios: an analysis of tourist preferences in the face of global warming. Ecol Econ 148:36–42. https://doi.org/10.1016/j.ecolecon.2018.02.003

Burrows MT, Schoeman DS, Buckley LB, Moore P, Poloczanska ES et al (2011) The pace of shifting climate in marine and terrestrial ecosystems. Science 334:652–655. https://doi.org/10.1126/science.1210288

Cadarso MA, Gómez N, López LA, Tobarra MA, Zafrilla JE (2015) Quantifying Spanish tourism's carbon footprint: the contributions of residents and visitors. A longitudinal study. J Sustain Tour 23(6):922–946. https://doi.org/10.1080/09669582.2015.1008497

Cadarso MA, Gómez N, López LA, Tobarra MA (2016) Calculating tourism's carbon footprint: measuring the impact of investments. J Clean Prod 111(part B):529–537. https://doi.org/10.1016/j.jclepro.2014.09.019

Canepa A, Fuentes V, Sabatés A, Piraino S, Boero F et al (2014) *Pelagia noctiluca* in the Mediterranean Sea. In: Pitt KA, Lucas CH (eds) Jellyfish blooms. Springer, Dordrecht, pp 237–266. https://doi.org/10.1007/978-94-007-7015-7_11

Cañada E (2014) Relocating tourism in times of climate change. In: Champ C, Zimmermann A (eds) Increasing the sense of urgency. Reflections on tourism and climate change. Brot für die Welt, Berlin

CEDEX (2013) Climate change adaptation needs of the core network of transport infrastructure in Spain. Madrid. http://www.cedex.es/NR/rdonlyres/872032C9-00FB-4DF4-BFA3-3C00B3E8DF1/122814/ACCITFinalreportSeptember2013.pdf. Accessed 14 May 2020

Civantos E, Thuiller W, Maiorano L, Guisan A, Araújo MB (2012) Potential impacts of climate change on ecosystem services in Europe: the case of pest control by vertebrates. Bioscience 62(7):658–666. https://doi.org/10.1525/bio.2012.62.7.8

Colom P, Carreras D, Stefanescu C (2019) Long-term monitoring of Menorcan butterfly populations reveals widespread insular biogeographical patterns and negative trends. Biodivers Conserv 28(7):1837–1851. https://doi.org/10.1007/s10531-019-01764-1

Cramer W, Guiot J, Fader M, Garrabou J, Gattuso J-P et al (2018) Climate change and interconnected risks to sustainable development in the Mediterranean. Nat Clim Chang 8(11):972–980. https://doi.org/10.1038/s41558-018-0299-2

Cramer W, Guiot J, Marini K (2019) Risks associated to climate and environmental changes in the mediterranean region. A preliminary assessment by the MedECC Network Science-policy interface, MedECC

Cursach J, Moragues E, Rita J (2018) The key role of accompanying species in the response of the critically endangered *Naufraga balearica* (Apiaceae) to climatic factors. Plant Ecol 219(5):561–576. https://doi.org/10.1007/s11258-018-0818-2

DaMatta FM, Grandis A, Arenque BC, Buckeridge MS (2010) Impacts of climate changes on crop physiology and food quality. Food Res Int 43:1814–1823. https://doi.org/10.1016/j.foodres.2009.11.001

del Pozo A, Brunel-Saldias N, Engler A, Ortega-Farias S, Acevedo-Opazo C et al (2019) Climate change impacts and adaptation strategies of agriculture in Mediterranean climate regions MCRs. Sustainability 11(10):2769. https://doi.org/10.3390/su11102769

Dessai S, Bhave A, Birch C, Conway D, Garcia-Carreras L et al (2018) Building narratives to characterise uncertainty in regional climate change through expert elicitation. Environ Res Lett 13(7):074005. https://doi.org/10.1088/1748-9326/aabcdd

De Vilchez P (2016) Broadening the scope: the urgenda case, the Oslo principles and the role of national courts in advancing environmental protection concerning climate change. Span Yearb Int Law 20:71–92. https://doi.org/10.17103/sybil.20.06

