**LIFE PROJECT**

# “Participatory and multi-level governance process to design a transformational climate change adaptation project at Cala Millor beach from an integrated and multidisciplinary science-based approach”

**DELIVERABLE NUMBER 3.2: Summary report about socio-economic consequences of the climate change in the Bay of Cala Millor and its influence area.**

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| PROJECT ACRONYM | **LIFE AdaptCalaMillor** |
| GRANT AGREEMENT NUMBER | **LIFE21/GIC/ES/101074227** |
| CALL AND TOPIC | **LIFE-2021-SAP-CLIMA-GOV** |
| FUNDING BODY | **CINEA** |
| PROJECT DATES | **1st of January 2021 – 30th of April 2027** |
| COORDINATOR BENEFICIARY | **Directorate General of Energy and Climate Change (DGECC)** |
| WEBSITE | |

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|---|---|
| DELIVERABLE NUMBER | D3.2 |
| DELIVERABLE TITLE | ***Summary report about socio-economic consequences of the climate change in the Bay of Cala Millor and its influence area*** |
| WORK PACKAGE AND TASK NUMBER | WP3; Task T3.3. |
| LEAD PARTICIPANT PARTNER | DG-UIB |
| DISSEMINATION LEVEL | **public** |
| DELIVERY DUE DATE | 30/09/2024 |
| LAST MODIFIED DATE | 30/09/2024 |
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*This project has received funding from the European Union’s LIFE programme under grant agreement Nº LIFE21/GIC/ES/101074227*

Project partners:

**Cita**: Pascual-Fuster, B., Rosselló-Nadal, J. (2024). DELIVERABLE NUMBER 3.2: Summary report about socio-economic consequences of the climate change in the Bay of Cala Millor and its influence area. http://doi.org/10.25704/WZKM-HV49

# EXECUTIVE SUMMARY

In economic terms, the Cala Millor area is highly specialised in tourism. The two municipalities in the area, Son Servera and Sant Llorenç des Cardassar, have around 35,000 tourist accommodation places and in 2023 the total number of visitors in hotel establishments exceeded 850,000 tourists, making it the third most important destination in the Balearic Islands. The type of tourist who visits Cala Millor is mainly attracted by the beach and the climate of the area, hence the high seasonality that characterises the economic activity of Cala Millor. In this context, it is to be expected that climate change will affect the economic activity of Cala Millor from different perspectives.

Firstly, and directly, the global increase in temperatures could flood (or affect areas during extreme events) areas currently occupied by urban areas dedicated to commercial, tourist accommodation or residential activities. Secondly, and indirectly, rising sea levels and temperature increase could affect the surface area of the beach used by tourists and their comfort, which are two of the main attractions of the area, leading to a loss of tourist demand (which would be reduced by the loss of attractiveness) and consequently a drop in the value of economic activities and residential properties. Finally, also indirectly, it is possible to think that climate change, as a global phenomenon, will affect the flow of tourists in demand worldwide, causing a redistribution of the same, which, in turn, may affect the tourist demand of the sun and beach segment that characterises tourism in Cala Millor.

In this project, the economic assessment of the risk caused by climate change has been based on a double classification. On the one hand, as regards economic activities, an attempt has been made to evaluate the total value in terms of sales. In this way, by basing the valuation on total sales, we try to capture that this amount is subsequently distributed to supplies, remuneration of employees, taxes, capital remuneration, financial expenses, etc. On the other hand, as regards the value of properties, a conservative perspective has been chosen, capturing only the cadastral value of the properties. All these values are exposed to two types of effects: the direct effects of rising sea levels and the flooding of land where there is currently some type of economic or residential activity and the indirect effects linked to the loss of tourist appeal of the area due to the loss of beach surface area and the increase in temperatures. In order to assess the indirect effects of beach loss and rising temperatures, surveys have been conducted to try to evaluate the importance of these two determinants when choosing Cala Millor as a tourist destination.

The results show that the total economic value of the Cala Millor area is 2,673 million Euros. This value is obtained after considering three main types of urban infrastructure: residential, hotel accommodation and other commercial establishments. Since this value is obtained by aggregating the values assigned to cadastral parcels, it is possible to obtain an estimate of the direct effects of climate change due to the loss of land related to rising sea levels and flood zones. As for the indirect effects due to the loss of beach surface and rising temperatures, the results of the survey show a potential loss of demand of 58% in the event of a possible scenario of a 50% loss of beach surface, which can be transferred to the loss of 50,3% of the economic value of the area.

# INDEX

# 1. INTRODUCTION

Cala Millor is a coastal town located on the east of Mallorca distributed between the municipalities of Sant Llorenç des Cardessar and Son Servera. Cala Millor has a population of about 5,200 inhabitants (INE, 2024) whose economic activity is based mainly on tourism. According to the official statistics, in 2023 the total number of visitors in hotel establishments in the two municipalities exceeded 850,000 while, from the supply side, there are around 35,000 tourist accommodation places. The most outstanding attraction of Cala Millor is its extensive beach with a length of 1,750 m and a width of 35 m. The accommodation offer is very varied and of quality, with most hotels and apartments located on the seafront, with a pedestrian area behind. Many tourists, year after year, choose one of these hotels to enjoy their holidays. There are also shops of all kinds and many cafes, bars and restaurants all of them linked to tourism activity.

Currently, due to the destruction of the dune system with the construction of hotels and apartments, together with the foreseeable rise in sea level because of climate change, concern is being raised about the consequences that the increase in temperatures, the disappearance of the environment and more specifically of the beach, may have on the main economic activity of the area. This working paper analyses and assesses the consequences of climate change risk on the Cala Millor from different levels.

In section two, we analyse the consequences of climate change on demand flows at a global level. Thus, Cala Millor, as an area of attraction for sun and beach tourism, may be affected by the changes expected at an international level for this type of segment, so it is necessary, firstly, to evaluate this general context. To assess the global context, this work is based, firstly, on the expected effects on climate indices and secondly on the effects of climate change on tourism demand, with special attention to the market segments most closely related to tourism in Cala Millor. In section three, the specific assessment of climate change risk for the Cala Milor area is carried out. The methodology for assessing the economic activity in the area is described, depending on whether it involves hotel and accommodation establishments, commercial activities and residential properties, using cadastral plots as the unit of value. We finish this section estimating the effects of beach loss and rising temperatures using scenarios of physical impact of climate change on the area. Finally, we discuss our results and conclude.

# 2. THE EFFECTS OF CLIMATE CHANGE ON TOURISM DEMAND

Climate change has been recognized as one of the main challenges facing society today and future generations (IPCC, 2022). When translating the impacts of climate change into economic terms, the wide variability in estimates highlights the difficulty in reaching definitive conclusions (Tol, 2018). Despite this uncertainty, tourism is frequently recognized as the economic activity with a higher degree of exposure to climate change, along with agriculture. In terms of risk analysis, agriculture is considered as an activity with more exposure but with less vulnerability, while tourism is considered an activity with more vulnerability but with variable exposure, depending on the market segment and the destination (Dogru, 2019; Scott et al., 2019). Thus, specifically, it is accepted that vulnerability is very high in the specific cases of snow or coastal tourism (Moreno and Becken, 2009).

It is not surprising, then, that the analysis of the effects of climate change on tourism has assumed an increasing role in scientific research on tourism (Rosselló-Nadal, 2014). In a current context of globalization and accelerated economic changes, the alteration of resources related to the physical environment will affect the economic activity of a territory and its development. In this way, the maintenance of the territorial resources that favour tourist activity in the main tourist destinations around the world is presented as a process full of uncertainties due to the changes that are indisputably experienced in climatic conditions all over the world. Added to this uncertainty is the limited capacity for adaptation that, in general, currently characterizes most of the destinations that, like Cala Millor, have based their model on the exploitation of closely linked natural resources to the specific climatic conditions of certain periods of the year and which have ended up coining the concept of "climate dependence".

In recent years, scientific research into the effects of climate change on tourism has moved from the physical description of the phenomenon to the economic estimation of its impacts, based on future climate projections, and the study and development of proposals for adaptation, as well as the analysis of the perception of the phenomenon by the agents involved. Despite the lack of specific projections for Mallorca or Cala Millor, it is possible to find specific references to Spain as a whole or for the tourism segment linked to the coasts in the specialized literature analyzing and quantifying the sensitivity of demand to the climatic conditions.

In this way, it is recognized that the increase in temperatures will be associated with a change in the feeling of comfort. Thus, based on Mieczkowski's (1985) proposal to create a comfort index based on different climate indicators (temperature, wind, hours of sunshine...), different scenarios have been estimated that consider the projections of these climate variables and the comfort temperature desired by tourists. In general, these projections show a loss of comfort in the case of Spain (Amelung et al., 2007) and in the specific case of the coasts of Mallorca (Moreno and Amelung, 2009).

When quantifying the impact on demand, most studies (Hamilton et al., 2005a and 2005b; Rosselló and Santana-Gallego, 2014) talk about a drop in the international market share of almost a percentage point of the Spanish market against an eventual warming of the global temperature. Projections for national tourism also show a redistribution of domestic tourism from the warmer areas of the south-east towards the north of the peninsula (Bujosa and Rosselló, 2013; Bujosa et al., 2015; Priego et al., 2015). However, it is worth saying that all these studies show a great dependence of tourism on other factors (such as, for example, income), so the future evolution of tourism depends on the future evolution of these as well factors and not only climate change. Regarding the perception of residents, 43.2% of Spaniards consider it likely that there will be a decrease in tourist activity in Spain in the medium term (2030) because of climate change and 69.8% consider probable loss of coastal areas due to sea level rise (Meira Cartea et al., 2013).

But it must be considered that not only the simple increase in temperatures and the deterioration of the average climatic comfort can change the patterns of the tourist typology that currently visits Mallorca and Cala Millor. It has been shown how climate change is associated with an increase in extreme weather phenomena, a reduction in precipitation (and, consequently, more scarcity of available water resources) and the transformation of natural spaces, among other impacts. Thus, everything suggests that climate change is associated with a loss of competitiveness of the tourist product traditionally called "sun and beach" that has characterized Mallorca and Cala Millor over the last decades, although, in these contexts, the loss of competitiveness it has not yet been quantified by the specialized literature.

The absence of this type of study in the literature on climate change could be explained by the uncertainty and complexity of the expected reactions of tourism demand. Gössling et al. (2012) highlight the complexity of understanding tourists' perceptions and reactions to climate change impacts as a means of anticipating the decline or increase of specific tourism markets and seasonal changes in tourism demand. They argue that tourism stands out for its substantial adaptive capacity, which must be combined with other uncertainties about the implementation of future mitigation policies and their impacts on transport systems, along with the wide range of impacts from climate change to the wider destinations and impacts on society and economic development.

However, the current tourism industry must anticipate the consequences of climate change on future demand. Despite the controversies about the weaknesses of statistical models in predicting tourist flows in climate change scenarios (Gossling et al., 2012; Bigano. at al., 2006), strategic planning is now necessary for the tourism sector in terms of new infrastructure and the detection of business opportunities in the medium and long term. The results of the literature on tourism and climate change must be contextualized, which implies that all determinants of tourism demand - except climate, whose influence is being analysed - must be held constant. Consequently, it must be assumed that a high level of uncertainty will remain, given the difficulties involved in forecasting social phenomena in the medium and long term. For example, with the winter tourism market segment, although it is almost impossible to provide information about the changing preferences of potential tourists visiting mountain resorts over the next 50 years, it is feasible to assess the physical consequences of a loss of snow cover due to climate change. An idea of future snow cover can then be predicted by quantifying expected snowfall, which in turn will implicitly determine the availability of winter tourism conditions.

Similarly, optimal tourism conditions can also be assessed by assuming that some tourism activities require a certain level of favourable climatic conditions. For example, visits to nature reserves, cycling, golf tourism, beach tourism, nautical tourism or city tourism may require certain weather conditions. In this case, an assessment of what tourists perceive as optimal conditions is needed, and further assessment of future climate conditions will determine the diminished or enhanced attractiveness of a destination for tourists. Obviously, changes in climate preferences are difficult to anticipate and only optimal climate conditions can be projected.

In recent years, the incorporation of climate variables (such as temperature, precipitation and wind) into tourism demand models has become more common (Goh, 2012). The effect of climate on tourism demand is taken as a short-run determinant in the time series context and as a structural push-and-pull determinant when considering both discrete choice and aggregate tourism models (Rosselló and Santana-Gallego, 2022). Since the estimation techniques usually entail the isolation of each of the determinants, it is possible to evaluate the marginal contribution of climatic factors to tourism demand while the other variables remain constant.

As a result, during the last fifteen years numerous tourism demand studies have tried to assess the consequences of climate change on tourism. To analyse the specific case of Cala Millor, in this section on aggregate effects on demand we will begin by analysing the results that have been published on ideal climatic conditions in similar areas and in specific studies on the Balearic Islands, and then analyse the results of the demand models. In section 3, we will deal with the possible consequences of the effects of climate change on the value of tourist infrastructure due to rising sea levels and their consequences.

## 2.1. Tourism climate indices

A tourism climate index serves as a concise measure indicating the suitability of climate conditions for tourism activities. It is generally accepted that the initial proposal to establish a climate index for tourism can be found in Mieczkowski (1985), who, using different climate data from multiple meteorological stations around the world, generated monthly world maps for tourism climate attractiveness, thus showing the important seasonal variations in climate conditions that occur at many destinations around the world throughout the year.

Mieczkowski's (1985) tourism climate index (TCI) comprised several components: a daytime comfort index, which integrates the maximum daily temperature and minimum daily relative humidity, scored from -6 to 10; a daily comfort index, calculated from the mean daily temperature and mean daily relative humidity, also rated from -6 to 10; a precipitation index, ranging from 0 to 10; a sunshine index, also rated from 0 to 10; and a wind index, scored from 0 to 10. With weights of 4, 1, 2, 2, and 1, respectively, these five variables make up the index, which can range from -30 to 100, making it possible to classify the climate of the destinations into categories ranging from "impossible" to "ideal." Since the initial Mieczkowski's proposal, the design and application of climate indices have evolved in different directions to overcome the shortcomings discussed below.

A first point of criticism was that the Mieczkowski's index did not account for potential intercultural and geographic differences in climate preferences. In this way, the perceptions of what constitutes a rainy day for a North-European tourist are probably very different from those of a tourist from North Africa. In this context, De Freitas et al. (2008) introduced a novel index that considers the dominant characteristics of certain weather elements while recognizing the presence of intercultural variations in climate preferences.

