SOCLIMPACT

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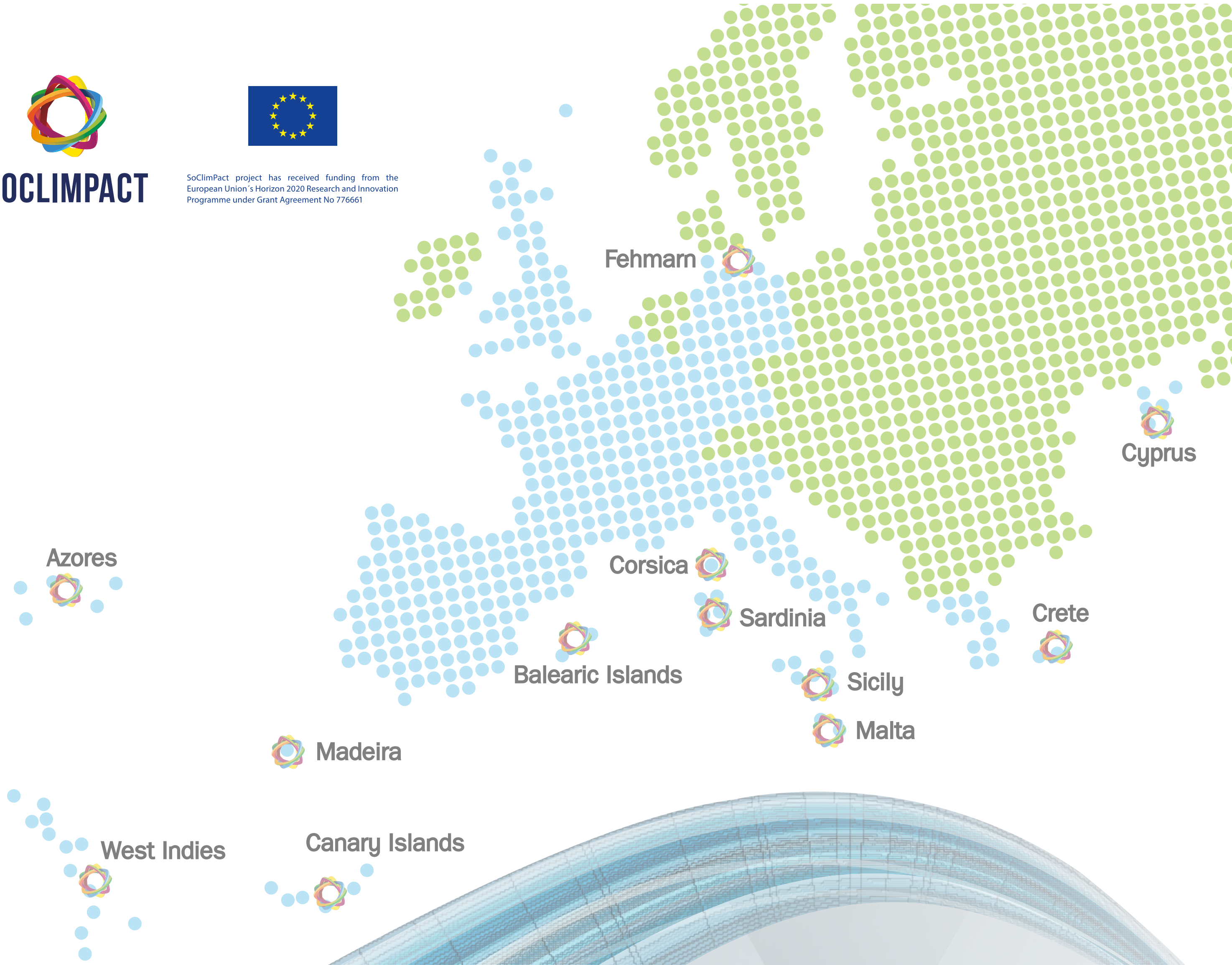

Downscaling climate change impacts, socio-economic implications and alternative adaptation pathways for Islands and Outermost Regions

Mc Graw Hill

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the book, or in the decision to publish the results.

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SOCLIMPACT

Executive Summary

This book provides a comprehensive overview of the future scenarios of climate change and management concerns associated with climate change impacts on the blue economy of European islands and outermost regions. The publication collects major findings of the SOCLIMPACT project's research outcomes, aiming to raise social awareness among policy-makers and industry about climate change consequences at local level, and provide knowledge-based information to support policy design, from local to national level. This comprehensive book will also assist students, scholars and practitioners to understand, conceptualize and effectively and responsibly manage climate change information and applied research. This book provides invaluable material for Blue Growth Management, theory and application, at all levels. This first edition includes up-to-date data, statistics, references, case material and figures of the 12 islands case studies. ¨Downscaling climate change impacts, socio-economic implications and alternative adaptation pathways for Islands and Outermost Regions¨ is a must-read book, given the accessible style and breadth and depth with which the topic is dealt. The book is an up-to-date synthesis of key knowledge on this area, written by a multidisciplinary group of experts on climate and economic modelling, and policy design.

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Chapter

11

Sicily (Italy)

SOCLIMPACT

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Sicily at a Glance

Sicily, in the south of Italy, is the largest and one of the most densely populated islands in the Mediterranean Sea. Together with its surrounding islands, Sicily forms an autonomous region of Italy. The island is mostly mountainous with a seismic and volcanic activity quite intense. Here there is the Europe's highest active volcano, Mount Etna (3,350 meters). The only wide valley is the fertile Plain of Catania in the east. The climate is subtropical and Mediterranean. Underground water and springs are plentiful. The natural vegetation of Sicily has been greatly reduced by human influence, and forests occupy only 4% of the territory.

The Blue Economy Sectors

- **Aquaculture**

  Aquaculture in Sicily is mainly based on seabass and seabream production, with an average ratio of 54 to 46%. Small and variable quantity of other marine species are produced, such as sharpsnout seabream, red porgy, common dentex, amberjack, meagre or Mediterranean bluefin tuna. Commercial shellfish culture is limited to small mussel farms in the provinces of Palermo, Messina and Syracuse. The Regional Pilot Centre for Aquaculture of Assessorato Agricoltura e Foreste of the Sicilian Region coordinates research, development and pilot scale production in fresh water aquaculture. This sector is expected to grow rapidly in the next few years.

- **Maritime Transport**

  Palermo is considered one of the Italian strategic ports for the Motorways of the Sea system by the Ministry of Transport. The Sicilian ports in which today Ro-Ro cabotage services are operated for the combined road-sea are: Palermo, Termini Imerese, Catania and Trapani. Considering the port facilities, Sicily exceeds the national average. Due to its geographical conformation, the region has in fact a large number of ports, but the type and quality of services offered is inadequate in relation to the structure of the production system and the demand for passenger and freight transport.

- **Energy**

  Renewable sources are hydroelectric, photovoltaics, from biomass. No renewable sources: Power stations with steam turbines powered by poly-fuel. Semi-thick dense oils and natural gas are used, creating a mix that has led to a certain control of emissions in compliance with environmental legislation. In the Aeolian Islands, it has been developed a "Plan for recovery and increase of installed capacity end adaptation of auxiliary systems" including the installation of 10 new electro diesel production groups. The end uses concern the equivalent consumption of primary energy sources in the four census macro-sectors: Primary, Civil, Industry and Transportation.

- **Tourism**

  Sicily's sunny, dry climate, scenery, cuisine, history and architecture attract many tourists from mainland Italy and abroad. The tourist season peaks in the summer months, although people visit the island all year round. Tourism is one of the most important sectors for the island economy. In 2018, Sicily had 15.1 million presences, with an increase of 4.9% respect the 2017, and almost 5 million of arrivals (+4.8% in respect of 2017). The average stay is 3 nights with a bed occupancy rate of about 20%, then very low. The most popular time of the year is from May to September.

11.1. Current Climate and Risks

The climate in Sicily is Mediterranean on the coast as well as in the little islands and archipelagos of the region, with a mild and rainy winter season and warm and sunny summers. The mid-seasons are quite mutable. On the coastline, specially on the south-west, the influence of the winds coming from Africa makes the climate torrid. In the inland, prevainly mountainous, the climate is almost continental on the hills, with winters moderately cold and summers quite torrid, and colder on the mountains.

In general, the rainfall is quite poor, specially at low altitude and on the coast, where the landscape is semi-arid. Over the 1,000 meters of altitude, snowfall can be abundant and frequent. For example, on the Etna Volcano, often snows also in the summer due to the Atlantic currents which affect the climate especially between the end of July and the beginning of August (see **Figure 11.1**).

CURRENT CLIMATE-RELATED RISKS

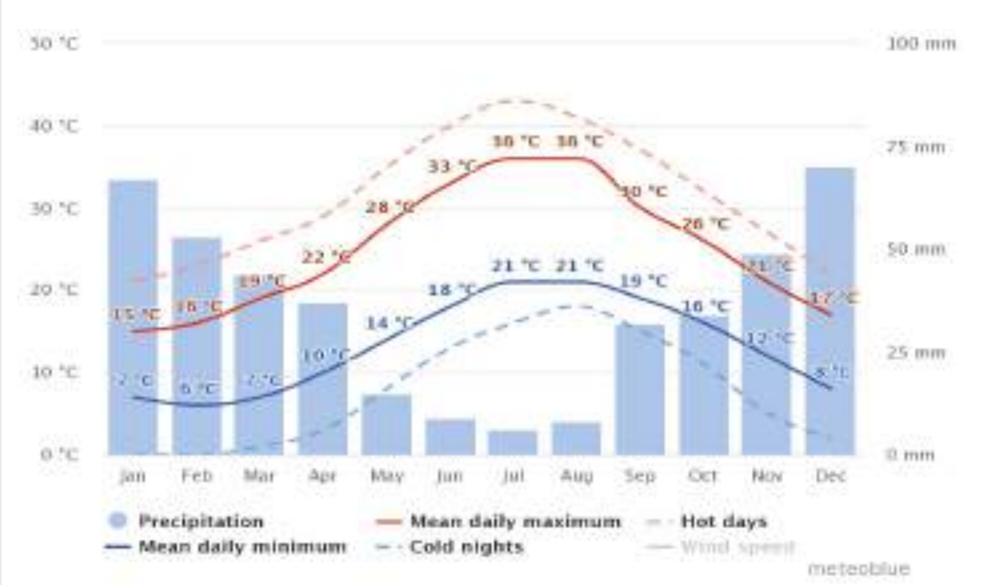
- Coastal flood High
- Wildfire High
- Water scarcity Medium
- Extreme heat Medium

SIGNIFICANT CLIMATE EVENTS

- Strong wind , February 2019
- Torrential rains and violent thunderstorms, November 2018
- Twister, August 2018, August 2013,
- Windstorm, November 2017, December 2009
- Windstorms, torrential rains and violent thunderstorms, October 2015.