De Vilchez P, Torres CM, Jordà G, Rita J, Miranda MA et al (2019) El canvi climàtic i les Illes Balears. Canvis, impactes i propostes d'acció. In Estudi sobre la prospectiva econòmica, social i mediambiental de les societats de les Illes Balears a l'horitzó 2030 (H2030). Consell Econòmic i Social de les Illes Balears, Palma (Mallorca), pp 135–213. http://lincc.uib.eu/wp-content/uploads/CES-UIB-Estudio-H2030_Cap%C3%ADtulo-5-castell%C3%A0.pdf. Accessed 14 May 2020

Díaz RJ, Rosenberg R (2008) Spreading dead zones and consequences for marine ecosystems. Science 321:926–929. https://doi.org/10.1126/science.1156401

ECDC (2018) Local transmission of dengue fever in France and Spain. European Centre for Disease Prevention and Control, Stockholm. https://www.ecdc.europa.eu/sites/portal/files/documents/08-10-2018-RRA-Dengue-France.pdf. Accessed 9 February 2021

ECDC (2020) Communicable Disease Threats Report. Week 40. https://www.ecdc.europa.eu/sites/default/files/documents/Communicable-disease-threats-report-3-oct-2020.pdf. Accessed 9 February 2021

ECF (2018) Net zero by 2050: from whether to how. Zero emissions targets to the Europe we want. Net Zero 2050 Series. European Climate Foundation. https://europeanclimate.org/wp-content/uploads/2019/11/09-18-net-zero-by-2050-from-whether-to-how.pdf. Accessed 14 January 2021.

EFSA (2015) Survival, spread and establishment of the small hive beetle (*Aethina tumida*). EFSA J 13:4328. https://doi.org/10.2903/j.efsa.2015.4328

Ekolu SO (2020) Implications of global CO_2 emissions on natural carbonation and service lifespan of concrete infrastructures–reliability analysis. Cement Concr Compos 114:103744. https://doi.org/10.1016/j.cemconcomp.2020.103744

Elimelech M, Phillip WA (2011) The future of seawater desalination: energy, technology, and the environment. Science 333(6043):712–717. https://doi.org/10.1126/science.1200488

Enríquez AR, Bujosa A (2020) Measuring the economic impact of climate-induced environmental changes on sun-and-beach tourism. Clim Chang 160:203–217. https://doi.org/10.1007/s10584-020-02682-w

Factor CO_2 Ideas (2015) Full de ruta per a l'adaptació al canvi climàtic a les Illes Balears. Anàlisi de risc climàtic. 01/2016. Bilbao, Espanya

Fader M, Giupponi C, Burak S, Dakhlaoui H, Koutroulis A et al (2020) Water. In: Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report [Cramer W, Guiot J, Marini K (eds.)] Union for the Mediterranean, Plan Bleu, UNEP/MAP, Marseille, France, 57pp, in press

Fatorić S, Morén-Alegret R, Niven RJ, Tan J (2017) Living with climate change risks: stakeholders' employment and coastal relocation in mediterranean climate regions of Australia and Spain. Environ Syst Decis 37:276–288. https://doi.org/10.1007/s10669-017-9629-6

Feehan J, Harley M, Van Minnen J (2009) Climate change in Europe. 1. Impact on terrestrial ecosystems and biodiversity. A review (Reprinted). Agron Sustain Dev 29:409–421. https://doi.org/10.1051/agro:2008066

Fernández-González F, Loidi J, Moreno JC (2005) Impactos sobre la biodiversidad vegetal. In: Moreno-Rodríguez JM (ed) Evaluación preliminar de los impactos en España por efecto del cambio climático. Ministerio de Medio Ambiente, Madrid, pp 183–270

Few S, Schmidt O, Offer GJ, Brandon N, Nelson J et al (2018) Prospective improvements in cost and cycle life of off-grid lithium-ion battery packs: an analysis informed by expert elicitations. Energy Policy 114:578–590. https://doi.org/10.1016/j.enpol.2017.12.033

Fisher MC, Henk DA, Briggs CJ, Brownstein JS, Madoff LC et al (2012) Emerging fungal threats to animal, plant and ecosystem health. Nature 484:186–194. https://doi.org/10.1038/nature10947