Mieczkowski's weightings were derived from his personal perspectives, expert insights, and existing biometeorological literature. Consequently, two significant critiques of the index are its lack of empirical validation and potential bias in the rating and weighting systems tailored to specific activities. Morgan et al. (2000) and Moreno and Amelung (2009) developed specific climate indices for beach tourism. Although both indices incorporated the same climate variables, the primary difference lay in their rating and weighting methodologies. While Mieczkowski's index relied on expert judgement , Morgan et al. (2000) and Moreno and Amelung (2009) based their schemes on the stated preferences of North-European beachgoers gathered through questionnaires.

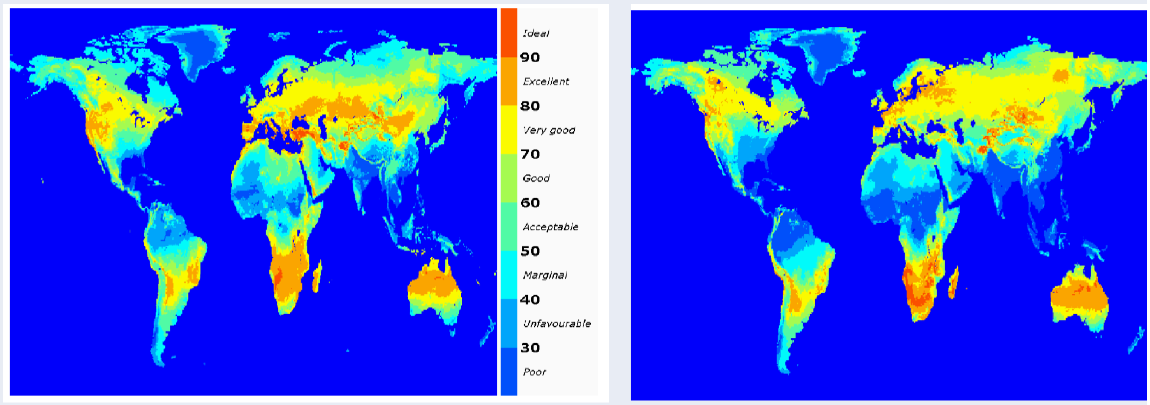
To more accurately assess the climatic suitability of destinations for leisure tourism, Scott et al. (2016) developed the Holiday Climate Index (HCI) where variable rating scales and component weighting system are based on tourists' stated climatic preferences. Using a comparative analysis of the results from HCI:Urban and TCI for geographically diverse urban destinations across Europe they evidence that HCI:Urban rates the climate of many cities higher than the TCI, particularly in the shoulder seasons and winter months, which aligns more closely with observed visitation patterns. Using tourists' stated climatic preferences for coastal-beach tourism Rutty et al. (2020) developed the HCI:Beach for three Caribbean destinations, finding how the new index presents a stronger relationship with tourist arrivals. In a similar way Ma et al. (2020) introduced the Camping Climate Index to examine the effects of weather and climate variability on camping occupancy and optimal camping conditions, employing the same climate variables but optimizing weights through multivariate regression analysis. More recently, Cardell et al. (2023) quantify the climate potentials for cultural, golf, sailing, hiking, cycling and football activities in Spain, finding a general future increase of excellent climate potentials in winter and a general improvement of the weather assets in the northern half of the country during the shoulder seasons, except for cycling and football.

Probably due to data availability or the proximity of some destinations to their origin markets, the literature has developed and applied the concept of climate indices to tourism, particularly for destinations where the seasonality of temperatures is significant. Therefore, and far from being exhaustive, applications of climate indices can be found for Europe (Amelung and Moreno, 2009; Perch-Nielsen et al., 2010), the Mediterranean (Amelung and Viner, 2006), Africa (Fitchett et al., 2017; Alonso-Pérez et al., 2021), and Asia (Lin and Matzarakis, 2011; Fang and Yin, 2015; Yu et al., 2020). On some occasions, when applied to tropical or subtropical zones, we see its inability to reflect seasonal behaviour (Alonso-Pérez et al., 2021; Noome and Fitchett, 2022).

In any case, the results of the assessment of ideal climatic conditions for tourism in the face of global warming scenarios have given rise to different evaluations in recent years. One of the first works is represented by the global assessment carried out by Amelung et al (2007) (Figure 1) where it is possible to observe a loss of ideal climatic conditions for the development of tourism in most of the temperate zones of the world, including the Mediterranean. It is important to highlight how, in contrast, the climatic conditions for the practice of tourism have substantially improved in the northernmost zones, where tourism is now practically impossible.

**Figure 1. The effects of climate change on the Tourism Climate Index. A world map**

1970 | 2050

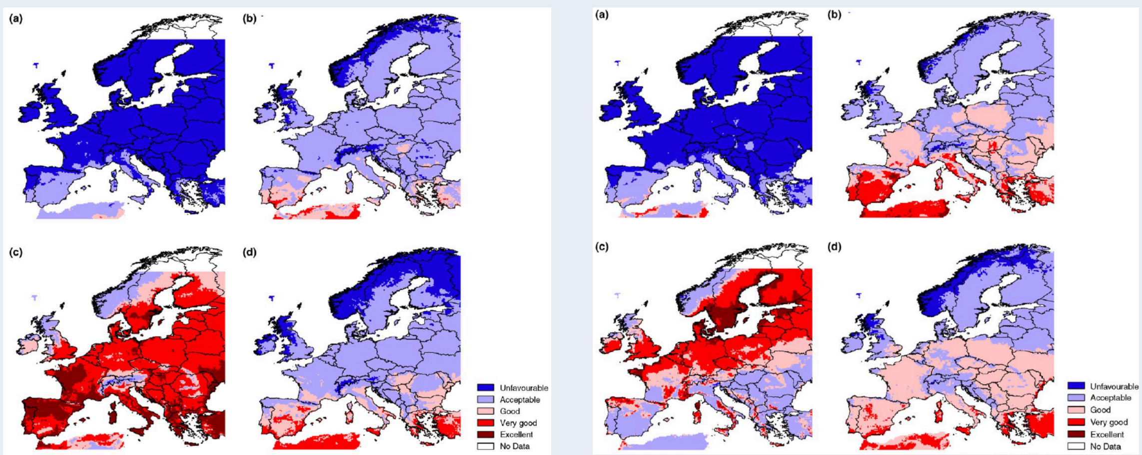



Source: Amelung, B.; Nicholls, S. and Viner, D. (2007)

In much more detail for the case of Europe, Hein et al. (2007) show how the consequences of climate change on the climatic attractiveness for tourists will be significantly affected. Thus, as shown in Figure 2, it is possible to observe how the Balearic Islands are expected to worsen the climatic conditions for the practice of tourism during the summer towards the period 2051-2080, a circumstance that, in any case, could be compensated by the improvement of the climatic conditions during the spring.

**Figure 2. The effects of climate change on the Tourism Climate Index. The Case of Europe**

1961–1990 | 2051–2080

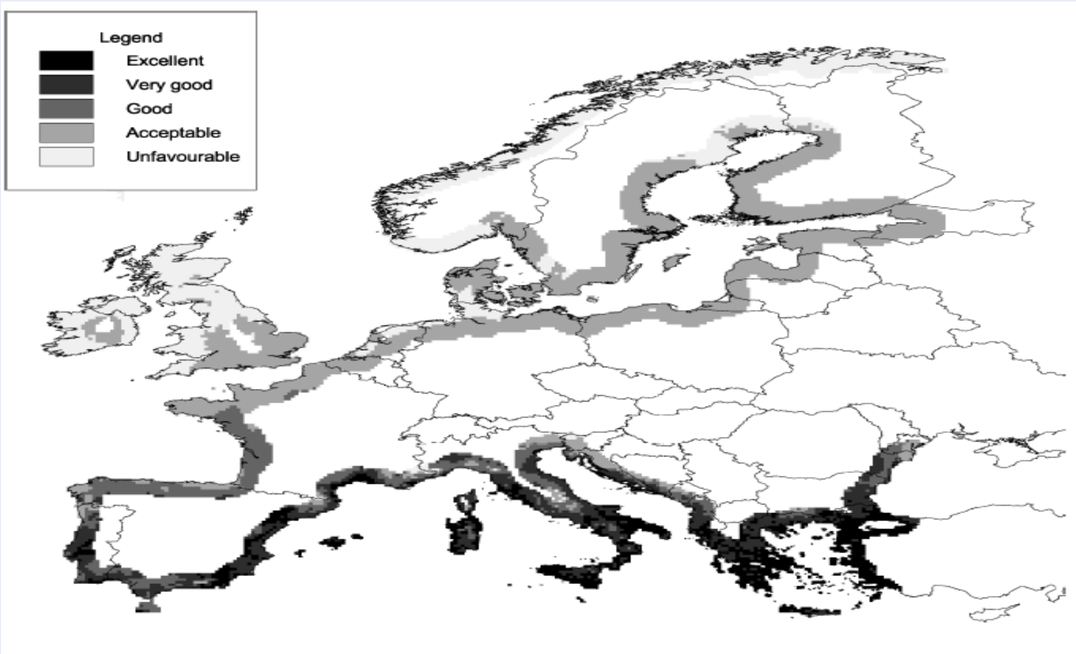



Notes: Maps for the Tourist Climate Index for the 1961–1990 baseline and 2051–2080 time slice and the HadCM3-A1 scenario: (a) Winter (December–February); (b) Spring (March–May); (c) Summer (June–August) and (d) Autumn (September–November).
Source: Hein et al., (2007)

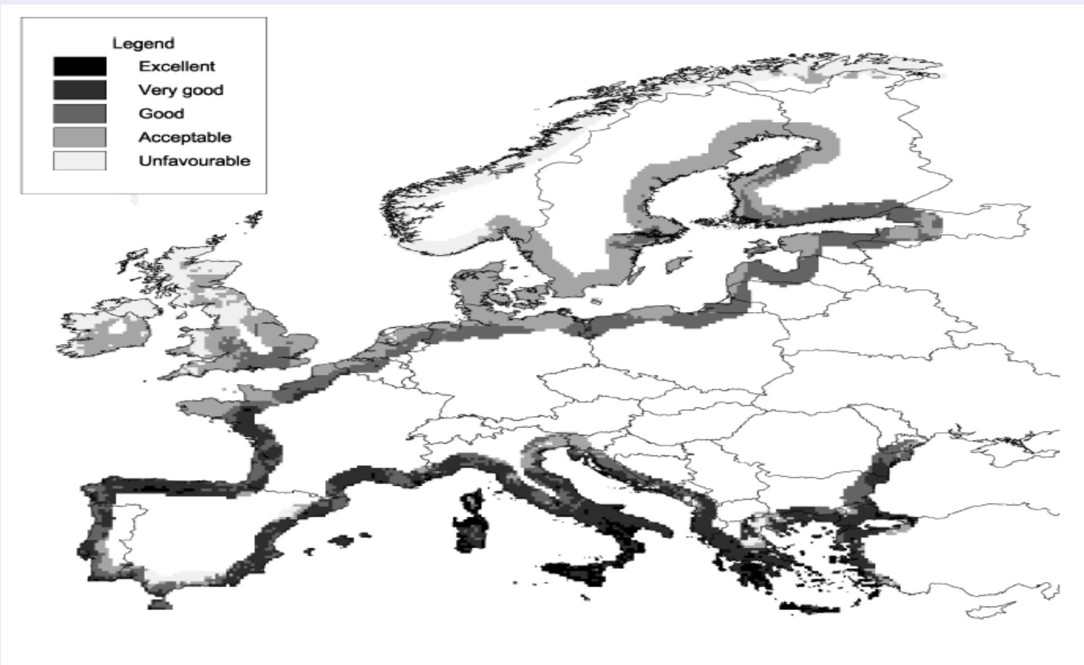
Moreno and Amelung (2009) adapt the tourist climate index to the climatic conditions for beach tourists and focus their attention on the European coast (Figure 3). Their results, again, predict a loss of climatic attractiveness for tourists in this segment in the Mediterranean areas, while the northern European coasts gain in terms of climatic attractiveness.

**Figure 3. The effects of climate change on the Tourism Climate Index. The Case of European Coastline**

1961–1990




2060

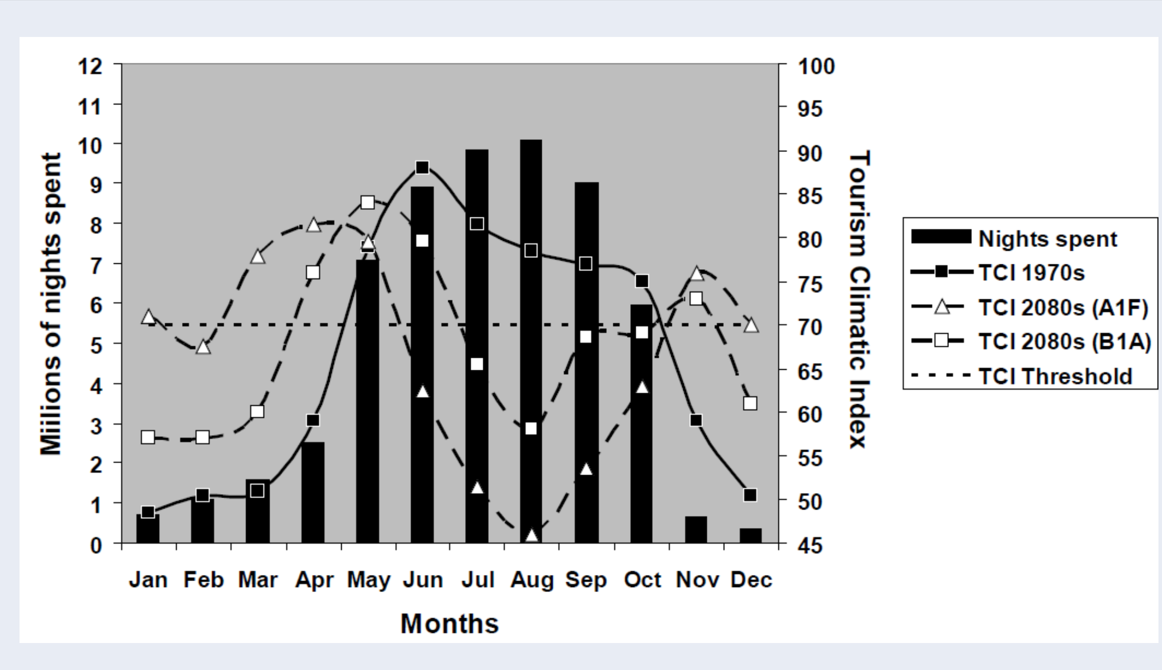



Notes: Beach tourism climate index during summer in the 2060's according to the HadCM3-A1FI

Source: Moreno and Amelung (2009)

Regarding climatic attractiveness for tourists, the last work worth mentioning is the case study carried out by Amelung and Viner (2006) for the specific case of the Balearic Islands, where a clear loss of tourist attractiveness is predicted in different scenarios for the year 2080.