CLIMATE CHARACTERISTICS (37.49°N 15.07°E, 7m asl)

Average temperature and precipitation



Wind speed

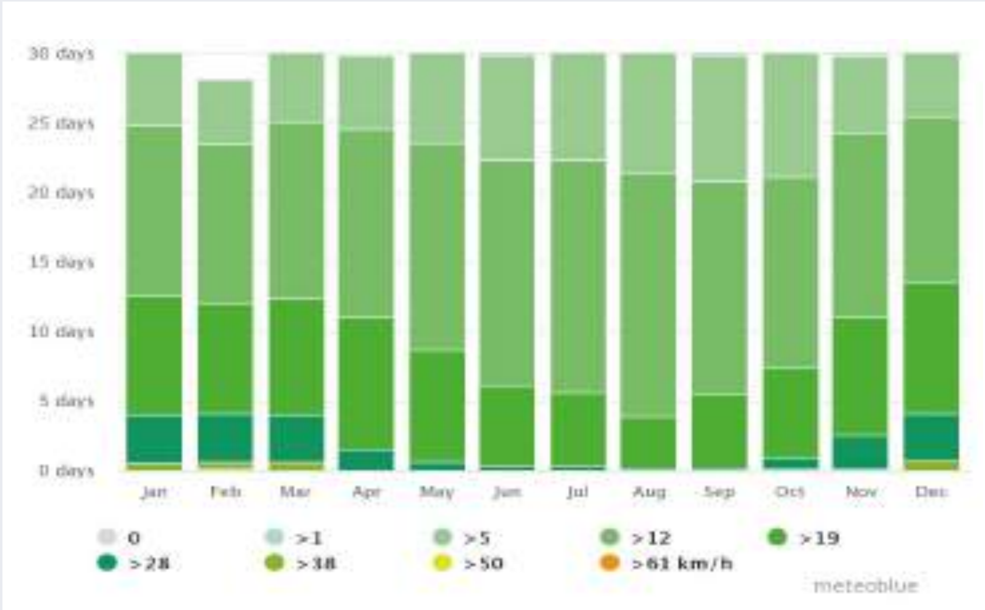
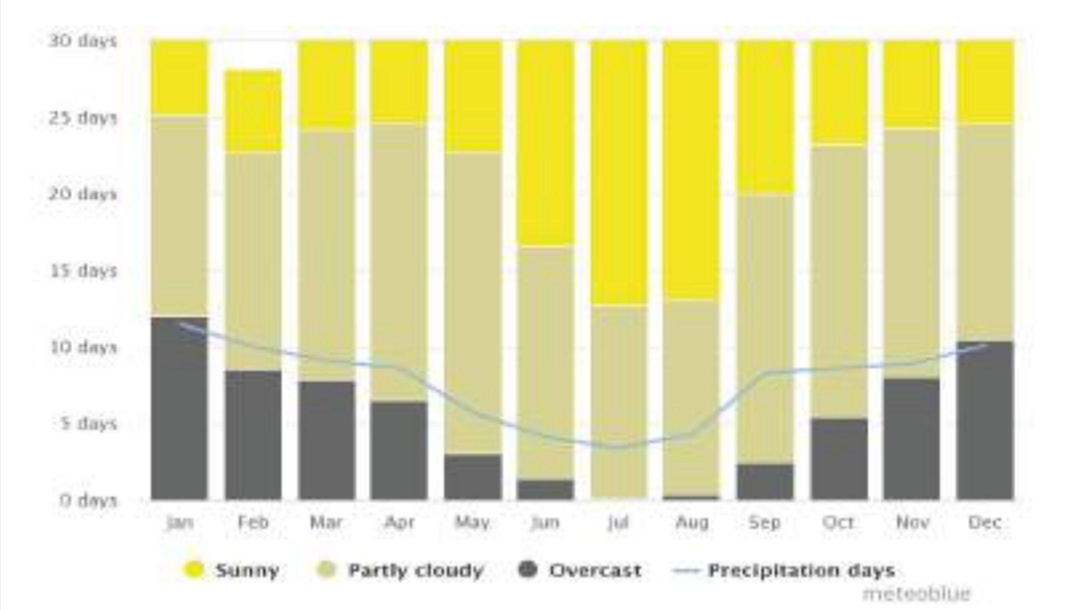


Figure 11.1. Climate factsheet

Source: Own elaboration with data from GFDRR ThinkHazard!; D7.1. Conceptual Framework and Meteoblue; Meteoblue global NEMS (NOAA Environmental Modeling System). *(Continued on the next page)*

Cloudy, sunny and precipitation



Wind rose

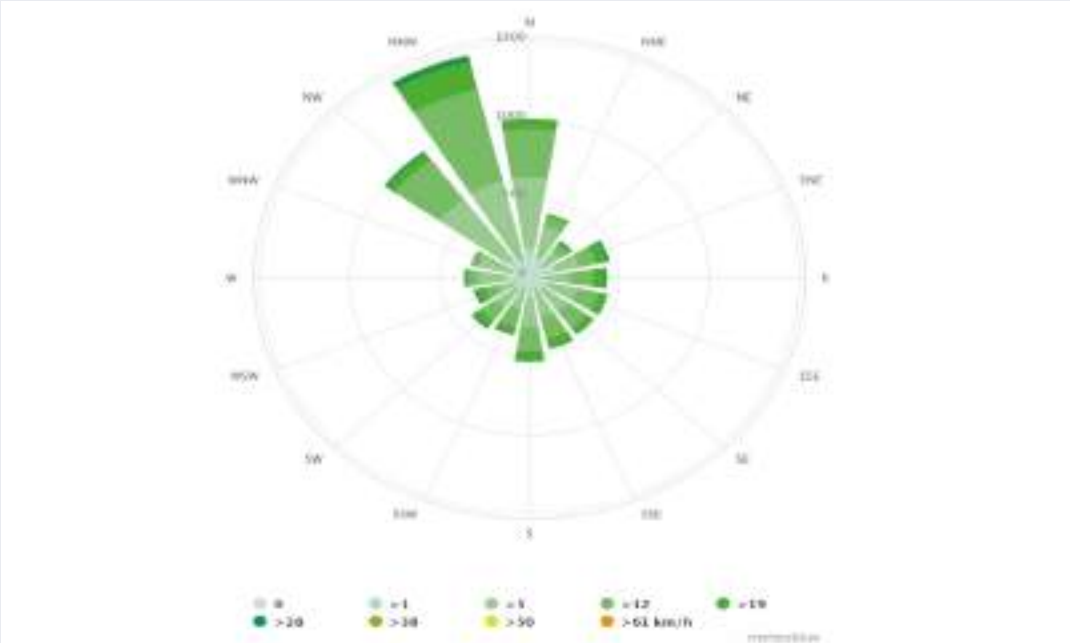


Figure 11.1 (Cont.). Climate factsheet

Source: Own elaboration with data from GFDRR ThinkHazard!; D7.1. Conceptual Framework and Meteoblue; Meteoblue global NEMS (NOAA Environmental Modeling System).

11.2. Macroeconomic Projections

In terms of GDP growth, Sicily registers a 1.3% yearly rate throughout the 2015-2100 period and a 1.1% rate in the 2015-2050 period. The main driver of growth during the entire period is investments, particularly in the short term, and a sustained private consumption throughout the period (Table 11.1).

As seen in Figure 11.2, the economy of Sicily is projected to become more sustainable, as the trade deficit gradually diminishes and the contribution of investments to GDP increases. The above imply a reduction of private and public consumption when expressed as a share of GDP. In particular, the share of public consumption in GDP, which was the highest among all islands in 2015, drops to levels similar to those of the rest of the islands (see **Table 11.1** and **Figure 11.2**).

Table 11.1. Sicily GDP and GDP components yearly growth rates in 2020-2100.

	2020	2025	2030	2035	2040	2045	2050	2060	2070	2100
GDP	1.3%	0.8%	0.5%	0.9%	0.9%	1.6%	1.6%	1.6%	1.5%	1.3%
Private consumption	1.7%	0.3%	-0.4%	0.2%	0.6%	1.3%	1.4%	1.4%	1.2%	1.1%
Public consumption	1.0%	0.4%	0.1%	0.6%	0.6%	1.2%	1.2%	1.3%	1.2%	0.8%
Investments	1.2%	2.7%	2.4%	2.9%	1.1%	1.9%	1.8%	1.7%	1.6%	1.3%
Trade	2.1%	0.0%	-1.4%	-0.2%	-0.7%	-0.1%	0.2%	0.4%	-0.2%	-1.8%

Source: SOCLIMPACT Deliverable Report - D6.2. Macroeconomic outlook of the islands' economic systems and pre-testing simulations.

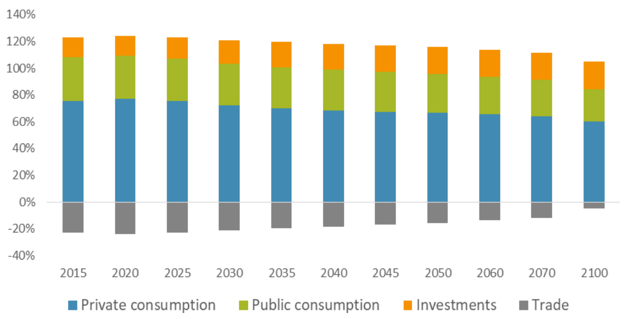


Figure 11.2. Macroeconomic components as a% share of GDP for Sicily in 2015-2100.

Source: SOCLIMPACT Deliverable Report - D6.2. Macroeconomic outlook of the islands' economic systems and pre-testing simulations.

11.2.1. Sectoral Projections

The economy of Sicily remains a service-led economy throughout the 2015-2100 period. However, a transition from non-market towards market services is projected. Construction registers an increasing share in total value added, following the trajectory of investments. The share of blue economy sectors in total value-added falls slightly in the 2015-2100 period, as tourism falls slightly below 10% of GDP (see **Figure 11.3** and **Table 11.2**).

11.2.2. Employment

Sicily registers high unemployment levels, particularly among young people, which poses a challenge for future economic

Table 11.2. Sectoral contribution as a% share of total gross value added for Sicily in 2015-2100.