Fraga H, Pinto JG, Viola F, Santos JA (2019) Climate change projections for olive yields in the Mediterranean Basin. Int J Climatol 40(2):769–781. https://doi.org/10.1002/joc.6237

Gavrilova T, Andreeva T (2012) Knowledge elicitation techniques in a knowledge management context. J Knowl Manag 16(4):523–537. https://doi.org/10.1108/13673271211246112

Garcia C, Servera J (2003) Impacts of tourism development on water demand and beach degradation on the island of mallorca (spain). Geogr Ann Ser B 85:287–300. https://doi.org/10.1111/j.0435-3676.2003.00206.x

Garrabou J, Gomez-Gras D, Ledoux J-B, Linares C, Bensoussan N et al (2019) Collaborative database to track mass mortality events in the Mediterranean Sea. Front Mar Sci 6. https://doi.org/10.3389/fmars.2019.00707

Giannakopoulos C, Hadjinicolaou P, Zerefos C, Demosthenous G (2009) Changing energy requirements in the Mediterranean under changing climatic conditions. Energies 2:805–815. https://doi.org/10.3390/en20400805

Gilman SE, Urban MC, Tewksbury J, Gilchrist GW, Holt RD (2010) A framework for community interactions under climate change. Trends Ecol Evol 25:325–331. https://doi.org/10.1016/j.tree.2010.03.002

Giorgi F (2006) Climate change hot-spots. Geophys Res Lett 33(8):L08707. https://doi.org/10.1029/02006GL025734

González A, Tonazzini D, Klarwein S (2019). Coherencia Política del Turismo de Costa y el Cambio Climático: Calvià (Mallorca, Islas Baleares). Eco-Union: Barcelona. http://www.ecounion.eu/wp-content/uploads/2019/08/Informe_Final_Pol%C3%ADticasTurismoyCC_Calvi%C3%A0_junio2019.pdf. Accessed 12 May 2021

Gössling S, Higham J (2020) The low-carbon imperative: destination management under urgent climate change. J Travel Res 1–13. https://doi.org/10.1177/0047287520933679

Gopalakrishnan S, Smith MD, Slott JM, Murray AB (2011) The value of disappearing beaches: a hedonic pricing model with endogenous beach width. J Environ Econ Manag 61:297–310. https://doi.org/10.1016/j.jeem.2010.09.003

Govern de les Illes Balears (2016) Anàlisi de pressions i impactes sobre l'estat de les aigües costaneres de les Illes Balears 2014–2015. Conselleria Medi Ambient, Agricultura i Pesca. Direcció General Recursos Hídrics. https://www.caib.es/sites/aigua/ca/analisi_de_pressions_i_impactes_sobre_lestat_de_les_aigaes/. Accessed 26 May 2021

Habel JC, Samways MJ, Schmitt T (2019) Mitigating the precipitous decline of terrestrial European insects: requirements for a new strategy. Biodiversity and Conservation. Springer, Netherlands. https://doi.org/10.1007/s10531-019-01741-8

Harris JE, Rodenhouse NL, Holmes RT (2019) Decline in beetle abundance and diversity in an intact temperate forest linked to climate warming. Biol Cons 240. https://doi.org/10.1016/j.biocon.2019.108219

Herrera S, Fernández J, Gutiérrez JM (2016) Update of the Spain02 gridded observational dataset for EURO-CORDEX evaluation: assessing the effect of the interpolation methodology. Int J Climatol 36(2):900–908. https://doi.org/10.1002/joc.4391

Institut Estudis Catalans and Generalitat de Catalunya (2016) Tercer informe sobre canvi climàtic a Catalunya. Institut Estudis Catalans and Generalitat de Catalunya, Barcelona

IPCC (2007) Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel. IPCC, Ginebra

IPCC (2008) Secretariat. 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change. IPCC, Geneva

IPCC (2013) Summary for policymakers. In: Working Group I Contribution to the IPCC Fifth Assessment Report Climate Change 2013: The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom

IPCC (2014) Intergovernmental panel on climate change. Summary for policymakers. In: Edenhofer O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner S, Seyboth K, Adler A, Baum I, Brunner S, Eickemeier P, Kriemann B, Savolainen J, Schlömer S, von Stechow C, Zwickel T, Minx JC (eds) Climate Change 2014. Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge

IPCC (2018) Summary for policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]

Jansà A, Homar V, Romero R, Alonso S, Guijarro JA et al (2017) Extension of summer climatic conditions into spring in the Western Mediterranean area. Int J Climatol 37(4):1938–1950. https://doi.org/10.1002/joc.4824

Jorda G, Marbà N, Duarte CM (2012) Mediterranean seagrass vulnerable to regional climate warming. Nat Clim Chang 2:821–824. https://doi.org/10.1038/nclimate1533

Kaniewskia D, Marriner N, Cheddadi R, Cau MA, Fornós JJ et al (2020) Recent anthropogenic climate change exceeds the rate and magnitude of natural Holocene variability on the Balearic Islands. Anthropocene 32:1–14. https://doi.org/10.1016/j.ancene.2020.100268

Kjellstrom T, Otto M, Lemke B, Hyatt O, Briggs D et al (2016) Climate change and labour: impacts of heat in the workplace. Climate change, workplace, environmental conditions, occupational health risks, and productivity-An emerging global challenge to decent work, sustainable development and social equity. United Nations Development Programme, New York

Klausmeyer KR, Shaw MR (2009) Climate change, habitat loss, protected areas and the climate adaptation potential of species in Mediterranean ecosystems worldwide. PLoS ONE 4(7):e6392. https://doi.org/10.1371/journal.pone.0006392

Kroeker KJ, Korda RL, Crim R, Hendriks IE, Ramajo L et al (2013) Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming. Glob Chang Biol 19:1884–1896. https://doi.org/10.1111/gcb.12179

Lee S-H, Wu S-C, Li A (2018) Low-carbon tourism of small islands responding to climate change. World Leisure J 60(3):235–245. https://doi.org/10.1080/16078055.2018.1496530

Lelieveld J, Hadjinicolaou P, Kostopoulou E, Chenoweth J, El Maayar M et al (2012) Climate change and impacts in the Eastern Mediterranean and the Middle East. Clim Chang 114(3–4):667–687. https://doi.org/10.1007/s10584-012-0418-4

Lenzen M, Sun Y-Y, Faturay F, Ting Y-P, Geschke A et al (2018) The carbon footprint of global tourism. Nat Clim Chang 8:522–528. https://doi.org/10.1038/s41558-018-0141-x

Linnenluecke MK, Stathakis A, Griffiths A (2011) Firm relocation as adaptive response to climate change and weather extremes. Glob Environ Chang 21(1):123–133. https://doi.org/10.1016/j.gloenvcha.2010.09.010

Loftus A-C, Howe C, Anton B, Philip R, Morchain D (2011) Adapting urban water systems to climate change: a handbook for decision makers at the local level. ICLEI European Secretariat, Friburg de Brisgòvia

López-Urrea R, Montoro A, Mañas F, López-Fuster P, Ferreres E (2012) Evapotranspiration and crop coefficients from lysimeter measurements of mature "Tempranillo" wine grapes. Agric Water Manag 112:13–20. https://doi.org/10.1016/j.agwat.2012.05.009

Lorite IJ, Gabaldón-Leal C, Ruiz-Ramos M, Belaj A, de la Rosa R et al (2018) Evaluation of olive response and adaptation strategies to climate change under semi-arid conditions. Agric Water Manag 204(C):247–261. https://doi.org/10.1016/j.agwat.2018.04.008

Lorite IJ, Cabezas-Luque JM, Arquero O, Gabaldón-Leal C, Santos A et al (2020) The role of phenology in the climate change impacts and adaptation strategies for tree crops: a case study on almond orchards in Southern Europe. Agric for Meteorol 294:108142. https://doi.org/10.1016/j.agrformet.2020.108142

Marba N, Duarte CM (2010) Mediterranean warming triggers seagrass (*Posidonia oceanica*) shoot mortality. Glob Chang Biol 16:2366–2375. https://doi.org/10.1111/j.1365-2486.2009.02130.x

MedECC (2020) Climate and environmental change in the Mediterranean basin – current situation and risks for the future. First Mediterranean Assessment Report [Cramer W, Guiot J, Marini K (eds.)] Union for the Mediterranean, Plan Bleu, UNEP/MAP, Marseille, France, 600pp, in press