**Figure 4. Visitation and TCI in the Balearic Islands**




Source: Amelung and Viner (2006)

Despite the pessimistic future pointed out by all these studies, it is worth noting that the use of the TCI to evaluate the climatic attractiveness of destinations, especially those based on sun and beach, has recently been questioned (Rutty and Scott, 2010; Cárdenas-Hernández et al., 2024). We should bear in mind that the TCI is based on the consideration of different meteorological variables where temperature has the most important weight and where the translation of temperatures to index values can be somewhat debatable, especially in the case of sun and beach tourism.[1]

Thus, it is not surprising then that applications that have focused their attention on the Caribbean have found that the reduction of the weight attributed to temperature manages to improve the adjustment of the index to the seasonal behaviour of demand. In this context, Rutty et al. (2020) found that the HCI:Beach achieves a better alignment with tourist demand by reducing the weight of temperature and increasing the weight of cloud cover and precipitation. Recently, Cárdenas-Hernández et al. (2024) demonstrate that by reducing the weight of temperature and increasing the weights of precipitation, wind, and cloud cover, it is possible to develop a tourist

[1] For instance, the TCI in its original version attributes a value of 4 (on a scale of 0 to 10) to a temperature of 32ºC. To find that same value in low temperatures, you must go down to 10ºC. It seems obvious that a sun and beach tourist prefers to find 32ºC and not 10ºC.

climate index that fits the seasonal behaviour of tourism demand in the Caribbean better than both HCI:Beach and TCI.

In any case, climate indices ultimately provide an idea of the loss of climatic attractiveness of destinations, but they do not quantify the effect on demand. This is why it is necessary to turn to demand models to obtain a quantification of the possible effects of climate change on tourism.

## 2.2. Tourism demand Models

In the framework of the modelling of tourist demand, three main perspectives have been adopted (Rosselló, 2014): time series analysis, discrete choice models and aggregate tourist models, which can serve as a basis for quantifying the effects of climate change on the tourist demand.

First, in the context of time series analysis, it is preferable to talk about weather (short-term atmospheric conditions) rather than climate (average atmospheric conditions over a region) because, with time series, the most popular approach is to try to capture some kind of short-term relationship between tourism demand and an extreme weather event. Taking a general framework and using a monthly time series model, it has been proposed that, on the one hand, the cyclical trend component can be captured through an ARIMA model (Rosselló et al., 2011), even including prices and other determinants (Álvarez & Rosselló, 2010; Rosselló et al., 2011). On the other hand, since meteorological variables can show high variability and are not present in the long term, they are hypothesized to affect the short term of the time series and, consequently, cannot be captured by ARIMA or economic factors, staying in the error Term. Thus, the hypothesis to be tested is whether short-term extreme weather episodes are related to this residual term. Analytically, the problem can be summarized in terms of a transfer function model:

$$\varphi_p(L)Y_t = \theta_p(L)a_t + \phi_b(L)d_t \qquad [1]$$

where $Y_t$ is the number of tourist flows per month $t$ ; $a_t$ is the innovation term or moving average; $d_t$ is the meteorological variable (or set of meteorological variables) that could influence the number of tourist flows; $\varphi_p(L)$ and $\theta_p(L)$ are the lag operator polynomials for both $Y_t$ and $a_t$ respectively, capturing the cyclical trend component (the long term component) of $Y_t$ , as is common practice in ARIMA modeling; and $\phi_b(L)$ is the polynomial of the delay operator (or transfer function) for the time-determining variables, thus assuming that there is some delay between the observation of the weather variables and the tourist flow data.

By estimating equation [1], intra-sample values can be predicted and compared with simulated predictions of $d_t$ variables under different climate change scenarios. Recent literature has been dominated using more complex structures. Kulendran and Dwyer (2012) use the autoregressive conditional heteroscedasticity modelling approach to identify the relationship between climate variables such as maximum temperatures, relative humidity, hours of sunshine and seasonal variations, defined as the repetitive and predictable movement around the holiday tourism demand trend line within the context of seasonal variations in holiday tourism demand in Australia. Otero-Giráldez et al. (2012) also found that there was a significant positive connection between the North Atlantic Oscillation - as a weather indicator - and tourism demand in Galicia (Spain) using an autoregressive distributed lag model. Goh (2012) built an Error Correction Model for tourism demand that also explores the presence of structural changes in estimates using the *Tourism Climate Index* (TCI) as a determinant variable, showing that the climate index has a significant positive relationship for all tourist demand series analysed.

**Table 1. Effects on UK outbound flows (x1000) due to increased temperature**

| | +1 | +2 | +3 | S1 | S2 |
|---|---|---|---|---|---|
| Yearly | −726.72 | −2,143.13 | −3,503.86 | −1,096.93 | −3,552.44 |
| Yearly (%) | −1.73% | −5.10% | −8.34% | −2.61% | −8.46% |
| January | −1.85% | −5.42% | −8.57% | −2.56% | −8.51% |
| February | −1.82% | −5.24% | −8.22% | −2.48% | −8.06% |
| March | −1.76% | −4.94% | −7.63% | −2.78% | −7.91% |
| April | −1.46% | −4.30% | −6.77% | −2.40% | −7.05% |
| May | −1.33% | −3.87% | −6.52% | −1.97% | −6.51% |
| June | −1.34% | −4.35% | −7.58% | −1.81% | −7.16% |
| July | −1.69% | −5.09% | −8.49% | −2.43% | −8.29% |
| August | −1.81% | −5.36% | −8.91% | −2.77% | −9.04% |
| September | −1.89% | −5.58% | −9.24% | −3.09% | −9.86% |
| October | −2.01% | −5.84% | −9.50% | −3.16% | −9.92% |
| November | −1.96% | −5.61% | −9.09% | −3.07% | −9.51% |
| December | −2.01% | −5.74% | −9.08% | −2.78% | −9.02% |

Source: Cardenas et al. (2011)

Although there are no specific studies that measure the changes induced by climate change on demand at destination for the case of the Balearic Islands or Spain using time series models, and that therefore allow us to make an assessment of the demand, using the transfer function methodology, Rosselló et al. (2011) found a significant relationship between British overseas tourists, one of the most important tourist markets in Cala Millor, and different British weather variables including temperature, heat waves, frost days and sunshine duration. Using different simulations of average temperature warming, they found that an 1ºC increase in average temperature will lead to an annual decrease of 1.73% of British outflows, a percentage that is not uniform throughout the year, given the strongest impact expected during the winter (see Table 1).

In summary, analysing the relationship between climate (or weather) and tourism using time series models have demonstrated a current and real relationship between tourism and climatology. However, it should be noted that within this framework, only short-term relationships can be captured, despite long-term climate change issues. Additionally results within the time series framework focus on evaluating scenarios where the only changing factor is the climate. However, it must be accepted that tourist movements have multiple determinants and that in this type of model it is difficult to introduce other types of conditions, so the results are partial.

Within the framework of demand models, a second approach is to use discrete choice models. In this context, the relevant question is why people choose a particular destination, and the theoretical background can be found in Lancaster (1966), where the proposed source of utility is the characteristics of goods and services and not the goods or services in themselves. Tourist choices are considered both a quantitative and a qualitative consumption process. The quantitative unit of tourism consumption can be represented by the number of days of stay, the number of visits, etc. The qualitative unit of tourist consumption is represented by the set of characteristics provided by the destinations. Different destinations provide different bundles of characteristics in the form of heterogeneous tourism goods. Attractions are characteristics whose amount will depend on the destination's climate, natural and historical attributes and other characteristics. By considering utility theory in the context of tourism decisions, as first formally described in Morley (1992), a new framework is introduced that allows the consideration of different perspectives of tourism decisions, together with a wider set of explanatory variables. Analytically, it is assumed that the utility $U_{ni}$ that a tourist *n* derives from choosing to visit the destination *and* takes the following form:

$$U_{ni} = \beta_n^{'} x_{ni} + \varepsilon_{ni} \qquad [2]$$

Where $\beta_n^{'} x_{ni}$ is the deterministic part of the utility received if destination *i* is visited. Therefore $x_{ni}$ are the observed attributes that characterize the alternatives open to tourists and $\beta_n$ is the vector of coefficients estimated for tourist *n,* which represents his tastes. Finally, the error term $\varepsilon$ captures the variation in preferences among the tourist population due to unobservable variables. Since it is assumed that individuals visit the destination that offers the highest utility, the probability $\pi_{ni}$ that they choose alternative *i* is:

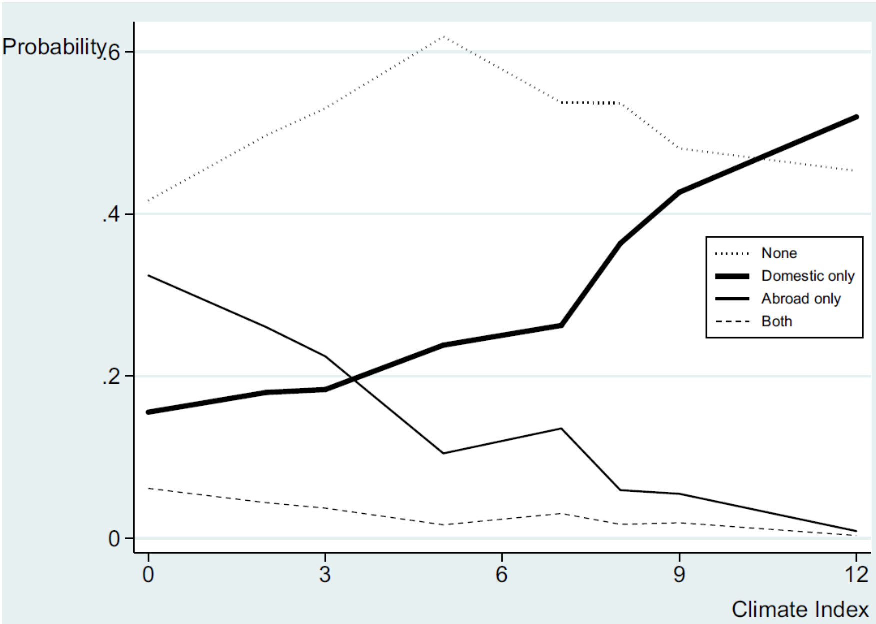
$$\pi_{ni} = Pr\left(\beta_n^{'} x_{ni} + \varepsilon_{ni} > \beta_n^{'} x_{nj} + \varepsilon_{nj}\right) \quad \forall j \neq i \qquad [3]$$

Thus, individuals or households with the same socio-economic and demographic characteristics could choose very different destinations. However, beyond the consideration of utility theory, through the use of random utility models it is generally recognized that tourists have different tastes and that choosing a final destination is not an independent decision, but the final decision of a set of options. In this sense, it is argued that once tourists have decided to go on vacation and have established a budget and a means of transport, they choose a destination conditioned by their preferences and the attributes that characterize the alternatives in the choice set (Eugenio-Martin, 2003).

This framework for modelling tourism demand from a microeconomic perspective has become of interest to different tourism agents, such as tourism marketing analysts, due to its high potential to identify the determinants of destination choice decisions. It is important to note that the choice of a destination is considered one of the most complex stages of the tourists' decision-making process, with a wide number of variables (depending on the objective of the study) that can influence these decisions (Marcussen, 2011).

In the context of climate change and tourism, using the discrete choice model for European households and with interest for the case of Cala Millor, Eugenio-Martín and Campos-Soria (2010) focus their analysis on the relationship between the climate of the area of origin and the choice to vacation in the tourist's home region or abroad, showing that climate in the home region is a strong determinant of vacation destination choices. They show that residents of regions with better climate indices have a higher probability of traveling domestically and a lower probability of traveling abroad, while residents of colder regions tend to travel abroad more often than residents of the warmest (Figure 5).

**Figure 5. Probabilities of trave ling for tourism in Europe and climate**




Source: Eugenio-Martín and Campos-Soria (2010)

By estimating the vector $\beta_n$ in equation [3], they project how individuals' choices change when the climate input changes, assessing the probability of foreign and/or domestic travel. Thus, under a climate change scenario, a relatively weak relationship is found when considering an assessment of both foreign and domestic travel. However, an increase in temperature appears to increase the probability of domestic travel and decrease the probability of foreign travel, a result that has also been obtained with time series.

Using a similar methodology, Bujosa and Rosselló (2013) investigate the impact of climate change on destination choice decisions in a context of domestic summer coastal tourism in Spain. Once destinations have been characterized in terms of travel cost and coastal “attractiveness” (attributes related to temperature and beach), the observed pattern of domestic interprovincial travel is modelled, showing trade-offs between temperature and attractiveness in the probability of a certain destination being chosen. Using climate change scenarios A1FI and B1, they show that the colder northern provinces of Spain would benefit from increased temperatures, while the southern provinces would experience a decrease in travel frequency. Unfortunately, the case of the Balearic Islands was not included in this study because there is no specific quantification of the effect of climate change on domestic tourism demand using discrete choice models. In any case, it should be remembered that tourism demand in Cala Millor is characterized by the international market and that the national tourism market is smaller.

The third approach within the framework of demand models is the aggregate tourism demand modelling. The reviews by Lim (1999), Li et al. (2005) and Song and Li (2008) show that tourism demand estimates focus mainly on time series models, including variables with significant short-term variability, such as prices and incomes, without neglecting the structural determinants, such as climate, which are expected to be captured by the constant term. However, with the growing interest in climate issues, a set of aggregate tourism demand models have emerged that focus on climate variables. Maddison's (2001) pioneering study presents a cross-sectional model of destinations chosen by British tourists, using classic price determinants of tourism demand and incorporating climate variables in terms of attractions. Estimation of the model allows the trade-off between climate and holiday expenditure to be quantified and, by introducing non-linear effects (using a fourth-order polynomial), the 'optimal' climate for generating British tourism is identified. The results are used to predict the impact of various climate change scenarios on different tourist destinations.