GVA% shares	2015	2020	2025	2030	2035	2040	2045	2050	2060	2070	2100
Agriculture	4.2%	4.0%	4.0%	4.0%	3.9%	3.9%	3.8%	3.7%	3.6%	3.5%	3.6%
Fishery	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%
Manufacturing	4.1%	3.7%	3.5%	3.5%	3.4%	3.2%	2.9%	2.6%	2.2%	2.0%	1.8%
Consumer goods	1.3%	1.3%	1.3%	1.3%	1.3%	1.4%	1.4%	1.5%	1.8%	2.0%	2.2%
Electricity	1.3%	1.2%	1.2%	1.2%	1.2%	1.1%	1.1%	1.0%	0.9%	0.8%	0.8%
Water	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.2%	1.2%	1.1%	1.1%	1.0%
Construction	4.9%	5.1%	5.6%	6.1%	6.7%	6.9%	7.3%	7.7%	8.5%	9.1%	10.8%
Water transport	0.7%	0.7%	0.6%	0.6%	0.6%	0.6%	0.5%	0.5%	0.4%	0.3%	0.2%
Other transport	4.5%	4.4%	4.4%	4.4%	4.4%	4.4%	4.3%	4.2%	4.1%	4.0%	3.9%
Accommodation and food services	2.9%	3.0%	3.0%	3.1%	3.1%	3.1%	3.2%	3.3%	3.4%	3.4%	3.6%
Travel agency and related activities	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Recreational services	4.8%	4.8%	4.8%	4.7%	4.6%	4.5%	4.5%	4.5%	4.4%	4.3%	3.9%
Other market services	37.%	38.%	38.%	38.%	39.%	40.%	40.%	41.%	43.%	44.%	46.0%
Non-market services	32.%	31.%	31.%	30.%	30.%	29.%	28.%	27.%	26.%	25.%	21.9%

Source: SOCLIMPACT Deliverable Report - D6.2. Macroeconomic outlook of the islands' economic systems and pre-testing simulations.

Figure 11.3. Sectoral value added as a% share to total GVA for Sicily in 2015, 2050 and 2100.

Source: SOCLIMPACT Deliverable Report - D6.2. Macroeconomic outlook of the islands' economic systems and pre-testing simulations.

policies. Our reference projections assume a declining unemployment rate that falls by 13% in the 2015-2100 period (see **Table 11.3** and **Figure 11.4**). This positive evolution, However, is not the result of economic transformation and job creation, but rather the effect of the declining population. The only sector that shows higher employment numbers is construction. The next Figure describes the share of each sector in total employment, indicating that almost half of the Sicilian jobs are in the market services, while almost 10% of total employment is related to tourism.

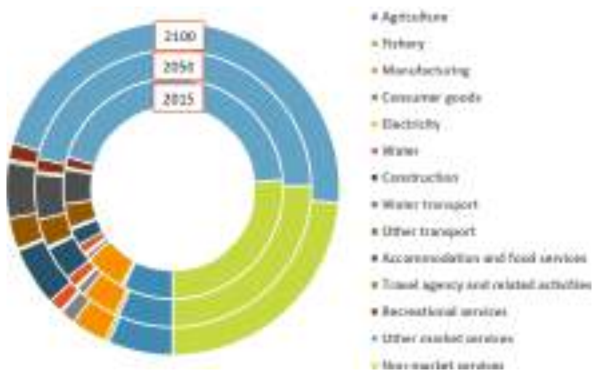


Figure 11.4. Sectoral employment as a% share of total for Sicily in 2015, 2050, 2100.

Source: SOCLIMPACT Deliverable Report - D6.2. Macroeconomic outlook of the islands' economic systems and pre-testing simulations.

Table 11.3. Unemployment rate in Sicily in 2015-2100.

	2015	2020	2025	2030	2035	2040	2045	2050	2060	2070	2100
Unemployment rate	21.4%	20.4%	18.3%	16.2%	12.3%	11.0%	9.4%	8.5%	8.4%	8.2%	8.2%

Source: SOCLIMPACT Deliverable Report - D6.2. Macroeconomic outlook of the islands' economic systems and pre-testing simulations.

11.3. Climate Change Outlook

Climate hazards indicators represent the entry point to understand the climate change exposure of the blue economy sectors. The indicators have been computed for two scenarios, RCP2.6 (low emission scenario) and RCP8.5 (high emission scenario) and for different horizon times namely: a reference period (1965-2005), mid-century (2046-2065) and end of century (2081-2100). Main source of climate projections (future climate) for the Sicily is MED-CORDEX ensemble (regional scale of the Mediterranean area) and CMIP5 ensemble (global scale) even if other model sources were applied when required, depending of available scales. Results are presented in form of maps, tables or graphs and only when the information shows an interesting outcome.

11.3.1. Tourism

11.3.1.1. Seagrass evolution

Posidonia Oceanica is a foundation species in Mediterranean waters. Foundation species have a large contribution towards creating and maintaining habitats that support other species. First, they are numerically abundant and account for most of the biomass in an ecosystem. Second, they are at or near the base of the directional interaction networks that characterize ecosystems. Third, their abundant connections to other species in an ecological network mostly reflect non-trophic or mutualistic interactions, including providing structural support for other species, significantly altering ecosystem properties to [dis]favor other species, altering metabolic rates of associated species, and modulating fluxes of energy and nutrient flow through the system.

Seagrasses are the main habitat for coastal marine ecosystems. They provide different services like sediment retention (and thus, clearer waters), coastal protection (in front of marine storms), shelter for marine organisms, etc. Therefore, the state of seagrasses is a convenient proxy for the state of coastal environment. One species is located in the coasts of Sicily: Posidonia. The results of RCP8.5 projections indicate a loss of 28.3% at end of century (see **Figure 11.5**).

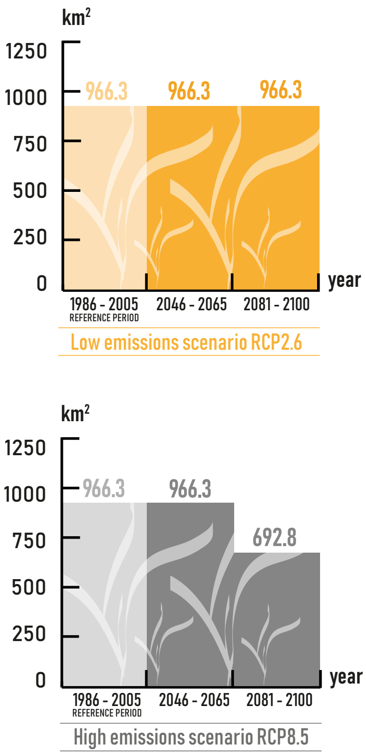


Figure 11.5. Projection of seagrass coverage.

Source: SOCLIMPACT project deliverable [D4.4e - Report] on estimated seagrass density.

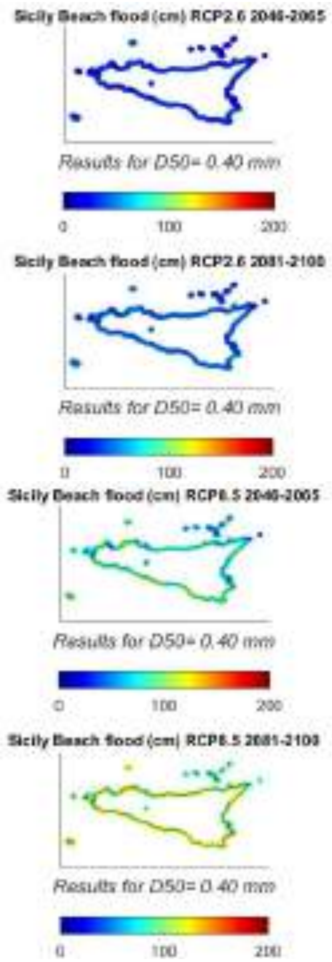


Figure 11.6. Projected extreme flood level (in the vertical, in cm) at beach locations with respect to the present (1986-2005) mean sea level values averaged for the islands under scenario RCP2.6 (left) and RCP8.5 (right). Own elaboration based on global and regional simulations.

Source: SOCLIMPACT Deliverable [Report - D4.4d]. Report on the evolution of beaches.

11.3.1.2. Beach flooding and related losses

One of the consequences of an increase in the mean sea level will be the flooding of coastal areas. This includes sand beaches, which are the main asset for tourism activities in most of the European islands. Therefore, estimating the potential risk of beach loss due to climate change is of paramount importance for the economy of those islands.

The 95th percentile of the flood level averaged was selected as an indicator of interest. The values are presented as anomalies with respect to the present mean sea level at beach location (i.e. including the median contribution of runup). An increase is expected being larger at the end of the century under scenario RCP8.5 (see **Figure 11.6**).

Under mean conditions, we find that, at end of century, the total beach surface loss range from ~34 % under scenario RCP2.6 to ~61 % under scenario RCP8.5 (see **Figure 11.7**).

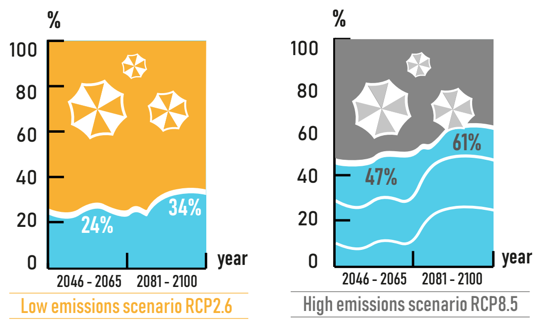


Figure 11.7. Beach reduction% (scaling approximation).

Source: SOCLIMPACT project deliverable [D4.4d - Report] on the evolution of beaches.

11.3.1.3. Fire Weather Index (FWI)

The FWI system provides numerical non-dimensional ratings of relative fire potential for a generalized fuel type (mature pine stands) based solely on weather observations. FWI is part of the Canadian Forest Fire Danger Rating System established in Canada since 1971 (van Wagner, 1987). Furthermore, since 2007, FWI has been adopted at the EU level and used in a harmonized way throughout Europe by the European Forest Fire Information System (EFFIS) of the Copernicus Emergency Management Service (since 2015).

It is selected for exploring the mechanisms of fire danger change for the islands of interest, as it has been proved to adequately perform for several locations, including the Mediterranean basin. The index was calculated for the fire season (defined from May to October) over the Mediterranean for all models, scenarios and periods.