Milano M, Ruelland D, Fernandez S, Dezetter A, Fabre J et al (2013) Current state of Mediterranean water resources and future trends under climatic and anthropogenic changes. Hydrol Sci J 58:498–518. https://doi.org/10.1080/02626667.2013.774458

Miranda MA, Borràs D, Rincón C, Alemany A (2003) Presence in the Balearic Islands (Spain) of the midges Culicoides imicola and Culicoides obsoletus group. Med Vet Entomol 17:52–54. https://doi.org/10.1046/j.1365-2915.2003.00405.x

Mitchell D, Heaviside C, Vardoulakis S, Huntingford C, Masato G et al (2016) Attributing human mortality during extreme heat waves to anthropogenic climate change. Environ Res Lett 11:74006. https://doi.org/10.1088/1748-9326/11/7/074006

Morales-Nin B, Federico-Cardona C, Maynou F, Grau AM (2015) How relevant are recreational fisheries? Motivation and activity of resident and tourist anglers in Majorca. Fish Res 164:45–49. https://doi.org/10.1016/j.fishres.2014.10.010

Mycoo M (2013) Sustainable tourism, climate change and sea level rise adaptation policies in Barbados. Nat Resour Forum 38(1):47–57. https://doi.org/10.1111/1477-8947.12033

O'Brien K, Leichenko RM (2000) Double exposure: assessing the Impacts of climate change within the context of economic globalization. Glob Environ Chang 10(3):221–232. https://doi.org/10.1016/S0959-3780(00)00021-2

O'Hagan A (2019) Expert knowledge elicitation: subjective but scientific. Am Stat 73(sup1):69–81. https://doi.org/10.1080/00031305.2018.1518265

Olmo D, Nieto A, Adrover F, Urbano A, Beidas O et al (2017) First detection of Xylella fastidiosa infecting cherry (*Prunus avium*) and *Polygala myrtifolia* plants in Mallorca Island Spain. Plant Dis 101(10):1820. https://doi.org/10.1094/PDIS-04-17-0590-PDN

Paredes-Esquivel C, Sola J, Delgado-Serra S, Puig Riera M, Negre N et al (2019) *Angiostrongylus cantonensis* in North African hedgehogs as vertebrate hosts, Mallorca, Spain, October 2018. Euro Surveill 24(33). https://doi.org/10.2807/1560-7917.ES.2019.24.33.1900489

Phaneuf DJ, Smith VK, Palmquist RB, Pope JC (2013) Integrating property value and local recreation models to value ecosystem services in urban watersheds. Land Econ 84:361–381. https://doi.org/10.1353/lde.2008.0003

Papakostas KT, Slini T (2017) Effects of climate change on the energy required for the treatment of ventilation fresh air in HVAC systems the case of Athens and Thessaloniki. Procedia Environ Sci 38:852–859. https://doi.org/10.1016/j.proenv.2017.03.171

Perkins KM, Munguia N, Ellenbecker M, Moure-Eraso R, Velázquez L (2020) COVID-19 pandemic lessons to facilitate future engagement in the global climate crisis. J Clean Prod. https://doi.org/10.1016/j.jclepro.2020.125178

Powney GD, Carvell C, Edwards M, Morris RKA, Roy HE et al (2019) Widespread losses of pollinating insects in Britain. Nat Commun 10:1018. https://doi.org/10.1038/s41467-019-08974-9

Pulido-Velazquez D, García-Aróstegui JL, Molina J-L, Pulido-Velazquez M (2015) Assessment of future groundwater recharge in semi-arid regions under climate change scenarios (Serral-Salinas aquifer, SE Spain). Could increased rainfall variability increase the recharge rate? Hydrol Process 29:828–844. https://doi.org/10.1002/hyp.10191

Purse BV, Carpenter S, Venter GJ, Bellis G, Mullens BA (2015) Bionomics of temperate and tropical *Culicoides* midges: knowledge gaps and consequences for transmission of *Culicoides*-borne viruses. Annu Rev Entomol 60:373–392. https://doi.org/10.1146/annurev-ento-010814-020614