Similarly, using aggregate data and a regression analysis, Lise and Tol (2002) find optimal travel destination temperatures for different tourists and tourism activities, showing that OECD tourists prefer an average temperature for the month hottest of the year 21ºC indicating that, in a progressive warming scenario, tourists will spend their holidays in different places than today. Taking a global perspective, Hamilton et al. (2005a and 2005b) present what is known as the Hamburg Tourism Model (HTM), consisting of the estimation of two equations for the departures and arrivals of international tourists for a specific year. Analytically:

$$ln\, A_d = \alpha_0 + \alpha_1 G_d + \alpha_2 T_d + \alpha_3 T_d^2 + \alpha_4 C_d + \alpha_5 ln\, Y_d \qquad [4]$$

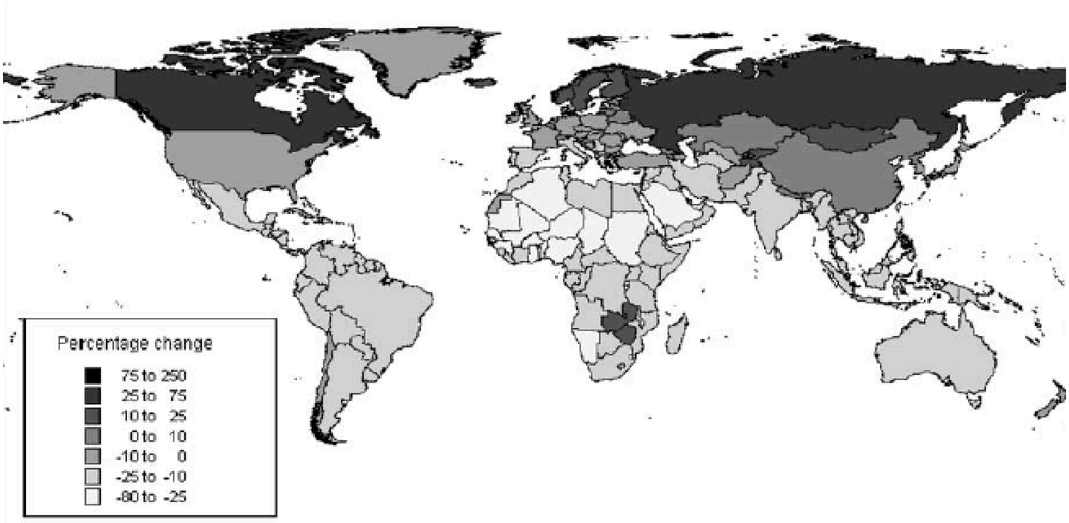
$$ln\, \frac{D_{OR}}{P_{OR}} = \beta_0 + \beta_1 T_{OR} + \beta_2 T_{OR}^2 + \beta_3 B_{OR} + \beta_4 Y_{OR} + \beta_5 ln\, G_{OR} \qquad [5]$$

where *A* refers to the total number of arrivals in country *d* ; *D* is the total number of departures from the origin country ; *P* is the population in thousands; *G* is the area in square kilometres; *T* is the average annual temperature of the country during the period 1961 - 1990; *C* is the length of the coastline in kilometres; *Y* is the per capita income of the country; *B* is the number of countries bordering a given country; and $\alpha$ and $\beta$ are parameters to be estimated.

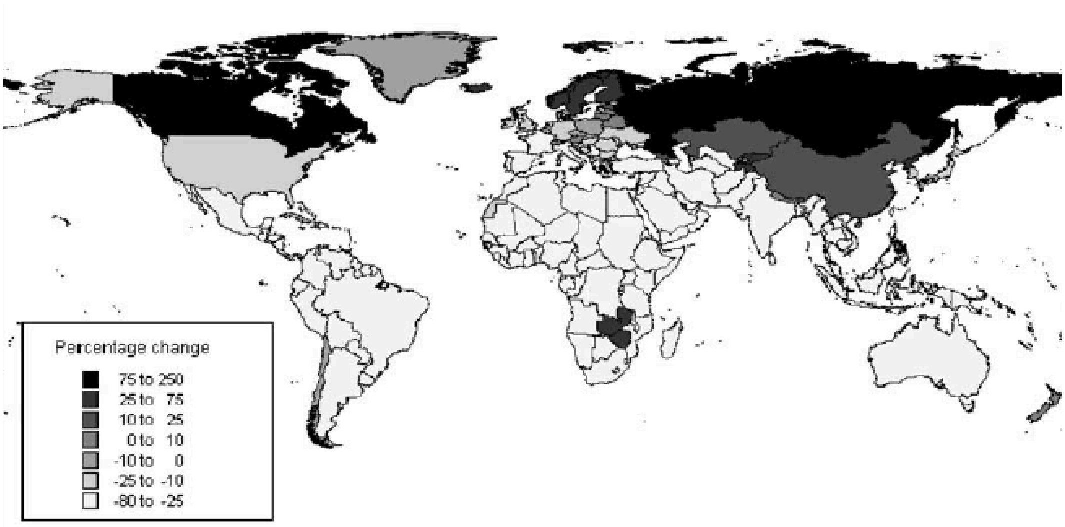
Hamilton et al. (2005a and 2005b) use the HTM to analyse how climate change alters the relative attractiveness of countries, studying the redistribution of tourist arrivals and departures due to changes in population, per capita income and climate change. The results (Figure 6) show that in the medium and long term tourism will grow in absolute terms, although this increase will be smaller than the changes in population and income and will not be homogeneously distributed, with higher growth for colder countries and lower for to the warmest. With climate change, the currently predominant group of international tourists – sun and beach lovers – would also stay closer to home, implying a relatively small drop in the total number of international tourists and the total distance travelled.

**Figure 6. Percentage change in international tourist arrivals as a result of 1º C (A) and 4º C (B) global warming in 2025 relative to 1995**

**A**



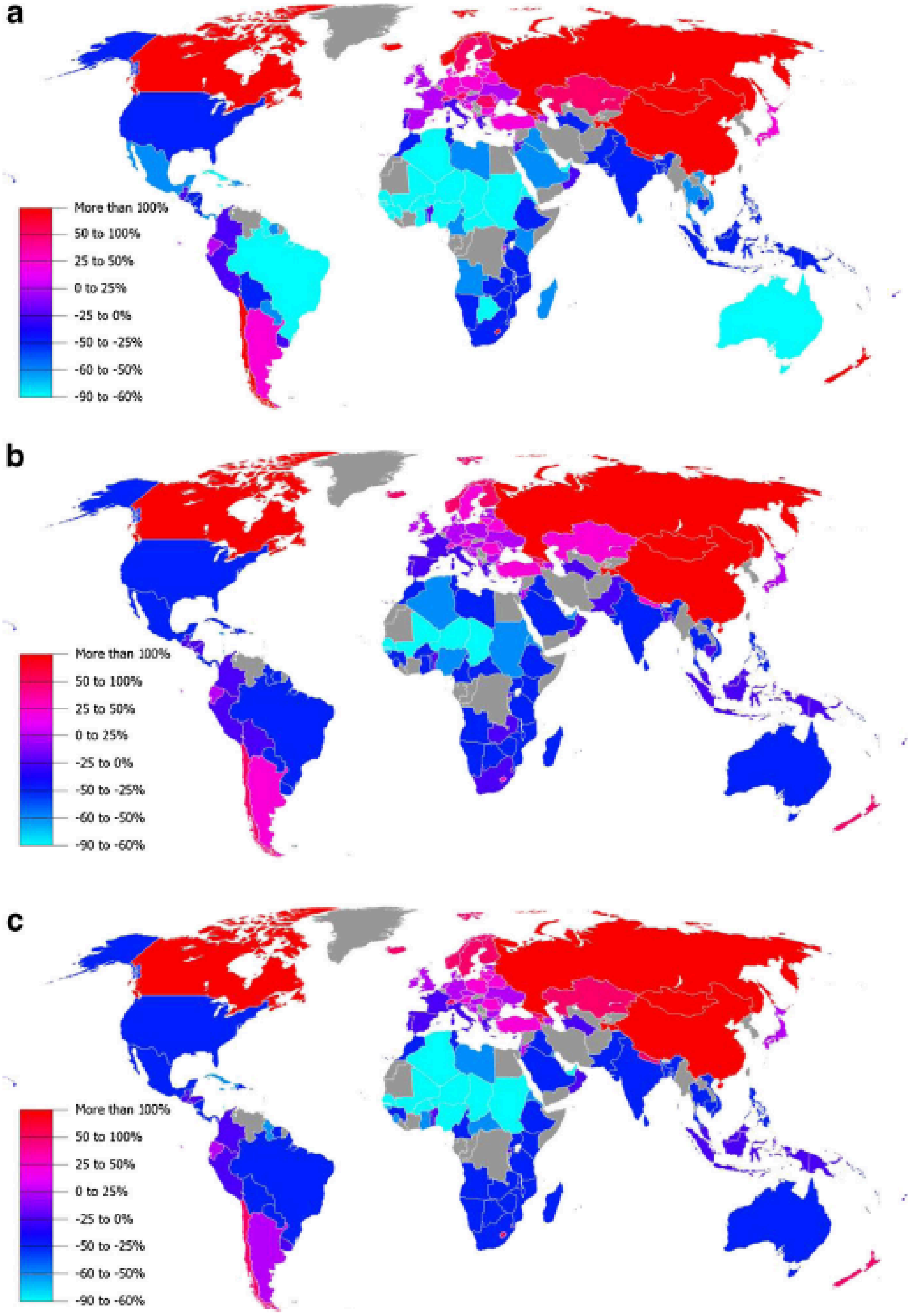

B




Source: Hamilton et al. (2005a)

As an aggregate model, HTM has been criticized and extended in many ways, although improvement in methodology has often involved a loss of generalizability. Bigano et at (2006) extend the HTM by considering the substitution between domestic and international tourism, while also analysing tourism expenditure. However, taking these two issues into account means limiting the sample of countries included in the model due to data restrictions, and only 45 origin countries traveling to 200 destination countries are considered. Hamilton and Tol (2007) assess the impact of climate change on tourism from a regional perspective in Germany, the United Kingdom and Ireland, based on different climate change scenarios for the regions analysed. They suggest that non-uniform warming within countries could lead to patterns of tourism behavior that are regionally distinct, pointing to the need to develop HTM methods at a sub-national scale.

**Figure 7. Percentage variation in tourist arrivals caused by change in temperatures**

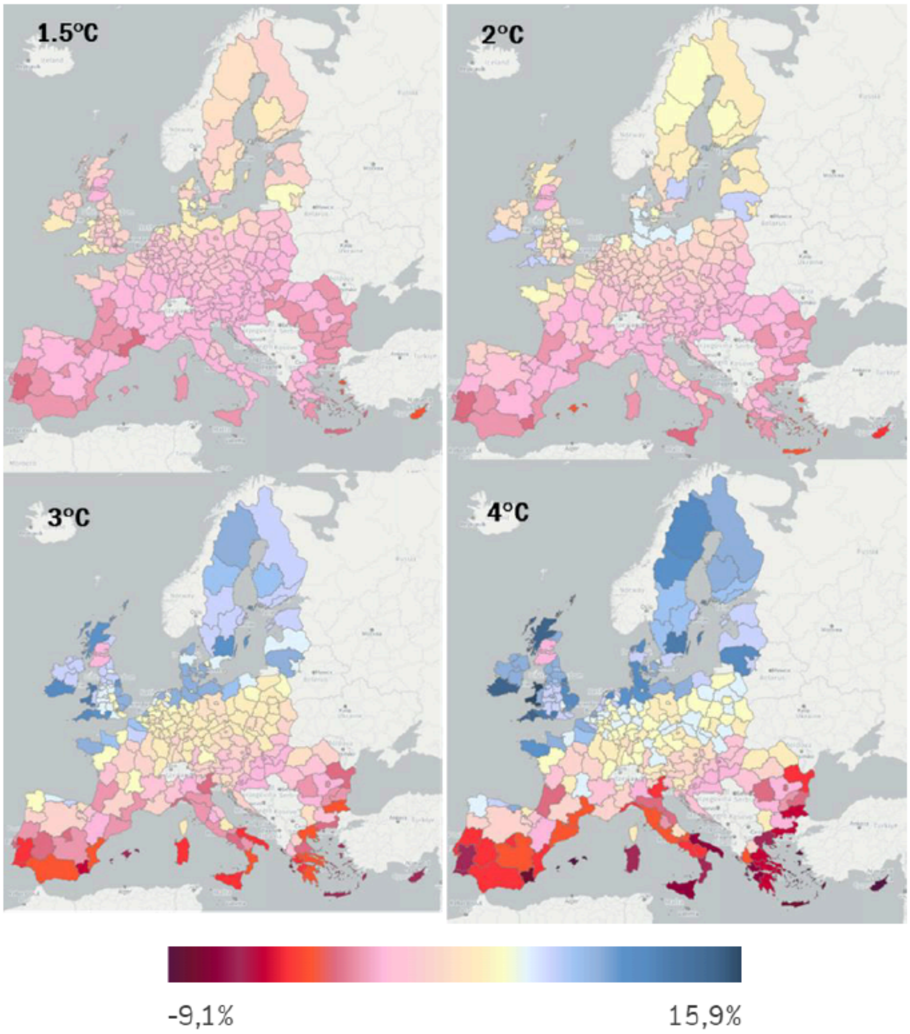



Note: Percentage change in international tourist arrivals for 2080, compared to arrivals in 2007, considering only the effect of temperature for scenarios A2 (a), B1 (b), and B2 (c)

Source: Rosselló and Santana (2014)

A more recent updates of the HTM can be found in Rosselló and Santana-Gallego (2014), who use bilateral tourist flows and consider the dynamic nature of the data by testing for changes in tourist preferences related to weather conditions. Despite the relatively high level of complexity of the specification and estimation process, using specific projected climate, population and economic data related to scenarios A2, B1 and B2, Rosselló and Santana-Gallego (2014) predicted tourist arrivals by 2080, finding similar results to previous works and thus providing more evidence that climate change would imply a weakening of the currently predominant international tourist flow from north to south. In all the cases analysed, it is possible to observe, as found by Hamilton et al. (2005a), how the demand for international tourism to Spain suffers significant falls that can reach values greater than 25% (Figure 7).