For Sicily, N = 195 grid cells were retained from the models domain. In the following figure, the ensemble mean and the uncertainty are presented for all periods and RPCs. While most of the areas exhibit very low, low and medium fire danger in the present climate, and under RCP2.6 for the near and the distant future as well, it seems that under RCP8.5, more areas exhibit medium danger at mid-century, while towards the end of the century a major part of the island will be under medium and high fire danger. The overall increase of the risk score for the island exceeds 30 % (see **Figure 11.8**).

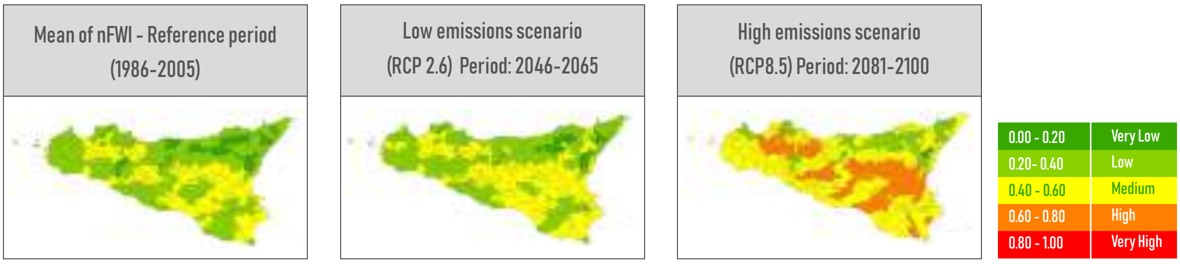


Figure 11.8. Fire Weather Index (EURO-CORDEX) with the color associated to the nivel of risk.
Source: SOCLIMPACT project deliverable D4.4c - Report on potential fire behaviour and exposure.

11.3.1.4. Humidex

For the assessment of climate hazard on heat related impacts of climate change on human health, the humidity index (Humidex) (Masterton and Richardson, 1979) has been used. Humidex value is an equivalent temperature, which express the temperature perceived by people (the one that the human body would feel), given the actual air temperature and relative humidity. As a more representative indicator for the assessment of inhabitants' and tourists' hazard on heat related climate change impacts, the number of days with Humidex greater than 35 °C was selected. From the above classification, a day with Humidex above 35 °C describes conditions from discomfort to imminent danger for humans.

For Sicily, N = 195 grid cells were retained from the models domain. In the following figure, the ensemble mean and the uncertainty are presented for all periods and RPCs. From less than 2 months in the present climate and quite above 2 months in the mid-century for both scenarios, Sicily will have almost 4 months with discomfort conditions by the end of the century under RCP8.5 (see **Figure 11.9**).

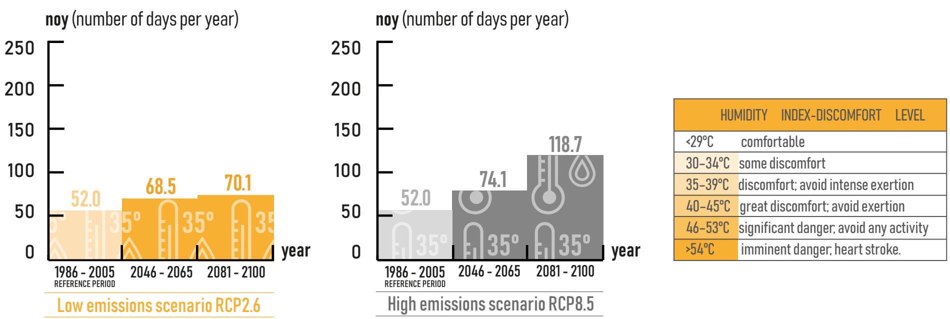


Figure 11.9. Number of days per year with Humidex > 35° C (Euro-CORDEX).
Source: SOCLIMPACT project deliverable D4.3. Atlases of newly developed indexes and indicator.

11.3.1.5. Length of the window of opportunity for vector-borne diseases

Vector Suitability Index for Aedes Albopictus (Asian Tiger Mosquito)

Climate change can influence the transmission of vector-borne diseases (VBDs) through altering the habitat suitability of insect vectors. This is mainly controlled by increases of ambient air temperature and changes in the hydrological cycle. We explore if potential changes to meteorological conditions can affect the distribution of the Asian tiger mosquito (Aedes albopictus). Asian tiger mosquito is native to the tropical and subtropical areas of Southeast Asia; however, in the past few decades, this species has spread to many countries through the international transport of goods and increased travel (Scholte and Schaffner, 2007). It is of great epidemiological importance since it can transmit viral pathogens and infectious agents that cause chikungunya, dengue fever, yellow fever and various encephalitides (Proestos *et al.,* 2015).

The multi-criteria decision support vector distribution model of Proestos *et al.* (2015) has been employed to estimate the regional habitat suitability maps. This is based on extending previous work on the environmental/climatic factors affecting the life cycle of the Asian tiger mosquito (Waldock *et al.*, 2013; Proestos *et al.*, 2015). The mosquito habitat suitability model combines seven meteorological indices based on field observations, extensive literature review and expert knowledge. The projection for the island indicates that the current situation will not be worsened. However, actual suitability index should be taken into account in climate policy design (see **Figure 11.10**).

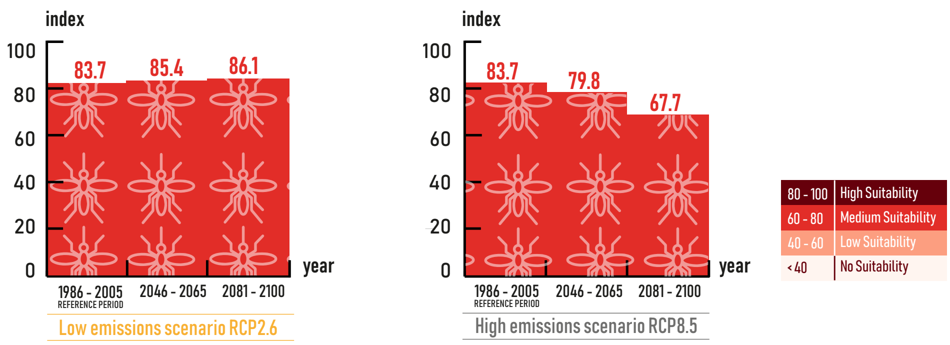


Figure 11.10. Habitat Suitability Index (HSI). [80-100: High Suitability; 60-80: Medium Suitability; 40-60: Low Suitability; <40 No Suitability]
Source: SOCLIMPACT project deliverable D4.3. Atlases of newly developed indexes and indicator.

11.3.2. Aquaculture

Temperature changes in seawater trigger physical impacts, such as increased harmful algal blooms, decreased oxygen level, increase in diseases and parasites, changes in ranges of suitable species, increased growth rate, increased food conversion ratio and more extended growing season. Furthermore, all these impacts lead to socio-economic implications among them: changes in production levels and an increase in fouling and pests. The objective of the current analysis is to identify and quantify the variations (future climate scenarios with respect to present climate) in the number and in the duration of events characterized by a Sea Surface Temperature (SST) exceeding a given threshold. The SST thresholds have been identified according to the farming and feeding necessities of several marine species, particularly relevant for the aquaculture sector in the Mediterranean Sea (MS) (see **Figure 11.11**).

More information can be found in the next section dedicated to risk assessment.

11.3.3. Energy

11.3.3.1. Standardized Precipitation Evaporation Index (SPEI)

As expected from the definition of SPEI, for our historical reference period, normal conditions are simulated for all islands. On average, simulations under pathway RCP2.6 indicate small changes in the SPEI values, and for most islands, near-normal conditions are expected throughout the 21st century as a result of the smaller changes in the precipitation regimes, combined with mild increases in near-surface temperature. Under the high emission RCP8.5 pathway all European Islands are expected to face much drier conditions. The signal becomes stronger towards the end of the 21st century (see **Figure 11.12**).

	Longest event (days) >20 degrees Mussels & clams	Longest event (days) >24 degrees Sea bream/Tuna	Longest event (days) >25 degrees Sea bass
Historic (1986-2005)	150 days	66.5 days	50 days
RCP 8.5 - mid century	172 days	93 days	73.5 days
RCP 8.5 - end century (2081-2100)	182 days	117.5 days	98.5 days

Species	Threshold (°C)
European seabass, Dicentrarchus labrax	25
Gilthead seabream, Sparus aurata	24
Amberjack, Seriola dumerili	23
Atlantic Bluefin tuna, Thunnus thynnus	23
Japanese clam, Ruditapes decussatus	21
Blue mussel, Mytilus edulis	21
Manila clam, Rudtape philippinarum	20
Mediterranean mussel, Mytilus galloprovinciales	20

Figure 11.11. Fish thermal threshold.

Source: SOCLIMPACT Deliverable Report - D4.5. Design of a comprehensive approach to climate and climate-related risk information to policy makers and the general public.

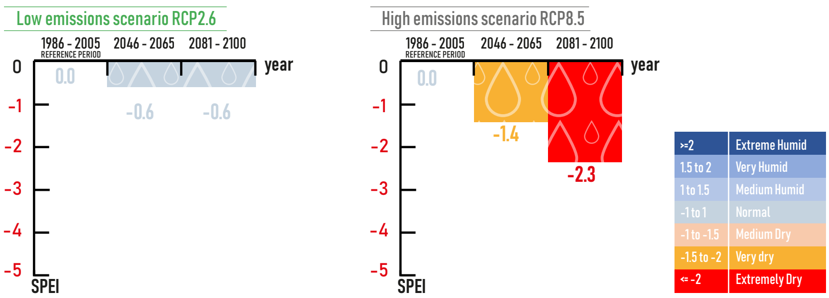


Figure 11.12. Ensemble mean, maximum and minimum values of the Standardized Precipitation Evaporation Index (SPEI) averaged over each SOCLIMPACT island and for each sub-period of analysis (EURO-CORDEX).

Source: SOCLIMPACT project deliverable D4.3. Atlases of newly developed indexes and indicator.

11.3.3.2. Percentage of days when T > 98th percentile - T98p

The T98p is defined as the percentage of time where the mean daily temperature T is above the 98th percentile of mean daily temperature calculated for the reference period 1986-2005. For Sicily, N = 195 grid cells were retained from the models domain. In the following figure, the ensemble mean and the uncertainty are presented for all periods and RCPs. It is found that T98p is about 5% during RCP2.6 towards mid-century and slightly decreases at the end of the century, while for RCP8.5 almost one fifth of the year will exhibit temperatures above the 98th percentile. The coastal grid cells are more affected by the temperatures increase compared to the inland grid cells (see **Figure 11.13**).