Ramos MC (2017) Projection of phenology response to climate change in rainfed vineyards in north-east Spain. Agric For Meteorol 247:104–115. https://doi.org/10.1016/j.agrformet.2017.07.022

Raitsos DE, Beaugrand G, Georgopoulos D, Zenetos A, Pancucci-Papadopoulou AM et al (2010) Global climate change amplifies the entry of tropical species into the Eastern Mediterranean Sea. Limnol Oceanogr 55:1478–1484. https://doi.org/10.4319/lo.2010.55.4.1478

Report of the Special Rapporteur on the issue of Human Rights Obligations Relating to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environment: Climate Change Report. UN Doc. A/74/161, 15 July 2019

Reside AE, Critchell K, Crayn DM, Goosem M, Goosem S et al (2019) Beyond the model: expert knowledge improves predictions of species' fates under climate change. Ecol Appl 29(1):e01824. https://doi.org/10.1002/eap.1824

Romagosa F (2020) The COVID-19 crisis: opportunities for sustainable and proximity tourism. Tour Geogr 22(3):690–694. https://doi.org/10.1080/14616688.2020.1763447

Santillán D, Garrote L, Iglesias A, Sotes V (2020) Climate change risks and adaptation: new indicators for Mediterranean viticulture. Mitig Adapt Strat Glob Chang 25(5):881–899. https://doi.org/10.1007/s11027-019-09899-w

Schmitt G (2009) Global needs for knowledge dissemination, research, and development in materials deterioration and corrosion control. World Corrosion Organization. http://corrosion.org/Corrosion+Resources/Publications/_/whitepaper.pdf. Accessed 14 May 2020

Shemer H, Semiat R (2017) Sustainable RO desalination – energy demand and environmental impact. Desalination 424:10–16. https://doi.org/10.1016/j.desal.2017.09.021

Simpson MC, Gössling S, Scott D, Hall CM, Gladin E (2008) Climate change adaptation and mitigation in the tourism sector: frameworks, tools and practices. UNEP, University of Oxford, UNWTO, WMO, Paris

Soto-Navarro J, Jordà G, Amores A, Cabos W, Somot S et al (2020) Evolution of Mediterranean Sea water properties under climate change scenarios in the Med-CORDEX ensemble. Clim Dyn 54:2135–2165. https://doi.org/10.1007/s00382-019-05105-4

Spathelf P, van der Maaten E, van der Maaten-Theunissen M, Capioli M, Dobrowolska D (2014) Climate change impacts in European