**Figure 8. Projected evolution of the European regional tourism demand for all the global warming scenarios, compared to 2019 in percentage terms.**




Source: Matei et al. (2023)

More recently, Matei et al. (2023) examine the impact of climate change on tourism demand in European regions in the 2100 time horizon. Using data from 269 European regions over a 20-year monthly timespan, they estimate the effect of current climatic conditions (rated with a Tourism

Climatic Index, TCI), on tourism demand, considering various regional typologies (Figure 8). Simulating the impacts of future climate change on tourism demand for four warming levels (1.5°C, 2°C, 3°C, and 4°C) under two emissions pathways (RCP4.5 and RCP8.5) findings reveal that climate conditions significantly affect tourism demand, with coastal regions being the most impacted areas. A clear north-south pattern in tourism demand changes is found, with northern regions benefiting from climate change and southern regions facing significant reductions in tourism demand, a pattern that becomes more pronounced for higher warming scenarios. It is important to note how, as is shown in Figure 8 the seasonal distribution of tourism demand would also change, with relative reductions in summer and increases in the shoulder and winter seasons.

Despite the negative consequences on tourism demand predicted by all these studies, it should be noted that climate change is a long-term process. Therefore, to obtain a reliable prediction of tourism demand, the rest of the determinants should be taken into account and not just the climate. In this sense, traditionally, population and income levels have been the main factors that have been pointed out by the literature as driving the demand for international tourism. Thus, if we consider that these determinants have an increasing tendency at a global level, when they are incorporated into the demand models together with the climate predictions, it is obtained that the demand projections are no longer so catastrophic, showing that the climate, although it plays a significant role when explaining the world tourist flows, is still a secondary factor behind economic and population growth. In this line Hamilton et al. (2009a) already confirm this idea by showing how a very marginal change in the market share of countries is obtained by incorporating temperature after having previously incorporated population and economic growth.

# 3. THE EFFECTS OF CLIMATE CHANGE ON CALA MILLOR: A PROPOSAL FOR ASSESSMENT

As highlighted in the introduction, the economic impact of climate change risks in the Cala Millor area can be analyzed from three distinct perspectives. The first examines the global shift in the tourism market, moving away from the sun-and-beach segment toward more temperate regions. This sets up an initial starting scenario. The second and third perspectives address the physical damage caused by climate change in Cala Millor. One focuses on the direct economic effects on areas that may be flooded or rendered unusable due to rising sea levels, while the other considers the indirect effects on non-flooded areas, stemming from beach loss and a significant rise in temperature.

As discussed in the previous section, rising temperatures will negatively impact tourism demand, particularly in temperate regions traditionally focused on the sun-and-beach segment. However, on a global scale, it's important to consider that tourism follows a strong positive trend driven by factors such as population growth, rising per capita income, and changing lifestyles, where tourism plays an increasingly prominent role. Major international organizations, such as the UNWTO and WTTC, project a growth rate of approximately 4% over the coming decades, a figure unlikely to be fully offset by rising temperatures. Therefore, in the case of Cala Millor, given the positive trend in international tourism and the growth limitations in the Balearic Islands' supply, a long-term environment of international stability has been assumed. In other words, the global outlook for the sun-and-beach segment in Cala Millor suggests a sustained demand in the long term, beyond the temporary fluctuations that periodically affect tourism demand.

With the global context established, the next step is to address the second and third perspectives by conducting a comprehensive economic assessment of the Cala Millor area. This assessment should involve defining smaller geographical zones to differentiate between the direct economic losses resulting from areas affected by rising sea levels (second perspective) and the indirect losses caused by beach erosion, also driven by sea level rise, and the increase in temperatures (third perspective). In this sense, Figure 9 details the study area according to the municipality to which it belongs, Son Servera or Sant Llorenç des Cardassar.

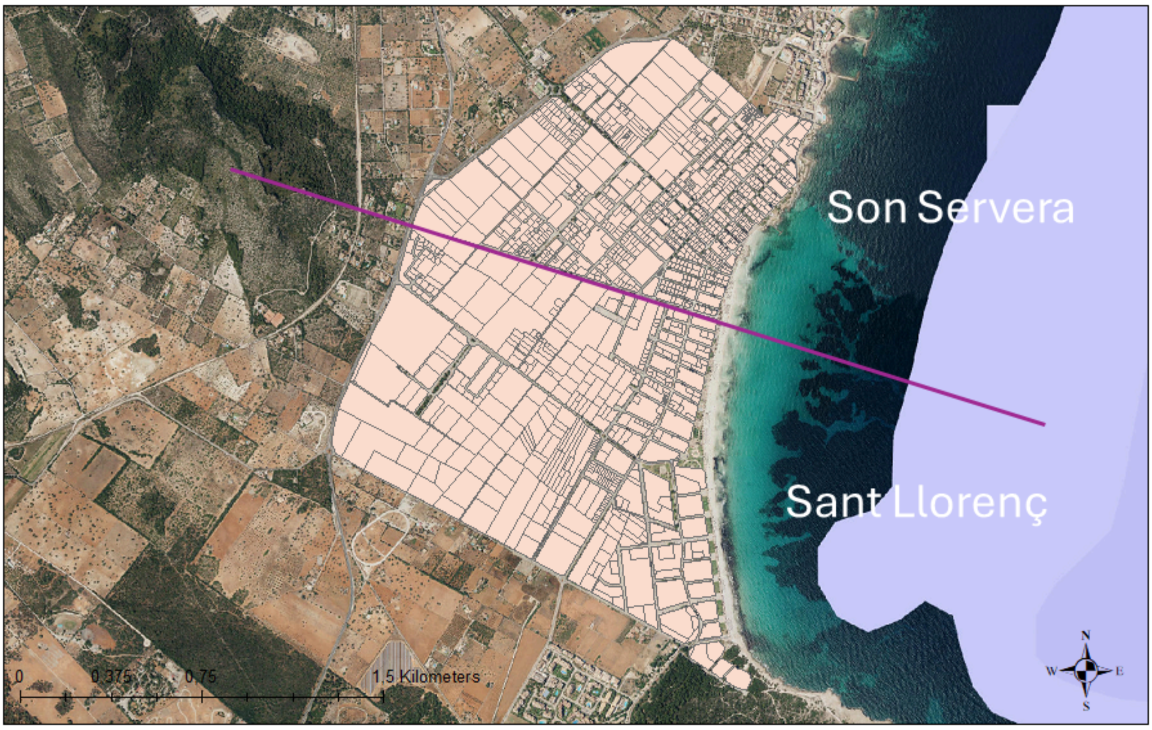
We use data from the Spanish cadastre, which is the analytical census of real estate property of the Spanish central government. This analytical census aims to locate, describe, and record the physical characteristics of each real estate property to detect the intrinsic particularities that define it both materially and specifically.[2] The Spanish cadastre identifies real estate properties with two types of codes:

- 14-digit codes. These are codes that refer to the plot, a unit of geographic surface and are used as units of value potentially affected by floods or other effects of climate change. Different properties, businesses, and common areas can be located on each plot. See Figure 9 for an overview of these plots in our area of analysis.

[2] More information at: https://www.sedecatastro.gob.es/

- 20-digit codes. The minimum value units used to calculate, by aggregation, the value of the cadastral plot (14 digits). These references refer to houses, flats, commercial premises, tourist apartments, warehouses, parking areas, existing in each cadastral plot.

**Figure 9. Cadastral plots (14-digit codes) in the area of analysis in Cala Millor**




To study the effect of climate change on the economy of the area being analyzed we compute the economic value of each 20-digit cadastral reference, and by aggregation, the value of each 14-digit cadastral reference (cadastral plot). From the economic valuation of each cadastral plot, we will be able to detect the direct effect of climate change on specific plots of the geographical area being analyzed, depending on the results of the physical dimensions, specifically on the identification of any plot that cannot be further used due to the climate change (i.e., floodings).

To assign an economic value to each of the 20-digit cadastral references, the following classification is considered:

1. Hotels and other tourism accommodations, and commerce.
2. Housing and other real estate properties.

Businesses in the analyzed area are mainly in the hospitality (e.g., hotels and tourist apartments) and commerce (e.g., shops, bars and restaurants) industries. The economic value generated by businesses depends on the cash flows generated by these businesses (Brealey et al., 2023; Ross et al., 2022) while the economic value of housing and other real estate properties depends on the dynamics of the real estate market (e.g., the quality of the materials and the specific characteristics of each neighborhood). The Spanish cadastre provides a value of each real estate property based on the dynamics of the real estate market, although it is computed mainly for taxation purposes, and it is generally considered a conservative valuation. Therefore, for housing and other real estate properties not used to develop business activities, we will measure their economic value with the value provided by the Spanish cadastre.

To compute the economic value of real estate properties (20-digit cadastral references) used to develop business activities (hospitality and commerce) we will compute its market value as the **present value of all the cash flows these businesses are expected to generate in the future for all their stakeholders**, which are their owners, workers, suppliers, and any other agent receiving cash flows from the businesses (e.g., taxes paid to the local government). **Therefore, we compute the economic value of businesses from an economic and social point of view**.

Given that revenues generated by the businesses are the source of cash flows paid to all the stakeholders, we will compute the market value of each 20-digit cadastral reference used by business activities as the present value of the revenues generated in this cadastral reference. Therefore, for businesses, we estimate the expected revenues generated in each 20-digit cadastral reference and then we compute its present value. This market value encompasses the market value of each 20-digit cadastral reference for all the stakeholders of the business activities developed there, therefore providing an economic and a social dimension to the value we are computing.

For this valuation methodology use publicly available information to approximate the revenues generated by business activities in each 20-digit cadastral reference. In the case of hotels and other accommodation businesses, we use data from IBESTAT, the regional government office of statistics, while for commerce we use public data on rental prices to proxy the capacity to generate revenues and accounting data that is also publicly available. In the next subsection (3.1), we explain how we estimate revenues in each of these types of businesses (3.1.1 and 3.1.2), and how we compute the market value from our estimations of expected revenues (3.1.3). In this way, section 3.1 provides a value map, defined geographically through cadastral references, which enables a straightforward and immediate assessment of the impacts of climate change due to rising sea levels and when these impacts directly affect plots currently occupied by residential buildings or businesses. To address the indirect effects, it is crucial to anticipate how tourists may respond to potential scenarios of beach surface loss and significant temperature increases. Thus, subsection 3.2 outlines the survey results and the methodology used to translate these findings into terms of demand, and subsequently into economic value. Lastly, subsection 3.3 presents the overall assessment of the area, divided into geographical zones corresponding to cadastral references, enabling a direct evaluation of climate change effects on flooded and flood-prone areas. However, no direct assessment is provided, as there is no map on flooded and flood-prone areas available at the time of writing the deliverable. For the indirect economic effects of beach loss and temperature increase an assessment has been conducted based on a hypothetical scenario of a 50% reduction in beach surface and or a temperature increase of 4º C.

# 3.1. Valuation Methodology and Data

## 3.1.1. Hotels and other tourism accommodations

We obtain data on hotels and other tourism accommodations from the open-access database of the regional government (https://catalegdades.caib.cat/). There we identify all tourism accommodations in the area analyzed, and their main magnitudes, especially category (from one to 5 stars in the case of hotels, and from one to 4 keys in the case of apartments) and number of rooms/apartments.

Then we use data from the regional government statistics agency (https://ibestat.es/) to obtain data to estimate the revenues of these tourism accommodations. This agency provides survey data about prices and the occupancy ratio of tourism accommodations, although more details are provided for hotels than for apartments.

For hotels, IBESTAT provides the overall average daily rate (per room) per month and municipality (Son Servera and Sant Llorenç), without information per category. The average daily rates per hotel category (one to 5 stars) are provided for the island. In Table 2 we show average daily rates (per room) per month and category in Mallorca.

**Table 2. Average Daily Rate per Month and Category in Mallorca for 2023 (€)**

| Category | 2023M12 | 2023M11 | 2023M10 | 2023M09 | 2023M08 | 2023M07 | 2023M06 | 2023M05 | 2023M04 | 2023M03 | 2023M02 | 2023M01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 stars | 252.2 | 196.1 | 238 | 312.6 | 371.2 | 382 | 288.2 | 276.4 | 233.3 | 175.1 | 145.9 | 177.8 |
| 4 Stars | 107.7 | 98.6 | 104.5 | 133.3 | 162.2 | 153.3 | 128.3 | 102.3 | 98.8 | 91 | 86.9 | 97.6 |
| 3 Stars | 68.5 | 56.7 | 83.2 | 106.3 | 137.1 | 112.2 | 98.3 | 79.8 | 78.6 | 58.8 | 60.3 | 85.7 |
| 2 Stars | | | 68.4 | 76 | 99.9 | 92.6 | 73.3 | 67.8 | 66.2 | 58.8 | | |
| 1 Star | | | | | | 61.8 | 51 | | | | | |

Source: IBESTAT (https://ibestat.es/)

We use the data in Table 2 to extrapolate the hotel average daily rates in Sant Llorenç and Son Servera per category. In Table 3 we show the average daily rates and occupancy rate provided by IBESTAT for Sant Llorenç and Son Servera, and our estimation of the revenues per room, category, month, and year obtained by extrapolating the differences in the average daily rates per category we obtain from Table 2 for Mallorca.

The total amount per room allows us to estimate the total annual revenues of each of the analyzed hotels. For this computation, we use hotel category, number of rooms, and the specific location of each hotel (municipality). For our analysis, we will use the total revenues in 2023 as the expected revenues in future years if no climate change occurs. This provides us a conservative approximation of the total revenues of each hotel since we only considered the average daily rate, and therefore we do not consider any additional expenses in the hotel non included on this rate.