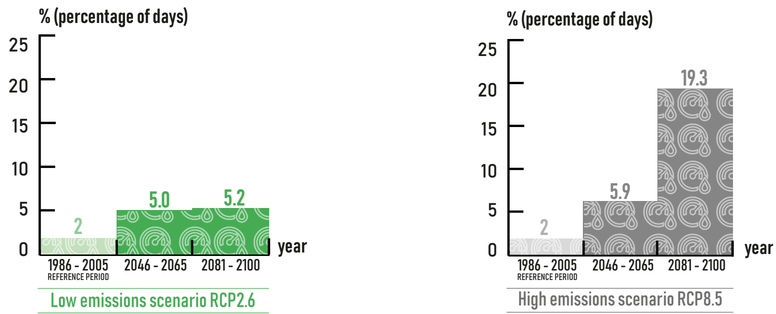


Figure 11.13. *Percentage of days when T > 98th percentile (EURO-CORDEX).*

Source: SOCLIMPACT project deliverable D4.3. Atlases of newly developed indexes and indicator.

11.3.3.3. Cooling Degree Days (CDD)

The Cooling Degree Days (CDD) index gives the number of degrees and the number of days that the outside air temperature at a specific location is higher than a specified base temperature, providing the severity of the heat in a specific time period taking into consideration outdoor temperature and average room (see **Figure 11.14**).

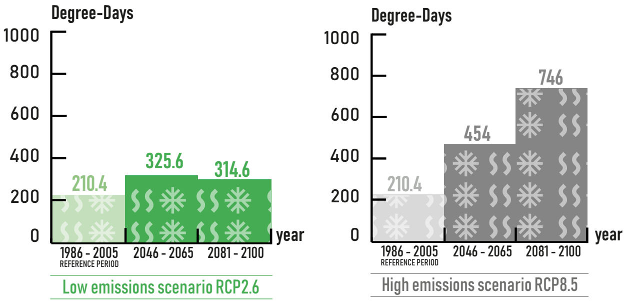


Figure 11.14. Cooling Degree Days (CDD). Ensemble mean of EURO-CORDEX simulations.

Source: SOCLIMPACT project deliverable D4.3. Atlases of newly developed indexes and indicator.

11.3.4. Maritime Transport

11.3.4.1. Sea Level Rise (SLR)

Sea Level Rise (SLR) is one of the major threats linked to climate change. It would induce permanent flooding of coastal areas with a profound impact on society, economy and environment. Moreover, an increase in the mean sea level would result in a larger impact of coastal storms with the consequent increase of risk. The results are presented in terms of mean sea level rise. For Sicily, the SLR ranges from 22.96 cm (RCP2.6) to 62.5 cm (RCP8.5) at the end of the century (see **Figure 11.15**).

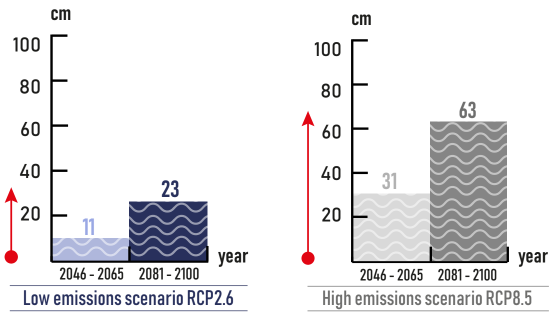


Figure 11.15. Mean sea level rise (in cm) with respect to the reference period (1986-2005). Own elaboration based on global and regional simulations.

Source: SOCLIMPACT project deliverable D4.4b - Report on storm surge levels.

11.3.4.2. Storm surge extremes

Storm surge events, characterized by positive extreme sea levels and mechanically forced by atmospheric pressure and wind are the main responsible for coastal flooding, especially when combined with high tides.

To date, the only ensemble populated with enough number of members to compute meaningful statistics on climate projections is the one produced for the Mediterranean by Lionello *et al.* (2017). This ensemble consists on 6 simulations run with the HYPSE model at 1/4° of spatial resolution and forced by the high-resolution wind fields from the MedCORDEX ensemble, which in turn is nested into CMIP5 global simulations. The simulations are run for the period 1950-2100, thus covering the historical period as well as the whole 21st century. Complementary, the ensemble includes three hindcast simulations that are used to establish present reference levels. Storm surge could decrease an amount of 20% under RCP8.5 (far future) (see **Figure 11.16**).

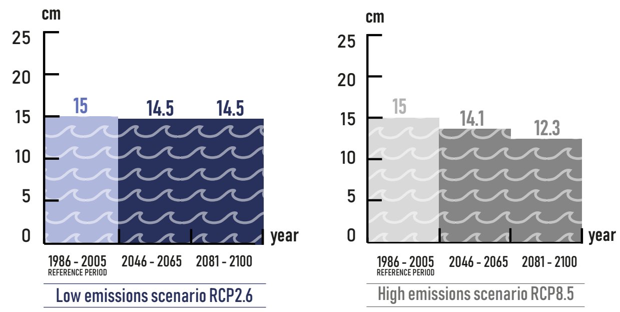


Figure 11.16. 99th percentile of atmospherically forced sea level (in cm) averaged for the hindcast period, the near future (2046-2065) and the far future (2081-2100) under scenarios RCP2.6 (with scaling approximation) and RCP8.5, relative change in brackets.

Source: SOCLIMPACT project deliverable D4.4b - Report on storm surge levels.

11.3.4.3. Wind extremes

The wind extremity index NWIX98 is defined as the number of days per year exceeding the 98th percentile of mean daily wind speed. This number decreases in the far future with a strongest value under RCP8.5 (16%). Like the NWIX98, the 98th percentile of daily wind speed, WIX98, decreases but with a more significant magnitude for RCP8.5 (see **Figure 11.17**).

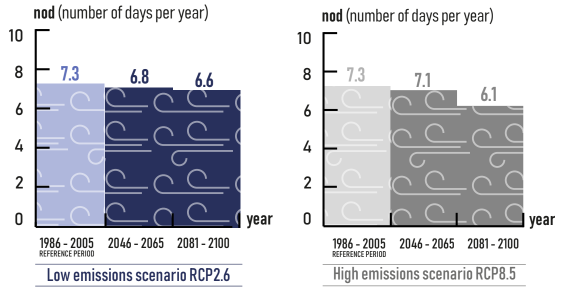


Figure 11.17. Wind Extremity Index (NWIX98). Ensemble mean of EURO-CORDEX simulations.

Source: SOCLIMPACT project deliverable D4.3. Atlases of newly developed indexes and indicator.

11.3.4.4. Wave extremes (99th percentile of significant wave height averaged)

Marine storms can have a negative impact on maritime transport, coastal-based tourism and aquaculture, among other activities. To illustrate this impact, the 99th percentile of significant wave height averaged has been chosen. A decrease in the extreme wave height is found being larger under scenario RCP8.5 (see **Figure 11.18**).

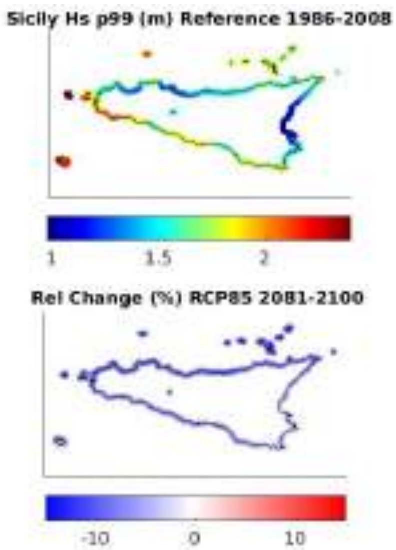


Figure 11.18. The 99th percentile of significant wave height averaged for the reference period and the relative change for the RCP8.5. Own elaboration based on global and regional simulations.

Source: SOCLIMPACT project deliverable D4.4b - Report on storm surge levels.

11.4. Risk Assessment

11.4.1. Tourism

11.4.1.1. Loss of attractiveness due to marine habitat degradation

Sicily ranks the best position regarding the climate change risk under analysis. The island does not outstand in any component of the risk, but neither shows critical pitfalls regarding it. With respect to the foundation species, the island holds the second largest surface, but lesser susceptible to sweater heating. This island also presents the most balanced tourist demand, as it treasures a wide range of cultural, social, landscape, gastronomic and historic resources to underpin a tourism industry not very dependent on the marine environment. All these factors together, but none of them particularly, make Sicily the most resilient island to the risk of its tourism industry being affected by seawater heating. The most salient weakness at this respect seems to be the seawater pollution due to a deficient capacity to treat sewage. Related investments should be a priority for this island.

The mentioned advantages and disadvantages of Sicily are depicted in the next figures. The further the criteria or sub-criteria is located from the centre of the graph, the more it affects the risk (see **Figure 11.19** and **Figure 11.20**).

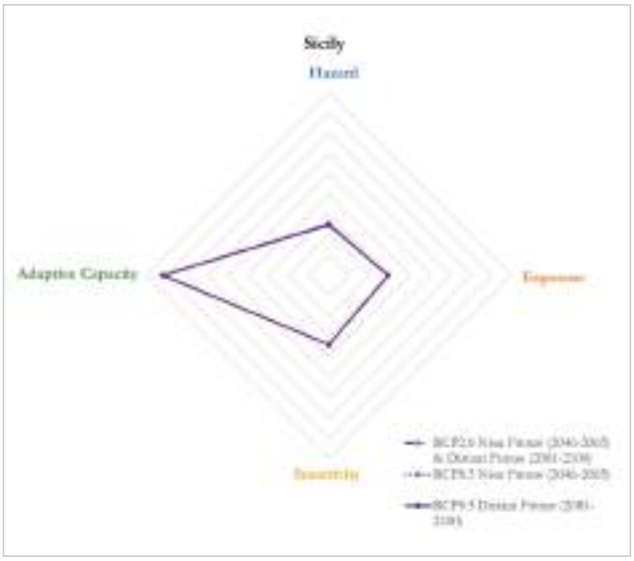


Figure 11.19. Global weights of each criteria and sub-criteria in the final score.

Source: SOCLIMPACT Deliverable Report – D4.5. Design of a comprehensive approach to climate and climate-related risk information to policy makers and the general public.