forests: the expert views of local observers. Ann for Sci 71:131–137. https://doi.org/10.1007/s13595-013-0280-1
Stewart MG, Wang X, Nguyen MN (2011) Climate change impact and risks of concrete infrastructure deterioration. Eng Struct 33:1326–1337. https://doi.org/10.1016/j.engstruct.2011.01.010
Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ et al (2004) Extinction risk from climate change. Nature 427:145–148. https://doi.org/10.1038/nature02121
Thornton PK, van de Steeg J, Notenbaert A, Herrero M (2009) The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agric Syst 101:113–127. https://doi.org/10.1016/j.agsy.2009.05.002
Torres CM, Hanley N (2017) Communicating research on the economic valuation of coastal and marine ecosystem services. Mar Policy 75:99–107. https://doi.org/10.1016/j.marpol.2016.10.017
Torres CM, Moranta J (2021) La emergencia climática en economías turistizadas: la necesaria transición económica, ecológica y social como base para una mitigación efectiva. Rev Econ Crít 30:120–135
Torres CM, Riera A, García D (2009) Are preferences for water quality different for second-home residents? Tour Econ 15:629–665. https://doi.org/10.5367/000000009789036620
Tuttle CM, Heintzelman MD (2015) A loon on every lake: a hedonic analysis of lake water quality in the Adirondacks. Resour Energy Econ 39:1–15. https://doi.org/10.1016/j.reseneeco.2014.11.001
UNCHR (1994) Final report of the Special Rapporteur to the United Nations Commission on Human Rights. UN Doc E/CN.4/Sub.2/1994/9
UNEP (2020) Global Climate Litigation Report: 2020 Status Review. United Nations Environment Programme, Nairobi. Available at https://wedocs.unep.org/bitstream/handle/20.500.11822/34818/GCLR.pdf?sequence=1&isAllowed=y. Accessed 18 February 2021
Valor E, Meneu V, Caselles V (2001) Daily air temperature and electricity load in Spain. J Appl Meteorol 40:1413–1421. https://doi.org/10.1175/1520-0450(2001)040%3c1413:DATAEL%3e2.0.CO;2
Vaquer-Sunyer R, Duarte CM (2008) Thresholds of hypoxia for marine biodiversity. Proc Natl Acad Sci U S A 105(40):15452–15457. https://doi.org/10.1073/pnas.0803833105
Vaquer-Sunyer R, Duarte CM (2011) Temperature effects on oxygen thresholds for hypoxia in marine benthic organisms. Glob Chang Biol 17:1788–1797. https://doi.org/10.1111/j.1365-2486.2010.02343.x
Vaquer-Sunyer R, Duarte CM (2013) Experimental evaluation of the response of coastal Mediterranean planktonic and benthic metabolism to warming. Estuar Coasts 36:697–707. https://doi.org/10.1007/s12237-013-9595-2
Vaquer-Sunyer R, Duarte CM, Jorda G, Ruiz-Halpern S (2012) Temperature dependence of oxygen dynamics and community metabolism in a shallow Mediterranean macroalgal meadow (*Caulerpa prolifera*). Estuar Coasts 35:1182–1192. https://doi.org/10.1007/s12237-012-9514-y
Vaquer-Sunyer R, Barrientos N, Martino S, Calvo J (2021) Plantes dessalinitzadores: volum d'aigua potable produïda i abocaments de salmorra. In: Vaquer-Sunyer, R, Barrientos N (eds). Informe Mar Balear 2021. https://informemarbalear.org/ca/pressions/imb-pressions-dessaladores-cat.pdf. Accessed 26 May 2021
Vargas M, García-Martínez MC, Moya-Ruiz F, Tel E, Parrilla G et al (2008) Cambio climático en el Mediterráneo Español. Instituto Español de Oceanografía. Ministerio de Educación y Ciencia, Madrid
Varotsos KV, Karali A, Lemesios G, Kitsara G, Moriondo M et al (2021) (2021) Near future climate change projections with implications for the agricultural sector of three major Mediterranean islands. Reg Environ Chang 21:16. https://doi.org/10.1007/s10113-020-01736-0
Verdolini E, Anadón LD, Baker E, Bosetti V, Aleluia Reis L (2018) Future prospects for energy technologies: insights from expert elicitations. Rev Environ Econ Policy 12(1):133–153. https://doi.org/10.1093/reep/rex028
Vergés A, Steinberg PD, Hay ME, Poore AGB, Campbell AH et al (2014a) The tropicalization of temperate marine ecosystems: climate-mediated changes in herbivory and community phase shifts. Proc R Soc B Biol Sci 281(1789):20140846. https://doi.org/10.1098/rspb.2014.0846
Vergés A, Tomas F, Cebrian E, Ballesteros E, Kizilkaya Z et al (2014b) Tropical rabbitfish and the deforestation of a warming temperate sea. J Ecol 102(6):1518–1527. https://doi.org/10.1111/1365-2745.12324
Vivo-Pons A, Alos J, Tomas F (2020) Invasion by an ecosystem engineer shifts the abundance and distribution of fish but does not decrease diversity. Mar Pollut Bull 160. https://doi.org/10.1016/j.marpolbul.2020.111586
Wall G, Badke C (1994) Tourism and climate change: an international perspective. J Sustain Tour 2(4):193–203. https://doi.org/10.1080/09669589409510696
Wilcox C, Hobday AJ, Chambers LE (2018) Using expert elicitation to rank ecological indicators for detecting climate impacts on Australian seabirds and pinnipeds. Ecol Ind 95(1):637–644. https://doi.org/10.1016/j.ecolind.2018.07.019
World Health Organization (2014) Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization, Geneva (ISBN 9789241507691)
Zarnetske PL, Skelly DK, Urban MC (2012) Biotic multipliers of climate change. Science 336(6088):1516–1518. https://doi.org/10.1126/science.1222732

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