**Table 3. Revenues per room in Son Servera and Sant Llorenç for 2023 (€)**

| | 2023M12 | 2023M11 | 2023M10 | 2023M09 | 2023M08 | 2023M07 | 2023M06 | 2023M05 | 2023M04 | 2023M03 | 2023M02 | 2023M01 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sant Llorenç | | | | | | | | | | | | | |
| Average Daily Rate (€) | | | 81.2 | 107.9 | 129.6 | 129.5 | 103.9 | 77 | 75.6 | | | | |
| Ocupancy Rate % | | | 62.93 | 83.39 | 92.83 | 87.43 | 80.23 | 63.67 | 31.09 | | | | |
| Estimated revenues per room and month | | | | | | | | | | | | | Total per room and year |
| 5 stars | 0 | 0 | 3539.2 | 6031.0 | 8332.7 | 7841.9 | 5587.3 | 3395.6 | 1575.4 | 0 | 0 | 0 | **36,303.04 €** |
| 4 Stars | 0 | 0 | 1598.8 | 2724.4 | 3764.2 | 3542.5 | 2524.0 | 1533.9 | 711.7 | 0 | 0 | 0 | **16,399.31 €** |
| 3 Stars | 0 | 0 | 1199.7 | 2044.3 | 2824.5 | 2658.2 | 1893.9 | 1151.0 | 534.0 | 0 | 0 | 0 | **12,305.59 €** |
| 2 Stars | 0 | 0 | 1007.9 | 1717.5 | 2373.0 | 2233.3 | 1591.2 | 967.0 | 448.7 | 0 | 0 | 0 | **10,338.68 €** |
| 1 Star | 0 | 0 | 670.0 | 1141.7 | 1577.4 | 1484.5 | 1057.7 | 642.8 | 298.2 | 0 | 0 | 0 | **6,872.16 €** |
| Son Servera | | | | | | | | | | | | | |
| Average Daily Rate (€) | | | 80 | 96.5 | 122.6 | 108.2 | 97.6 | 77.5 | 73.5 | | | | |
| Ocupancy Rate % | | | 58.71 | 81.83 | 93.55 | 88.42 | 82.91 | 70.39 | 29.81 | | | | |
| Estimated revenues per room and month | | | | | | | | | | | | | Total per room and year |
| 5 stars | 0 | 0 | 3253.1 | 5292.9 | 7943.7 | 6626.3 | 5423.8 | 3778.4 | 1468.6 | 0 | 0 | 0 | **33,786.73 €** |
| 4 Stars | 0 | 0 | 1469.5 | 2391.0 | 3588.5 | 2993.3 | 2450.1 | 1706.8 | 663.4 | 0 | 0 | 0 | **15,262.61 €** |
| 3 Stars | 0 | 0 | 1102.7 | 1794.1 | 2692.7 | 2246.1 | 1838.5 | 1280.7 | 497.8 | 0 | 0 | 0 | **11,452.64 €** |
| 2 Stars | 0 | 0 | 926.4 | 1507.3 | 2262.3 | 1887.1 | 1544.6 | 1076.0 | 418.2 | 0 | 0 | 0 | **9,622.06 €** |
| 1 Star | 0 | 0 | 615.8 | 1001.9 | 1503.8 | 1254.4 | 1026.7 | 715.2 | 278.0 | 0 | 0 | 0 | **6,395.83 €** |

Source: IBESTAT (https://ibestat.es/) and own elaboration.

For apartments, IBESTAT provides average daily rates per month at the regional level (Balearic Islands), and occupancy rates per month and municipality. However, no data on occupancy rates is provided for Son Servera, and therefore we use the occupancy rates provided for Sant Llorenç in Son Servera also. Additionally, IBESTAT does not provide average daily rates per category in the case of apartments. Therefore, the average daily rates for apartments in Son Servera and Sant Llorenç are adjusted to obtain the rates per category of apartments according to the data in Table 2 for hotels. For this adjustment the 4 key apartments assimilated to 4 star hotels, and equivalently for 3, 2, and 1 key apartments (see Table 4).

**Table 4. Revenues per Apartment in Son Servera and Sant Llorenç for 2023 (€)**

| | 2023M12 | 2023M11 | 2023M10 | 2023M09 | 2023M08 | 2023M07 | 2023M06 | 2023M05 | 2023M04 | 2023M03 | 2023M02 | 2023M01 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Daily Rate | | | 151 | 199.1 | 313 | 308.1 | 178.8 | | | | | | |
| Ocupancy Rate % | | | 45.60 | 85.44 | 91.42 | 87.96 | 70.40 | | | | | | |
| Revenues per apartment and month | | | | | | | | | | | | | Total per apartment and year |
| 4 keys | | | 2154.35 | 5150.69 | 8952.80 | 8479.11 | 3811.30 | | | | | | **28,548.26** |
| 3 keys | | | 1616.56 | 3864.94 | 6717.94 | 6362.49 | 2859.90 | | | | | | **21,421.82** |
| 2 keys | | | 1358.17 | 3247.17 | 5644.15 | 5345.52 | 2402.77 | | | | | | **17,997.78** |
| 1 key | | | 902.78 | 2158.41 | 3751.69 | 3553.19 | 1597.13 | | | | | | **11,963.20** |

As a result of these computations, we obtain the total revenues per apartment of different categories, which allows us to compute the total revenues of each apartment business in 2023. As in the case of hotels, we will use the total revenues in 2023 as the expected revenues in future years if no climate change occurs.

## 3.1.2. Commerce

We use data from the Spanish cadastre to identify and geo-localize each real estate property (20-digit cadastral reference) dedicated to commerce activities in our area of analysis.[3] In this database, we may identify different characteristics of each real estate property, such as its primary use and the total area of land and of any building. In the analyzed area most of the businesses are in the tourism and hospitality industry (hotels, bars, restaurants, shops, etc.).

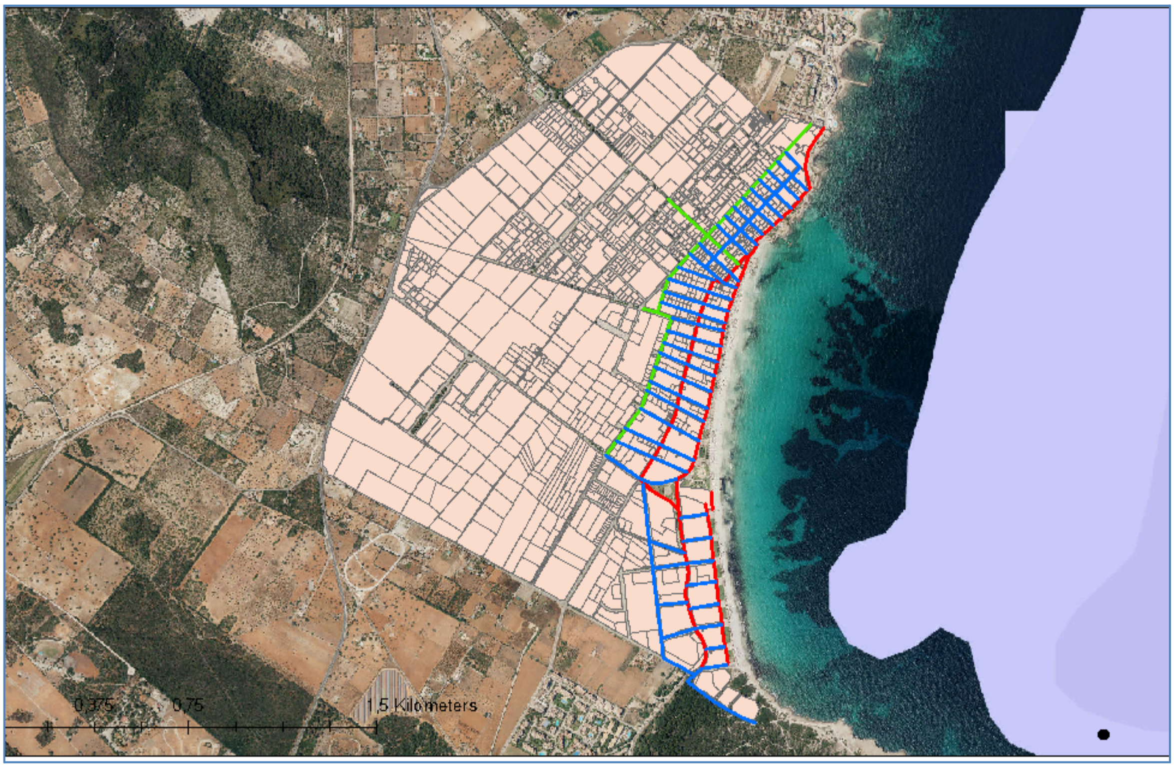
For all real estate properties used for business, except hotels and apartments for tourists, we compute the total meters of the building and estimate annual revenues according to the rent price per square meter paid in similar businesses. This implies two steps. In the first step, we

[3] This data was provided by the government of the two municipalities in our area of analysis (Sant Llorenç and Son Servera).

estimate the market rent price that could be paid for each real estate property dedicated to businesses in our area of analysis. In the second step, we estimate the standard relation between revenues and rent prices paid in similar real estate properties dedicated to businesses. The logic is that in equilibrium rent prices of real estate properties are adjusted to the expected revenue capacity of the businesses developed there.

For the first step, we proxy the rent each real estate property dedicated to businesses would pay by the information obtained from the announcements found in *Idealista* (https://www.idealista.com/ ), which is a very large real estate agency in Spain. To this end, we divide the area of analysis into 4 zones according to their proximity to the town's commercial center. We consider all the real estate properties dedicated to businesses available on *Idealista* (August 5 and 6 of 2024) in similar and close tourist towns from Cala Millor. Specifically, we consider "Puerto de Pollença, Puerto de Alcudia, Can Picafort, Cala Ratjada, Canyamel, Cala Millor, Cala Bona, Sa Coma, S'Illot, Porto Cristo, Cala d'Or, Porto Petro". See Figure 10 to see the different zones in Cala Millor (Zone 1, 2, 3, and 4), and Table 5 for the data we obtained of real estate properties for business purposes in these towns on rent in *Idealista*.

**Figure 10. Commercial zones in Cala Millor**




Note: The main commercial center is in red (zone 1), the second commercial center is in green (zone 2), and the zone with the third level of commercial activity is in blue (zone 3).

In each announcement, there is the price per month asked and the number of square meters of the real estate property on rent. In some cases, the owners ask for a down payment in addition to the price per month. In such cases, we compute a homogenized price per month and square meter by adding the equivalent portion of the down payment as if it was paid per month and square meter for 10 years, dividing the down payment by the number of months in ten years times the square meters of the property (12 x 10 x square meters). Then we compute the average homogenized price per month and square meter in each commercial zone. We use this average to proxy the year rental price per square meter in each commercial zone in Cala Millor. Finally, we simply multiply this price by the square meters of each property (20-digit cadastral reference) to estimate the annual rental price that each business would pay according to the current expectations of future revenues for businesses in the area.

**Table 5. Rental prices of real estate properties for businesses in similar towns per commercial zones**

| Town | Zone | Price per month | Squate Meters | Price per month and square meter | Down payment | Homogenized Down Payment | Homogenized price per month and square meter |
|---|---|---|---|---|---|---|---|
| Cala Millor | 1 | 650.00 € | 50 | 19.00 € | 72,000.00 € | 12.00 € | 31.00 € |
| Port Pollença | 1 | 1,500.00 € | 85 | 17.65 € | - € | - € | 17.65 € |
| Cala d'Or Por | 1 | 2,700.00 € | 95 | 28.42 € | 135,000.00 € | 11.84 € | 40.26 € |
| Cala Ratjada | 1 | 1,700.00 € | 150 | 11.33 € | 190,000.00 € | 10.56 € | 21.89 € |
| **Average** | | | | | | | **27.70 €** |
| Alcudia | 2 | 650.00 € | 26 | 25.00 € | 70,000.00 € | 22.44 € | 47.44 € |
| Sa Coma | 2 | 650.00 € | 36 | 26.39 € | - € | - € | 26.39 € |
| Sa Coma | 2 | 1,100.00 € | 55 | 20.00 € | - € | - € | 20.00 € |
| Alcudia | 2 | 1,200.00 € | 67 | 17.91 € | - € | - € | 17.91 € |
| Cala d'Or Por | 2 | 1,670.00 € | 70 | 23.86 € | 30,000.00 € | 3.57 € | 27.43 € |
| S'Illot | 2 | 1,500.00 € | 82 | 18.29 € | 330,000.00 € | 33.54 € | 51.83 € |
| Cala d'Or Por | 2 | 918.00 € | 100 | 9.18 € | 25,000.00 € | 2.08 € | 11.26 € |
| Port Pollença | 2 | 1,500.00 € | 132 | 11.36 € | - € | - € | 11.36 € |
| Alcudia | 2 | 2,500.00 € | 140 | 17.86 € | - € | - € | 17.86 € |
| Alcudia | 2 | 2,400.00 € | 200 | 12.00 € | 100,000.00 € | 4.17 € | 16.17 € |
| Alcudia | 2 | 1,500.00 € | 200 | 7.50 € | - € | - € | 7.50 € |
| **Average** | | | | | | | **23.19 €** |
| Cala d'Or Por | 3 | 950.00 € | 60 | 15.85 € | - € | - € | 15.85 € |
| Can Picafort | 3 | 1,100.00 € | 65 | 16.92 € | - € | - € | 16.92 € |
| S'Illot | 3 | 600.00 € | 70 | 8.57 € | - € | - € | 8.57 € |
| Porto Cristo | 3 | 1,300.00 € | 100 | 13.00 € | - € | - € | 13.00 € |
| Alcudia | 3 | 1,200.00 € | 120 | 10.00 € | 100,000.00 € | 6.94 € | 16.94 € |
| S'Illot | 3 | 1,200.00 € | 122 | 9.84 € | 12,000.00 € | 0.82 € | 10.66 € |
| S'Illot | 3 | 1,200.00 € | 140 | 8.45 € | 105,000.00 € | 6.25 € | 14.70 € |
| Cala Ratjada | 3 | 1,800.00 € | 153 | 11.76 € | 95,000.00 € | 5.17 € | 16.93 € |
| Cala Ratjada | 3 | 1,500.00 € | 199 | 7.54 € | 80,000.00 € | 3.35 € | 10.89 € |
| Cala Ratjada | 3 | 1,100.00 € | 210 | 5.24 € | - € | - € | 5.24 € |
| Port Pollença | 3 | 2,200.00 € | 214 | 10.28 € | - € | - € | 10.28 € |
| Cala Ratjada | 3 | 1,100.00 € | 259 | 4.25 € | - € | - € | 4.25 € |
| Alcudia | 3 | 2,400.00 € | 270 | 8.89 € | - € | - € | 8.89 € |
| Cala Ratjada | 3 | 1,820.00 € | 300 | 6.07 € | 55,000.00 € | 1.53 € | 7.60 € |
| Cala Ratjada | 3 | 870.00 € | 375 | 2.32 € | 99,990.00 € | 2.22 € | 4.54 € |
| **Average** | | | | | | | **11.02 €** |
| Port Pollença | 4 | 850.00 € | 70 | 12.14 € | - € | - € | 12.14 € |
| Cala d'Or Por | 4 | 950.00 € | 120 | 7.92 € | - € | - € | 7.92 € |
| S'Illot | 4 | 1,200.00 € | 142 | 8.45 € | - € | - € | 8.45 € |
| Port Pollença | 4 | 1,300.00 € | 150 | 8.67 € | - € | - € | 8.67 € |
| Port Pollença | 4 | 1,300.00 € | 175 | 7.43 € | - € | - € | 7.43 € |
| Sa Coma | 4 | 1,000.00 € | 200 | 5.00 € | - € | - € | 5.00 € |
| Porto Cristo | 4 | 2,000.00 € | 228 | 8.77 € | - € | - € | 8.77 € |
| Cala d'Or Por | 4 | 1,200.00 € | 248 | 4.84 € | - € | - € | 4.84 € |
| Port Pollença | 4 | 1,500.00 € | 300 | 5.00 € | - € | - € | 5.00 € |
| | | | | | | **Average** | **7.58 €** |

Source: *Idealista* (https://www.idealista.com/) and own elaboration. Zone 1 is the best commercial zone, and zone 4 is the worst.