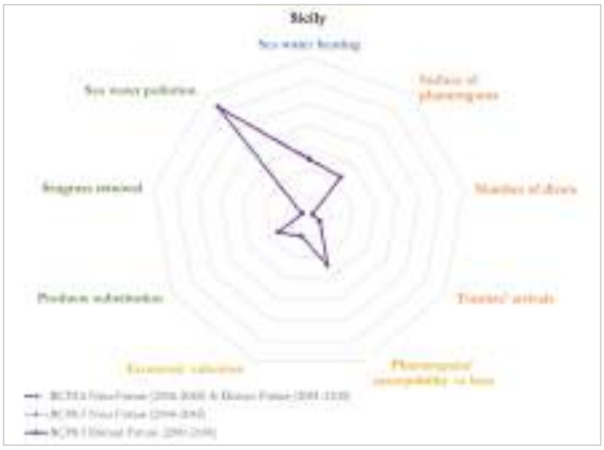


Figure 11.20. Global weights of each criteria and sub-criteria in the final score.

Source: SOCLIMPACT Deliverable Report – D4.5. Design of a comprehensive approach to climate and climate-related risk information to policy makers and the general public.

11.4.1.2. Loss of attractiveness due to increased danger of forest fires in touristic areas

For the reference period (1986-2005), the overall risk of forest fires is low for Sicily. It is maintained low in the near future (2046-2065) for both RCPs and even for RCP2.6 in the distant future (2081-2100). However, for RCP8.5 in the distant future, it moves to an overall medium risk of forest fires. This is mainly due to the increase of fire danger (hazard) for the end of the century and the medium score of exposure (population density and extense cultivated areas). Despite this, having the lowest score of flammability index prevents forest fires from becoming at greater risk in the future (see **Figure 11.21** and **Figure 11.22**).

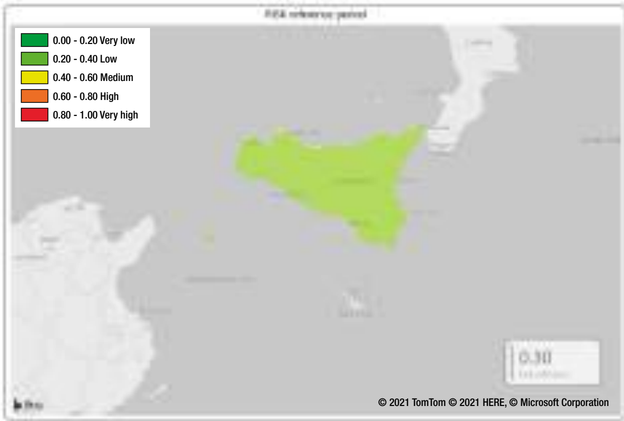


Figure 11.21. Risk score for the reference period.

Source: SOCLIMPACT Deliverable Report – D4.5. Design of a comprehensive approach to climate and climate-related risk information to policy makers and the general public.

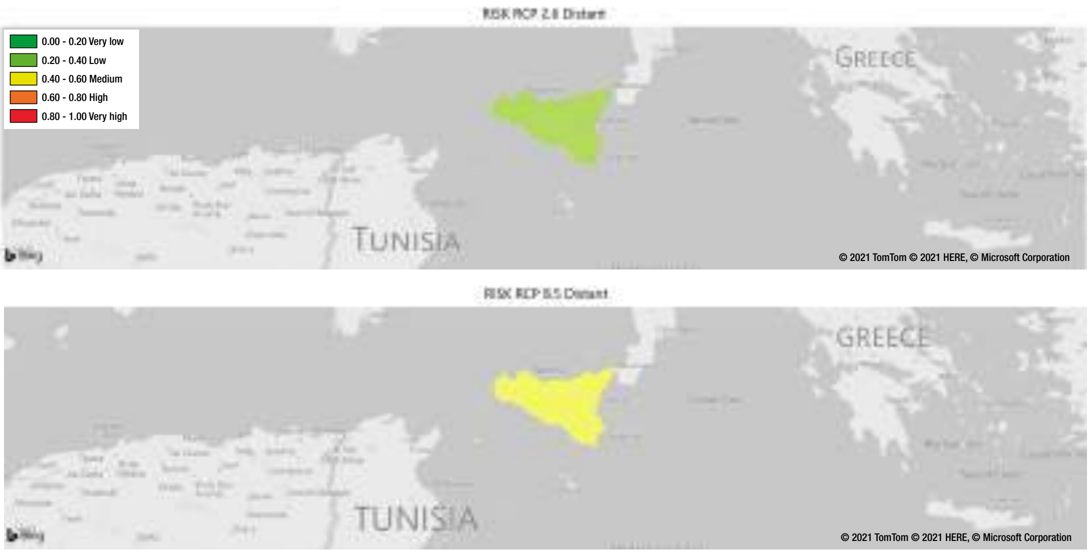


Figure 11.22. Risk score at the end in the distant future (2081-2100) under RCP2.6 (Ambitious Mitigation Policies) and RCP8.5 (Business as usual).

Source: SOCLIMPACT Deliverable Report – D4.5. Design of a comprehensive approach to climate and climate-related risk information to policy makers and the general public.

11.4.2. Aquaculture

11.4.2.1. Risk of increased fragility of aquaculture activity due to extreme weather events

Results for the hazard induced by mean wave motion appear to classify most Mediterranean offshore farm locations as semi-exposed sites (unlike those in the Atlantic, which are offshore). The probability of occurrence of extreme events that might prove unendurable for infrastructures moderately lowers the cumulative hazard. Results for Sicily exhibit increased uncertainty, clearly deriving from the extreme event component (see **Table 11.4**).

Table 11.4. Risk results for impact chain "Extreme Weather Events" for the Mediterranean islands.

Risk	Best-case scenario					Worst-case scenario				
	Reference period	Mid century		End century		Reference period	Mid century		End century	
	Hist	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	Hist.	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Corsica	0.19	0.19	0.19	0.20	0.21	0.25	0.25	0.26	0.28	0.26
Cyprus	0.23	0.23	0.23	0.23	0.22	0.23	0.23	0.23	0.23	0.22
Malta	0.26	0.26	0.26	0.26	0.26	0.42	0.45	0.56	0.45	0.36
Sardinia	0.30	0.32	0.32	0.28	0.31	0.33	0.33	0.34	0.33	0.33
Sicily	0.20	0.20	0.20	0.20	0.20	0.30	0.34	0.33	0.33	0.26

11.5. Impacts on the Blue Economy Sectors

11.5.1. Tourism (Non-Market Analysis)

In order to analyse the reactions of tourists to the impacts of climate change and the preferences for adaptation policies, several hypothetical situations were posed to 290 tourists visiting Sicily, whereby possible climate change impacts were outlined for the island (i.e., beach erosion, infectious diseases, forest fires, marine biodiversity loss, heat waves, etc.) (see **Figure 11.23**).

Firstly, tourists had to indicate whether they would keep their plans to stay on the island or find an alternate destination if the impact had occurred, which allows predictions of the effects on tourism arrivals to be made for each island. Secondly, tourists were asked to choose between various

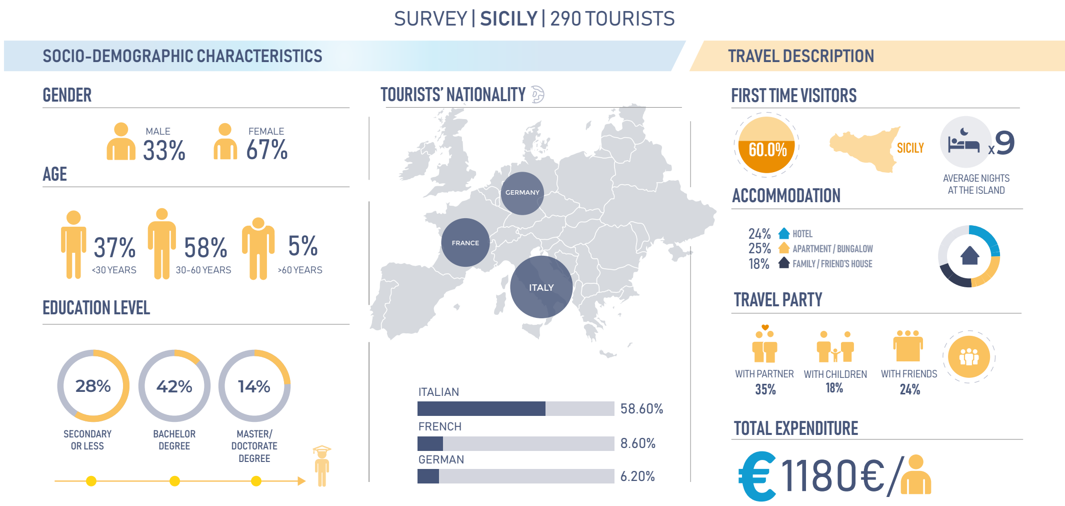


Figure 11.23. Socio-economic characteristics and travel description: tourists visiting Sicily.
Source: SOCLIMPACT Deliverable Report - D5.5. Market and non-market analysis.

policy measures funded through an additional payment per day of stay – the tourists' choices being an expression of their preferences for attributes/policies. To estimate the results, the conditional logit model was run by using the Stata software.

In general, data confirms that tourists are highly averse to risks of infectious diseases becoming more widespread (75.30% of tourists would change destination). Moreover, they are not willing to visit islands where the cultural heritage is damaged due to weather conditions (52.40%), where wildfires occure more often (52.10%) or where water is scarce for leisure activities (52.10%). Consequently, policies related to the prevention of infectious diseases (3.5€/day), the protection of the cultural heritage (3.5€/day), and the marine habitats restoration (3.2€/day) are the most valued, on average, by tourists visiting this island.

Although climate change impacts are outside the control of tourism practitioners and policy-makers, they can nevertheless utilise this knowledge to improve the predictability of the effect that certain adaptation policies and risk management strategies, and develop their plans accordingly (see **Figure 11.24**).

The impact of increased temperatures and heat waves on hotels' prices and revenues

In order to assess how the variation in temperature impacts the tourism sector through changes in tourism demand, our research question was: "How do increasing temperatures (and heat waves) impact prices and, more in general, expenditure of tourists?" Arguably, when temperatures grow, tourists adjust their behaviour: they might switch destination, or they might stay longer or shorter depending on their attitudes and preferences. In turn, all these changes modify the market equilibrium, pushing tourism companies to adjust their prices to re-establish the equilibrium between demand and supply. The change in demand and the change in price determine the change in tourism expenditure which is, from the destination's perspective, tourism revenue.

We monitored current weather conditions posted on several weather forecast providers and daily prices posted on Booking.com by hotels. We then estimated the link between daily temperature and daily price, controlling for all the other factors affecting prices. We finally applied these estimates to the increase in the number of days with excessive tempera-

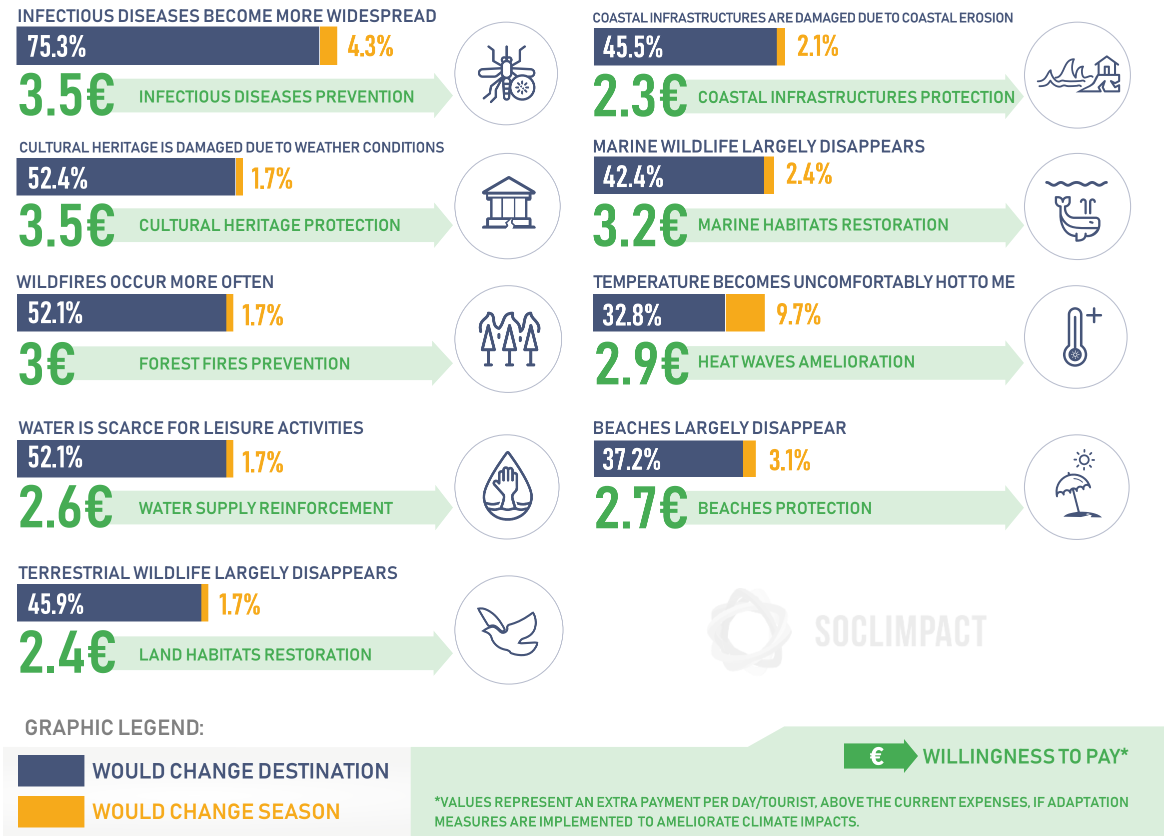


Figure 11.24. Tourists' response to climate change impacts and related policies: tourists visiting Sicily.
Source: SOCLIMPACT Deliverable Report - D5.5. Market and non-market analysis.

ture projected for the future in two scenarios (RCP2.6 and RCP8.5) and in two time horizons (near future, about 2050; distant future, about 2100).

Among the different indicators linked to thermal stress, we focus on two: the number of days in which the temperature is above the 98th percentile and the number of days in which the perceived temperature is above 35 °C. Although the impact for both indices was computed, in this document we only report the second one (named Humidex) because it is the most intuitive and because human thermal stress is more related to the absolute value of the temperature than its deviation from some pre-determined distribution. We assumed that thermal stress appears when the perceived temperature grows above 35 °C.

As thermal stress is delimited in the summer months, and this is when the great majority of tourists arrive in these islands, the whole analysis has been carried out in six months only: from May to October included. In other words, we assume that there is no thermal stress (and hence, no impact on tourism) in the rest of the year.

Initially, three islands were investigated: Corsica, Sardinia, and Sicily, given the massive amount of potential data. We focused the analysis in three specific areas, represented in the map below: the south-east area of Corsica (between Porto Vecchio and Boniface), the north-east area of Sardinia (Costa Smeralda) and the south-east area of Sicily (the coastal area of Catania and Siracusa provinces). Arguably, these are among the most important coastal tourism areas of these islands. Overall, 60 hotels (for a total of about 240,000 observations) were monitored in Corsica; 150 hotels (for a total of about 620,000 observations) were monitored in Sardinia; 129 hotels were monitored in Sicily (for a total of about 726,000 observations) over the period May 1, 2009 – October 31, 2009 (see **Figure 11.25**).

Figure 11.25. Map of the region.

Source: SOCLIMPACT Deliverable Report - D5.3. Data Mining from Big Data Analysis.

Nowadays, 28.49% (column 1 of the table below) of "summer" days (days in the period between May 1 and October 31) have a Humidex higher than 35 °C in the area under investigation (coastal area of Catania and Siracusa).

In the future, this share (column 3) will increase to about 37-38 % in RCP2.6, to 40.60 % in RCP8.5 (near), and to 65.04 % in RCP8.5 (distant). Consequently, demand for holidays in Sicily will increase, and the new equilibrium shows an increase in the average price posted by hotels in the destination (column 4) and an increase in overnight stays (column 5, this is estimated using the past correlation between average prices and occupancy rates in hotels, data provided by STR). The joint impact of price and demand will lead to an increase in hotels revenues (last column of the table) and, assuming that the change in revenues spreads to the other tourism products in a similar way, an increase in tourism revenues for the whole destination will be recorded. Hence, the estimation reported in the last column of the table below can be interpreted as the percentage increase in tourism revenues for the island (see **Table 11.5**).

According to these findings, the average increase in temperature, which is correlated to a growing thermal stress for tourists, brings an economic advantage to tourism destinations. This is only an apparent contradiction with previous findings. This study does not neglect the fact that if islands are too hot, tourists will choose to move to other (cooler) destinations, that theoretically exist. In this study, the underlying assumption is instead that growing temperatures are

Table 11.5. Estimation of increase in average price and revenues for Sicily.

Actual share of days in which Humidex > 35 degrees	Future scenario considered	Days in the corresponding scenario in which Humidex > 35 degrees	Increase in the average price	Increase in the tourism overnight stays	Increase in tourism revenues
28.49%	RCP 2.6 near	37.53%	0.4%	0.1%	0.5%
	RCP 2.6 far	38.41%	0.5%	0.1%	0.6%
	RCP 8.5 near	40.60%	0.6%	0.1%	0.7%
	RCP 8.5 far	65.04%	1.7%	0.3%	2.1%

Source: SOCLIMPACT Deliverable Report - D5.3. Data Mining from Big Data Analysis.

a global issue, thereby not modifying the relative position of a destination. Then, the increase in tourism (and tourism revenues) stem from the fact that, when the temperature is too hot, people would prefer to move to coastal areas (where the climatic conditions are more bearable) than staying inland or in cities. Future trends will also facilitate this pressure of tourism demand (think about the spreading of smart working activities where, in principle, the worker can relocate wherever he/she wants).

11.5.2. Aquaculture

The effects of increased sea surface temperatures on aquaculture production were calculated using a lethal temperature threshold by species, and considering the production share of the region. Four different future scenarios shown by IPCC estimations (RCP2.6 and RCP8.5 near and distant) were analysed, which correspond to four water temperature increases in the region (mean values), with respect to the reference period.

To do this, we assume two main species cultured in this region: Seabream (SB) and Tuna (T), and a model of production function, calculating the monthly biomass production which depends on the monthly water temperature. Results are presented on a yearly basis (mean values). In order to facilitate the interpretation of the results, we present the value of production of the last year available, for which we calculate the new values under the different climate change scenarios.

As expected, the production levels (tons) will decrease for both, low and high emissions scenarios. In both cases, the average annual temperatures are projected in levels below 23 °C and 24 °C, which are the thresholds of thermal stress for Bluefin tuna and Seabream species (see **Figure 11.26**).

Reference period	Mid century	End century
4,794.90 *	4,699.00 ▼ (-2%)	4,699.00 ▼ (-2%)
19.00	19.80	19.80

PRODUCTION SHARE	%
SEABREAM	30
SEABASS	26
MED. MUSSEL	44

Reference period	Mid century	End century
4,794.90 *	4,574.33 ▼(-4.6%)	4,161.97 ▼(-13.2%)
19.00	20.40	21.60

Figure 11.26. Estimations of changes in aquaculture production (tons), due to increased sea surface temperature.

Source: SOCLIMPACT Deliverable Report - D5.6. Integration and coordination of non-market and big data analysis of economic values resulting from climate change impacts to GEM-E3-ISL and GINFORS models.

11.5.3. Energy

Climate change may impose welfare reductions to the European islands' societies by affecting thermal comfort. Cooling Degree Days (CDD) are a measure of how much (in degrees), and for how long (in days), outdoor air temperature is higher than 21 °C. The CDD is used as a measure of the energy needed to cool buildings. The increase in CDD and the energy demand (GWh/year) for cooling are estimated for the islands under different scenarios of global climate change.

Under the high emissions scenario, it is expected that the CDD increase to 5112 CDD[1]. Under this situation, the increase in cooling energy demand is expected to be 235 % (see **Figure 11.27**).

[1] The indicator is computed by multiplying the number of days exceeding the threshold by the difference in temperatures. For example, the CDD for 100 days at 20 °C is computed as 100* (20-18) = 200 CDD.

The Standardized Precipitation Evapotranspiration Index (SPEI) is analysed as a representative indicator for increases in water demand for islands' residents, tourists and agriculture, while it also provides an indication on the available water stored in dams or underground resources. To estimate the increase of energy demand due to the increase in water demand, it was assumed that most of the islands will have to produce desalinated seawater (or groundwater) to meet further increases of demand. Thus, the estimation of the increase in energy demand (GWh/year**)** to produce more drinking water has been done based on the energy consumption required to desalinate seawater.

Under the low emissions scenario (RCP2.6), there are not significant changes in the SPEI indicator, that will remain in its ¨normal¨ level, as it is nowadays. Nevertheless, an increase of 24 % in desalination energy demand is expected. Under RCP8.5, the scenario alerts on a severe aridity leading to an increase of 138 % of the energy demand (see **Figure 11.28**).