For the second step, we use data from SABI of Bureau Van Dijk, which provides accounting data of all Spanish firms elaborating and registering their accounting data in the central government archive for accounting information (*Registro*). We consider data from retail firms, bars, and restaurants in all the municipalities where we collected data on real estate rentals from *idealista*. Specifically, “Alcudia, Pollença, Santa Margalida, Capdepera, Son Servera, Sant Llorenç, Manacor, and Felanitx”. In the SABI database, there is accounting data of 873 firms developing these activities in these municipalities. We obtain their total revenues and *Other Operating Expenditures* for the last year available (generally 2022). Some of these firms (33) are close to bankruptcy since their revenues are not sufficient to pay *Other Operating Expenses*, and therefore their rentals (included in *Other Operating Expenses*) are not a good proxy of their capacity to generate revenues (their managers overestimated their capacity to generate revenues). Using the remaining firms (840), on average we obtain that total revenues are 4.8 times *Other Operating Revenues*.

Assuming that the whole amount of *Other Operating Expenditures* are real estate rentals we obtain a conservative estimation of the total expected revenues generated by all real estate properties dedicated to businesses (except hotels and apartments) by multiplying the market real estate rental price per square meter by the square meters of the property and by 4.8.

### 3.1.3. Market value of the economic activity

We compute the market value of the economic activity generated by businesses located in our area (including hotels and apartments) as the present value of their expected revenues in the future (e.g., Ross, Westerfield, and Jordan, 2022). We assume that future years’ revenues will be as in 2023. Our baseline computation assumes that no climate change happens. In such a case, we do not know how long the economic activity in the area analyzed would last. Then, one possibility is to assume it lasts forever. However, we choose a more conservative valuation strategy which is to assume the 2023 revenues for the next 50 years and replace the revenues of the remaining years with the real estate value of these businesses at the end of these 50 years (as if those businesses were running for 50 years and then closed and the real estate sold).[4] As a proxy of the value of the real estate of these businesses in 50 years, we use the current real estate values provided by the Spanish cadastre, which computes these values mainly for taxation purposes and generates a conservative valuation. This real estate valuation is based on the dynamics of the real estate market. In sum, the value of the economic activity developed by businesses located on each property (20-digit cadastral reference) is computed as follows:

$$Value\ of\ Economic\ Activity_i = \sum_{t=1}^{50} \frac{Revenues_{i,t}}{(1+r)^t} + \frac{Residual\ Value_{i,50}}{(1+r)^{50}} \qquad [6]$$

[4] We also estimated the economic values assuming different time horizons (30, and 40 years) and the results are similar (in thousand euros; 2,577,135, 2,646,574 respectively, similar to the overall value assuming 50 years – 2,673,468 ) since discounted cash flows become less valuable the farther away in time are.

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Where *Revenues* are the revenues of the economic activity developed in property *i* in year *t*, and the *Residual Value* of the economic activity developed in property *i* in year *50* is proxied as the current real estate value provided by the Spanish cadastre for this property *i*.

The discount interest rate *r* to compute the present value of revenues is the expected return that in equilibrium compensates investors for the risks of the businesses where they invest. We compute this expected return using the Capital Asset Pricing Model (CAPM) introduced simultaneously by Treynor (1962), Sharpe (1964), Lintner (1965), and Mossin (1966), based on the portfolio theory (Markowitz, 1952 and 1999). This is a standard method to compute the discount interest rate to estimate the market value of businesses (e.g., Brealey et al., 2023). For the valuation of the economic activity developed in our area of analysis, we compute the equilibrium market return that compensates for the type of risks of the economic activity developed in the area, which is mainly related to tourism.

According to the CAPM model, the equilibrium expected return of assets (business) depends on the return of risk-free assets and a risk premium rewarding the risks of the specific economic activity being analyzed. This risk premium is a function of the market risk premium and the systematic risk of the asset to be valued. Systematic risk is the portion of risk that cannot be eliminated by diversification and may be computed from stock market data as the covariance between the returns of the asset being analyzed and the returns of the stock market index divided by the variance of the returns of the stock market index. This measure is commonly known as Beta. Since the businesses developed in our area of analysis are not listed on stock markets, we proxy their systematic risk with the systematic risk of Spanish-listed corporations operating in the tourism and hospitality industry.

The interest rate on the European Central Bank's main refinancing operations (updated in September 2024, 3.65%) is used to proxy the return of risk-free assets. We proxy the systematic risk of the businesses in our area of analysis as the average of the systematic risk (Beta parameter using the IBEX-35 to compute the stock market index return calculated from the stock returns over the last five years) of the two major Spanish hotel companies (Minor Hotels Europe & America S.A. – previously known as NH Hotel Group S.A. - and Meliá Hotels International S.A.) and the two largest technological operators of the tourism and hospitality industry (Amadeus IT Group SA, and Edreams Odigeo S.A) listed on the Spanish Stock Exchange. These four companies are subject to the risks of the tourism and hospitality sector, similar to the tourism and hospitality businesses located in Cala Millor, which represent the vast majority of businesses in this area. The systematic risk measure used in our valuation amounts to 1.287 (average of the Beta parameter of Minor – 1.240 -, Meliá – 1.359 -, Amadeus – 1.247 - and Edreams – 1.303 -). This measure indicates that the tourism companies have a systematic risk higher than the market average (IBEX-35). Regarding the market risk premium (expected return for the market – IBEX 35 -, less the return on risk-free assets), we use the estimation by Fernández et al (2023) for Spain (6.6%), which is consistent with the forecasts of Damodaran (2023) for the US (5.98%) and other European countries of similar characteristics than Spain (i.e., Italy, 7.21%).

Below we show how the CAPM model generates the market equilibrium return we use to compute the market value of the businesses in our area of analysis:

$$E\left(r_j\right) = r_f + \beta_j(Market\ risk\ premium) = 3.65\% + 1.287 * 6.6\% = 12.14\%$$

On the other hand, the Bank of Spain foresees a decreasing annual inflation, from 3% in 2024 and 2% in 2025, to up to 1.8% in 2026. To obtain a prudent valuation, an annual inflation of 2% is assumed during the valuation period. Thus, a nominal return of 12.14% per year translates into a return of 9.95% in real terms – at constant prices - ($(1 + r_{Nominal})=(1 + r_{Real})*(1+Expected\ Inflation)$).

The forecasts made for future revenues above are at constant prices (expecting the same revenues as in 2023 in future years) although in nominal terms all prices are expected to rise by an average of 2% each year. Therefore, we use a discount rate of 9.95% (in real terms) to compute the present value of revenues at constant prices, which is the market value of the economic activity developed in Cala Millor.

## 3.2. The indirect effects of beach loss and rising temperatures

As previously mentioned, the effects of climate change on the Cala Millor area will be determined by the direct effects (loss of land due to rising sea levels and flood zones) but also by the indirect effects, which means that tourists in Cala Millor in areas not directly affected by rising sea levels will see their level of satisfaction reduced by the loss of beach surface area and by the increase in temperatures. The purpose of this section is to establish what the effect of the loss of beach and increase of temperature on demand may be and, consequently, to be able to assess this decrease in economic terms. Due to the impossibility of simulating real situations or scenarios in which tourists face beach losses or increases in temperature, this project has opted to survey tourists directly to assess a temperature increase of 4ºC and the loss of 50% of the beach surface.

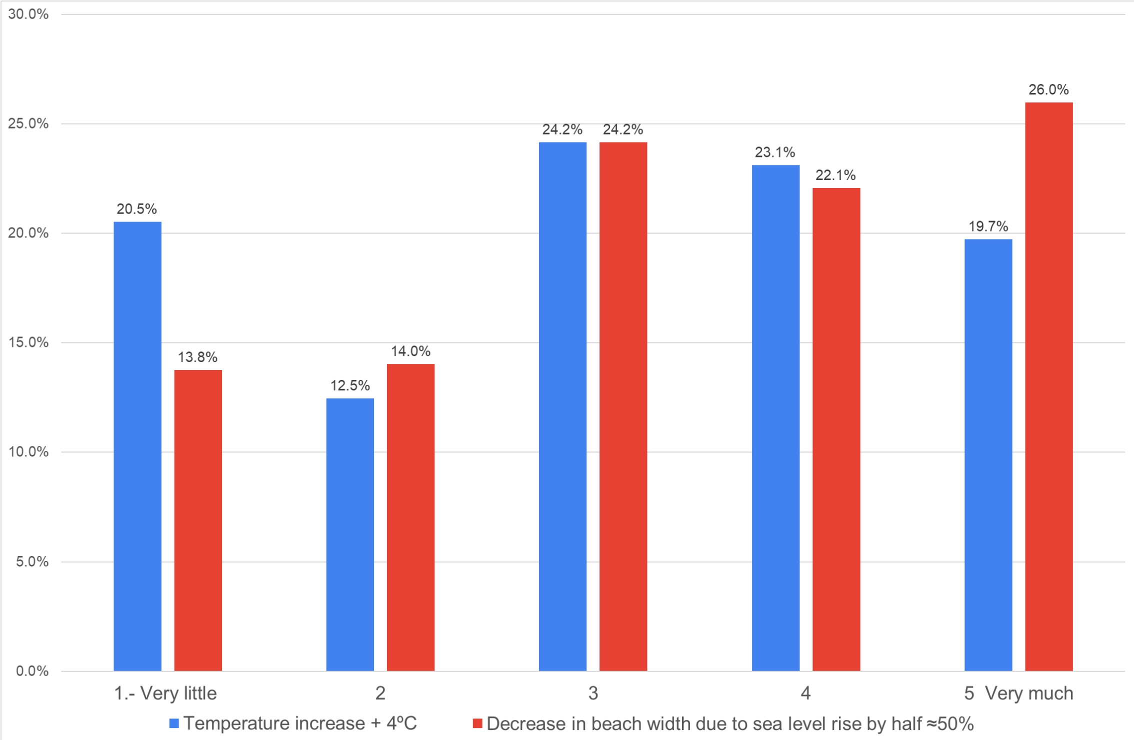
To carry out the surveys, the opportunity was taken to include two questions in a survey that was being developed within the framework of the project and which aimed to assess the perception of tourists on the impacts and risks of climate change in Cala Millor (Pericás et al., 2024). A total of 385 surveys were carried out between April 8 and June 26 2024 in the tourist offices located in strategic transit areas in Cala Millor. The survey analysed tourists' opinions and attitudes on climate change, the impact on ecosystems, individual action, beach use and preferences on possible adaptation measures for the management of ecosystem services.

Regarding the sociodemographic characteristics of interviewees, most tourists are over 65 years old (35%), and women (58%), mainly from the United Kingdom (37%) and Germany (32%). People with secondary education prevail (38%), followed by those with university studies (29%). This characterization is similar to the sociodemographic data provided by IBESTAT (2024) for Mallorca island.

Regarding the relationship of interviewees with Cala Millor, the majority is visiting the area for the first time (61%), followed by those who visit the area every few years (30%) and 9% who do so annually. Regarding the use of the Cala Millor beach, 31% only stay in this beach and do not visit other beaches; 7% never use it, and the rest alternate their visit with other beaches (62%). In relation to the choice of destination, 37% of the people surveyed prioritise recreational activities as the main reason for their visit, followed by 24% who value the tourist offer. The most valued aspects of Cala Millor are contact with nature (35%) and physical health, together with the recreational space (28%). Regarding the severity of climate change, 34% of respondents perceive it as a very serious problem, 30% as serious, 25% see it as moderately serious, and only 11% consider it to be not very serious or not at all serious.

Focusing on the case of the economic valuation of the Cala Millor area and the effects of climate change, tourists were interviewed about whether a temperature increase of +4ºC[5] and a 50% loss of beach would affect their intention to return to the area, the results appear in Figure 11.

**Figure 11. Elements that may influence your future choice of Cala Millor as a destination**




To translate the results of the surveys into terms of demand, we define the conversion factor as:

$$Conversion\ factor = \sum_{r=1}^{5} L_r \cdot P_r \qquad [7]$$

Where *L* is the probability associated with each one of the values of the Likert Scale (*r*={1, 2, 3, 4 and 5}, where 1 refers that it would not affect you or very little and 5 means that it would affect you a lot), and *P* the percentage of the tourists that have answered each item in the Likert Scale. For our case study, Likert scale values in relation to the probability of visiting the destination take the following form. If the surveyed tourist has answered that she is not affected by the reduction of the beach or a 4ºC increase in temperature (1 on the Likert scale), the probability that she would choose the destination in the case of the reduction of the beach surface or a 4ºC increase in temperature would be equal to 1 (*L*=1); while in the case that she would be very affected (5 on the Likert scale) the probability that she would choose the destination would be equal to 0 (*L*=0). For the rest of the values of the Likert scale we assume linear distribution, thus, L=0.75 when Likert Scale is 2; L=0.5 when Likert Scale is 3; L=0.25 when Likert Scale is 4. In this way, on the one hand, we can check that if all the tourists, hypothetically, had answered 1 on the Likert scale (A 50% reduction in beach or a 4ºC increase in temperature would have very little effect on them

[5] This temperature increase is based on the temperature increase obtained by Copernicus for the RCP8.5 scenario for 2050 and 2100.

when it comes to returning to the destination) then the conversion factor would be equal to 1, and we interpret that their decision to visit Cala Millor would not change in case the analized potential effects of climate change happened (effects on beach area and temperature). On the other hand, if all the tourists had answered 5 (A 50% reduction in beach or a 4ºC increase in temperature would have a great effect on them when it comes to making the decision to return to Cala Millor) then the conversion factor would be equal to 0, and we interpret they would not come to Cala Millor with a probability of 100%. Similarly, we interpret the probability they would come to Cala Millor as 75% if the Likert Scale is 2, and equivalently with the other values of the Likert Scale.

Therefore, for the case of temperature increase, the conversion factor obtained is 0.48 while for the case of beach loss it is 0.42. Given the high relationship between the answers to both questions,[6] we take the most restrictive factor corresponding to the loss of beach (0.42). This implies that only 42% of tourists that currently visit Cala Millor would not change their decision if the beach shrinks by 50% or the temperature increases by 4º C.

# 3.3. Results

## 3.3.1. The current value of the economic activity developed in Cala Millor

There are 1,313 cadastral plots in our area of analysis. Our valuation methodology leads to an overall market value of the economic activity developed there of **2.67 thousand million euros** (2,673,468,000 euros). The average value per cadastral plot is 2,036,152 euros. Figure 12 shows a map of our area of analysis where each plot is colored according to the market value of the economic activity developed there (from low values in green to high values in red).

Consistently with the type of economic activity developed in the area of analysis, mainly dedicated to the sun and beach type of tourism, Figure 12 shows that the most valuable cadastral plots are close to the sea, especially the beach. However, cadastral plots are heterogeneous in size, and larger plots tend to have a higher value. To control for this, Figure 13 shows the same map but when colors are according to the market value of the economic activity developed in each plot divided by the area of the plot (square meters).

[6] 38% of the answers are exactly the same in both questions and 70% of the answers do not diverge by more than one point on the Likert scale.

**Figure 12. Valuation map according to the total market value of the economic activity developed in each cadastral 14-digit plot (thousand euros).**

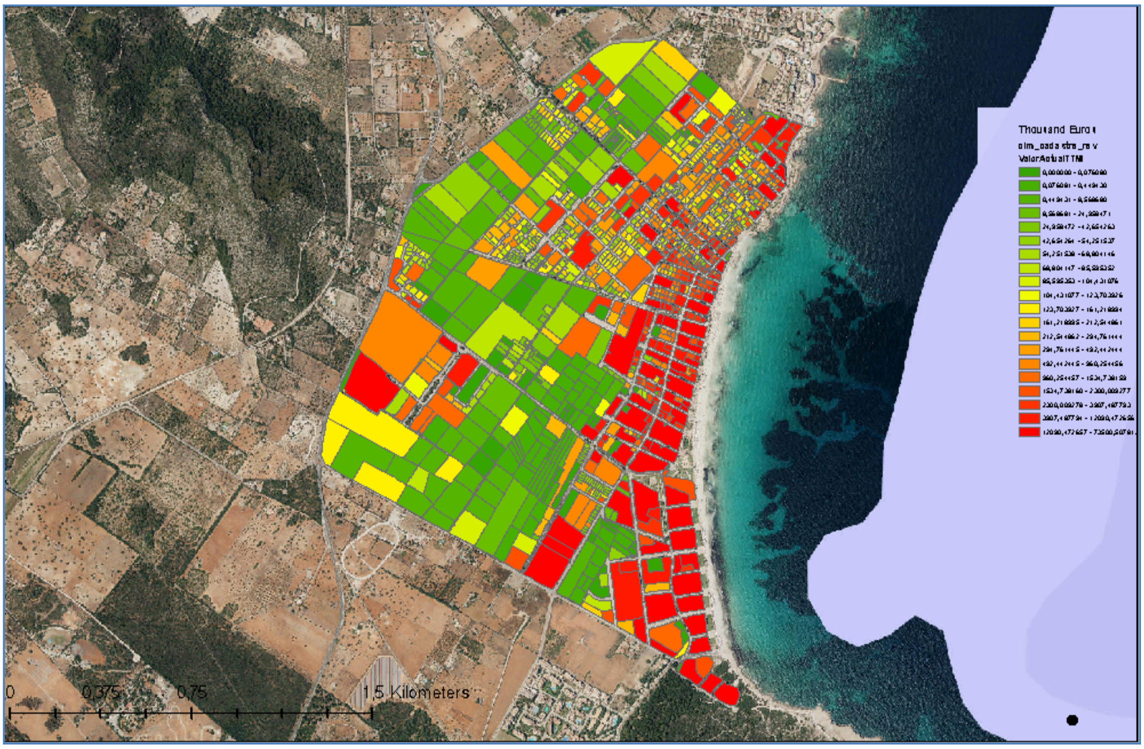
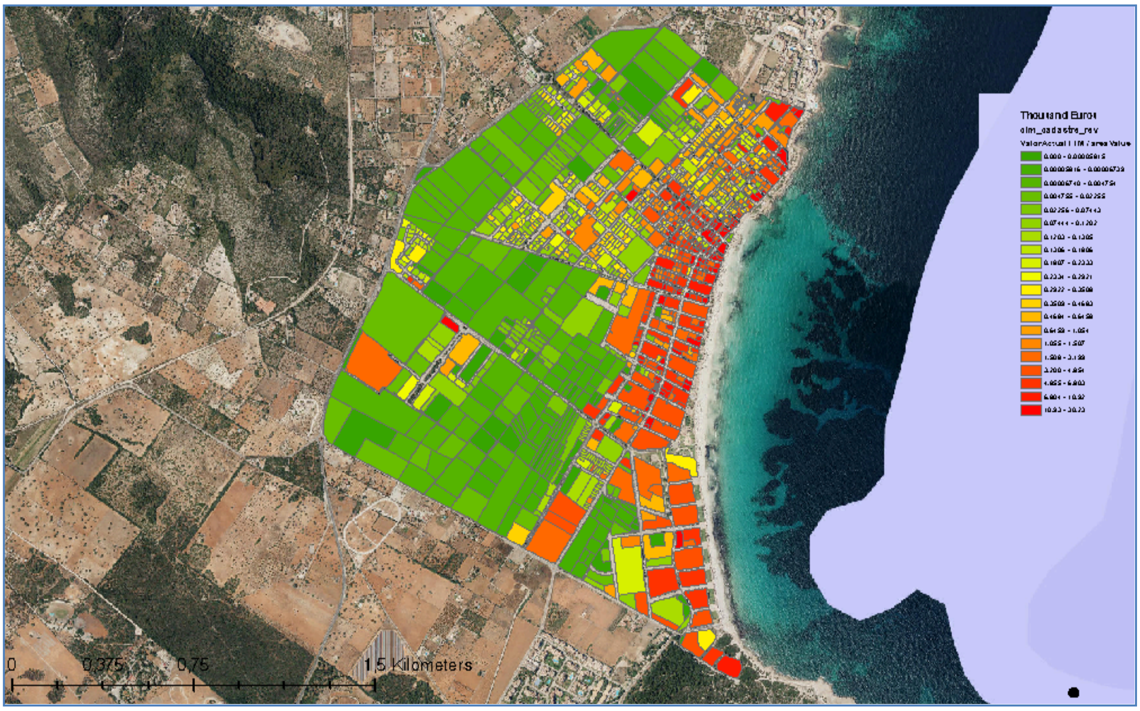



**Figure 13. Valuation map according to the total market value of the economic activity developed in each cadastral 14-digit plot per square meter (thousand euros).**



Therefore, Figure 13 shows a clearer view of the market value of the economic activity developed in each cadastral plot. The main result remains that the most valuable plots tend to be close to the sea, especially the beach, although it also offers a clearer view of the most valuable streets, those in or close to the commercial center of the area.

There are 65 hospitality businesses (hotels and tourist apartments). On average the value of their economic activity is 17.5 million euros. The value of the economic activity developed by these businesses depends on the number of rooms. On average the market value is 117 thousand euros per room, ranging from an average value of 362 thousand euros per room in five-star hotels to an average of 47 thousand euros per room in one-star hotels. For apartments, the average values per apartment range from 285 thousand euros in case of the highest category to 36 thousand euros in the lowest category. These valuations are quite conservative since we only consider revenues per accommodation, we do not have data on other revenues, such as bar and revenues for using other facilities (e.g., spa, tennis court). Therefore, the real value of the economic activity developed by the analyzed hospitality businesses is larger than our estimation. Our methodology provides a very reliable minimum value.

Regarding commerce, we considered all real estate properties used by bars, restaurants, shops, and business offices. In total, in our area of analysis, there are 684 such properties. On average the market value of the economic activity developed in such properties is 1.7 million euros. This value depends on their proximity to the commercial center and their physical size (square meters). The average market value per square meter ranges from 15.9 thousand euros in the commercial center to 4.3 thousand euros in the farthest properties from the commercial center.

Finally, there are 5,785 non-business-related activities properties (land, apartments, etc…), with an average value of 61 thousand euros. This is again a very conservative valuation since it is computed by the Spanish cadastre, mainly for taxation purposes.

### 3.3.2. The Effect of Climate Change

Our analysis of the survey data in the previous subsection leads us to expect that only 42% of the current tourist visitors of Cala Millor would come if the beach shrinks by 50% or the temperature increases by 4ºC. This implies a very large reduction in the number of tourists (58%) and now we analyze its impact on the market value of the economic activity developed in Cala Millor. For this, we assume that the number of tourists would be only 42% of the current number of tourists if these severe effects of climate change happened in the future. Consequently, we assume that total revenues of hospitality businesses and commerce would be only 42% of their current revenues if these severe events happen. Additionally, as a conservative strategy, we will maintain the value of the real estate properties. The value of real estate properties depends on the dynamics of the real estate market, and we are using a very conservative valuation, the one provided by the Spanish cadastre, that usually is below the market value, but that is objective and is computed according to the main factors affecting the value of real estate properties, not only the economic activity developed in the area. Table 6 shows how it would change the value of the market value of the economic activity developed in our area of analysis if the considered severe effects of climate change happened.

In Table 6, the first rows show the effect on the total value and the average value of all 1,313 cadastral plots in the analyzed area. The market value of all the economic activity developed in the area would drop from 2.67 thousand million euros to 1,32 thousand million euros. This implies that 1,34 thousand million euros would be lost, which is a very large amount. With a 58% reduction in visitors, we expect around 50% reduction in the market value of the overall economic activity developed in Cala Millor. On average, the value of each cadastral plot would drop from 2 million euros to 1 million euros.

The 65 hospitality businesses in our area of analysis would lose 58% of their customers and revenues, and the market value of their economic activity (considering all their stakeholders) would decrease from 1,39 thousand million euros to less than 0,5 thousand million euros, which implies a reduction of almost 58%. The average value of each hospitality business would decrease from 17,5 million euros to only 7,3 million euros.

**Table 6. The Effect of Climate Change – Indirect effects (50% beach reduction, 4 degrees increase of temperature)**

| | | Market value (Thousand euros) | | | |
|---|---|---|---|---|---|
| | | No Climate Change | Climate Change | Variation | % Variation |
| **14-digit cadastral plots** | **Total** | 2,673,468.00 | 1,328,906.00 | -1,344,562.00 | -50.29% |
| | **Average** | 2,036.15 | 1,012.12 | -1,024.04 | -50.29% |
| | **# Units** | 1313 | 1313 | | |
| **Hospitality businesses** | | | | | |
| | **Total** | 1,139,533.00 | 480,216.10 | -659,316.90 | -57.86% |
| | **Average** | 17,531.27 | 7,387.94 | -10,143.33 | -57.86% |
| | **# Units** | 65 | 65 | | |
| **Commerce** | | | | | |
| | **Total** | 1,182,056.00 | 496,811.20 | -685,244.80 | -57.97% |
| | **Average** | 1,728.15 | 726.33 | -1,001.82 | -57.97% |
| | **# Units** | 684 | 684 | | |
| **Non-business-related properties** | | | | | |
| | **Total** | 351,879.10 | 351,879.10 | - | 0.00% |
| | **Average** | 60.83 | 60.83 | - | 0.00% |
| | **# Units** | 5785 | 5785 | | |

The market value of the economic activity developed in the 684 properties used for commerce (mainly bars, restaurants, and shops) would also suffer a large loss of value, from 1.18 thousand million euros to less than 0,5 thousand million euros. The average value of one of these properties would drop from 1,7 million euros to 0,72 million euros. These properties would lose almost 58% of their value. Finally, consistent with our assumption that the value of the real estate properties is not affected by the effects of climate change on the beach and the temperature, we predict no drop in the value of non-business-related properties.

# 4. DISCUSSION AND CONCLUSION

Climate change will affect the distribution of global tourist flows. Cala Millor, a destination where the main attractions are tied to its climate and sea level, will experience the consequences of these changes. In this deliverable, we have aimed to develop a methodology and provide an initial assessment of how to evaluate the climate change risks facing the area. Globally, models predict a negative impact of climate change on tourist arrivals in temperate regions, such as Cala Millor.

However, the strong growth in global tourism demand, driven by other market factors, suggests that the effects of climate change will be offset by this positive trend in the coming years. Therefore, the most appropriate global outlook to consider is one where overall tourist demand remains steady. However, despite the continued demand at a global level, it should be noted that climate change will lead to higher temperatures and rising sea levels, which could result in a loss of beach surface area, and at a local level, in a loss of attractiveness in certain areas, such as in the case of Cala Millor.

Based on an objective and replicable methodology we obtain a measurement of the value of the economic activity developed in the area surroundings of the beach of Cala Millor. We consider the social dimension of this economic activity, considering the value for all the stakeholders, not only the owners. Our data comes from public sources (Spanish cadastre, IBESTAT, *Idealista*, and business accounting data) and our methodology is conservative. For example, we do not consider some unobservable (from public sources) revenues of hospitality businesses (e.g., revenues from the bar of each hotel), and we rely on the value provided by the Spanish cadastre to obtain the residual value of businesses and the value of non-businesses-related properties. Even so, we obtain a very large value (2,67 thousand million euros), that therefore could be considered as the minimum market value of such economic activity.

In the second step, we analyze the potential effect of climate change on the market value of the economic activity developed in the area surrounding Cala Millor's beach. For this analysis, we also make a conservative assumption, which is that the value of the real estate properties would not be affected by the effects of climate change. Even so, our results imply a very large loss of value, more than half of this current value, around 1,3 thousand million euros. This estimation is very large and relies on a survey and on our assumptions about how a tourist would react depending on their answers in the survey. This is a limitation of any study based on survey data. In any case, we got answers from a representative sample of tourist visitors of Cala Millor showing relevant concerns about the size of the beach and the temperature. Therefore, we may expect a significant reduction in the number of tourists in Cala Millor if the beach shrinks and the temperature increases significantly. Then, given the high value of the economic activity developed in the area, we may expect a large economic loss in case of severe consequences of climate change. This loss of value is as high as to justify very large investments to protect the area from the effects of climate change.

Finally, it is worth mentioning that we considered severe possible effects of climate change in terms of beach shrink and temperature increase (50% of beach reduction and 4ºC increases in temperature). If the effects of climate change were worse, the effect on the value of the economic activity developed in Cala Millor would be worse, considering also the flooding of some urban areas and the direct loss of the market value of the economic activity developed there.

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