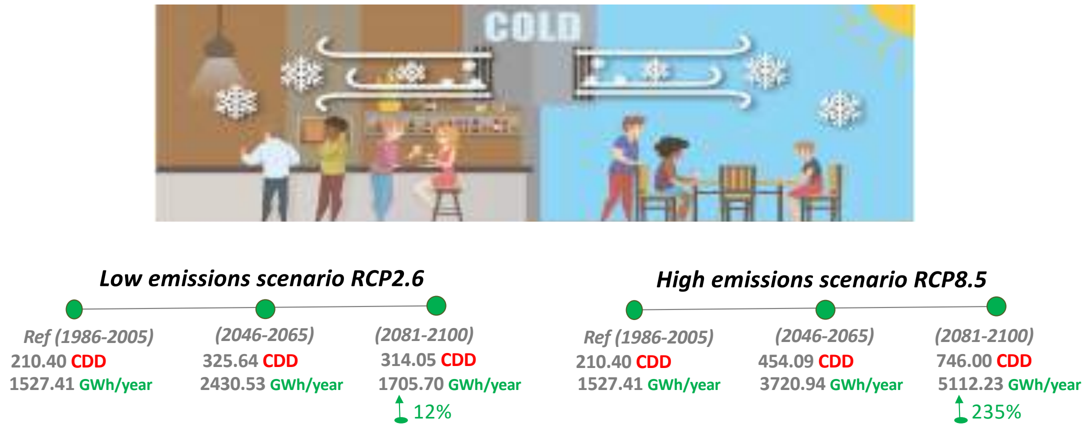


Figure 11.27. Estimations of increased energy demand for cooling in Sicily under different scenarios of climate change until 2100.

Source: SOCLIMPACT Deliverable Report - D5.6. Integration and coordination of non-market and big data analysis of economic values resulting from climate change impacts to GEM-E3-ISL and GINFORS models.

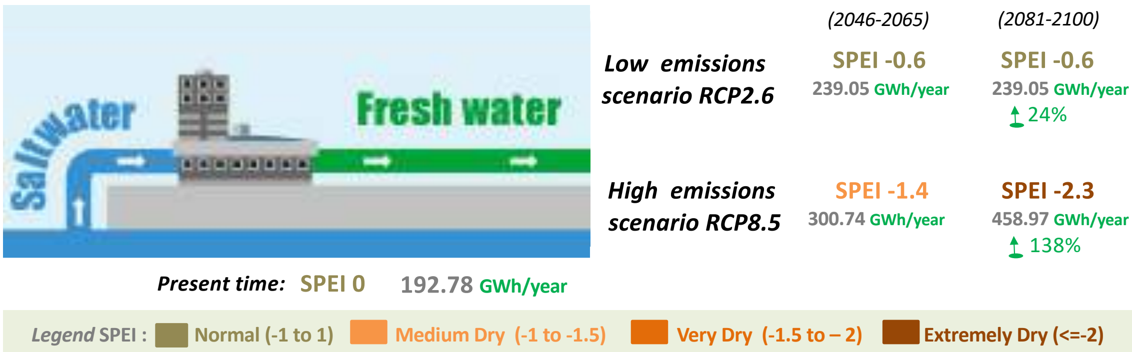


Figure 11.28. Estimations of increased energy demand for desalination in Sicily under different scenarios of climate change until 2100.

Source: SOCLIMPACT Deliverable Report - D5.6. Integration and coordination of non-market and big data analysis of economic values resulting from climate change impacts to GEM-E3-ISL and GINFORS models.

11.5.4. Maritime Transport

For maritime transport, it has been estimated the impact of Sea Level Rise on ports' operability costs of the island. The costs have been calculated with reference to 1 meter; this is, the investment needed to increase the infrastructures' height by 1 meter. There is not necessarily a strict correspondence between the SLR and the required elevation of port infrastructures, which also depends on the coastal hydrodynamic and the shape of dikes of each port. By experts' recommendation, we have assumed that 1 meter increase in port height is required to cope with the SLR under RCP8.5

scenario of emissions. Extrapolation for other RCP scenarios is then conducted based on proportionality.

The starting point was the identification of the principal ports in each island (economic relevance). Second, the analysis of the different port areas (exterior, ramps, oil, etc.), and their uses. Third, the elevation costs were estimated per each area and port separately (considering 1 meter elevation). Thus, the costs of 1 meter elevation presented are the sum of all areas and ports analysed, and including the rest of the ports of the island (if applicable) based on proportionality. Estimations consider that all ports areas of the entire zone should be elevated at the same time. In other words, the economic values can be interpreted as the depreciation (amortization) costs of the investment needed to increase all ports' infrastructures' in the island for 125 years time horizon. No discount rate has been applied.

As expected, the rising of sea levels will affect the sector, as new investment will be needed to keep ports' operability. Under the high emissions scenario, it is expected that these costs could increase 3.6 million of euros per year until the end of the century (see **Figure 11.29**).

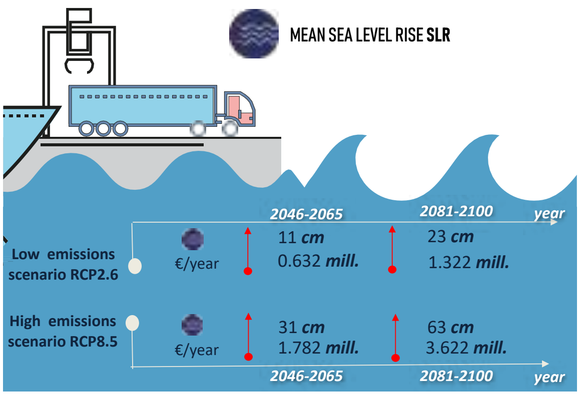


Figure 11.29. Increased costs for maintaining ports' operability in Sicily under different scenarios of SLR caused by climate change until 2100.

Source: SOCLIMPACT Deliverable Report D5.6. Integration and coordination of non-market and big data analysis of economic values resulting from climate change impacts to GEM-E3-ISL and GINFORS models.

11.6. Impacts on the Island's Economic System

In order to assess the socio-economic impacts of biophysical changes for the island of Sicily, we have used the GEM-E3-ISL model, a single-region, multi-sectoral general equilibrium model based on the principles of neo-classical theory, and GINFORS, a macro-econometric model based on the principles of post-Keynesian theory.

Both models include 14 sectors of economic activity, with an emphasis on services and specifically on those composing the tourism industry. The GEM-E3-ISL model also includes endogenous representation of labor and capital markets as well as bilateral trade flows by sector.

Changes in the mean temperature, sea level and precipitation rates are expected to affect energy consumption, tourism flows and infrastructure developments. These impact-chains have been examined and quantified under two emission pathways: RCP2.6, which is compatible with a temperature increase well below 2 °C by the end of the century, and RCP8.5, which is a high-emission scenario. The impact on these three factors was used as input in the economic models, which then assess the effects on GDP, consumption, investments, employment, etc.

In total, 18 scenarios have been quantified for Sicily. The scenarios can be classified in the following categories:

1. Tourism scenarios: these scenarios examine the reduction in tourism revenues due to changes in human comfort as captured by the hum-index, the degradation of marine environment, the increased risk of forest fires and beach reduction. The aggregate tourism scenario (TOURSC6) assesses the economic impacts of a simultaneous change of all (the above-mentioned) factors.
2. Energy scenarios: the aggregate energy scenario (ENERSC3) assessed the impacts on regional economic performance of increased total electricity demand driven by cooling and water desalination demand.
3. Infrastructure scenario: this scenario assesses the impact of port infrastructure damages (INFRA-MAR).

Table 11.6. Aggregate scenario –inputs.

	Tourism revenues (% change from reference levels)	Electricity consumption (% change from reference levels)	Infrastructure damages (% of GDP)
RCP2.6 (2045-2060)	-7.24	10.50	-0.04
RCP2.6 (2080-2100)	-10.06	3.10	-0.04
RCP8.5 (2045-2060)	-13.76	25.30	-0.10
RCP8.5 (2080-2100)	-38.44	43.50	-0.12

Source: SOCLIMPACT Deliverable Report - D5.6. Integration and coordination of non-market and big data analysis of economic values resulting from climate change impacts to GEM-E3-ISL and GINFORS models.

4. Aggregate scenarios: these scenarios examine the total impact of the previous-described changes in the economy.

In the aggregate scenario, we examine the impacts of a simultaneous change in electricity consumption, tourism revenues and infrastructure damages. The scenario specifications for the two climatic variants are presented below (see **Table 11.6**).

The theoretical and structural differences of the two models mean that this study produces is a reasonable range of impacts, given the uncertainty embodied in economic analysis and especially in the long-term.

In GEM-E3-ISL, the economy is in equilibrium at each point in time. Prices adjust to ensure that supply equals demand (market clearing) and capital is fully used; however, the model allows for equilibrium unemployment as it takes into account labor market rigidities. The impacts are driven mainly by the supply side through changes in production costs which influence relative prices; hence, competitiveness and trigger substitution effects. The GEM-E3-ISL model assesses the impacts on the economy up to 2100.

The macro-econometric type of models, such as GINFORS, do not require that all markets are in equilibrium; idle capital and involuntary unemployment are some other features of this type of models where the results are driven mainly by adjustments in the demand side of the economy. The GINFORS assesses the impacts on the economy up to 2050.

With respect to GDP, the estimated change compared to the reference case is between -0.5% and 0.05% in the RCP2.6 in 2050 and between -1.1% and -1.6% in the RCP8.5. The cumulative reduction over the period 2040-2100 is estimated (by GEM-E3-ISL) to be equal to 0.54% in the RCP2.6 and 2.6% in the RCP8.5. In GINFORS, increased investments are the driver of GDP increases in the RCP2.6, while in the GEM-E3-IS model increased investments in electricity crowds-out other productive investments and drive capital prices higher resulting in competitiveness losses; hence, these two effects cancel out the positive impact of increased investments (see **Figure 11.30**).

With respect to sectoral impacts, both models show a significant decrease in the activity of tourism related sectors and an increase in the activity of the non-service sectors, highlighting the opportunities for the development of other secondary sectors' activities (see **Figure 11.31**).

Overall, employment falls in the economy and especially in tourism related sectors. In GEM-E3-ISL, increases in employment in non-tourism related activities are associated with labor costs reductions (as wages fall and their competitiveness increases) and a consequent substitution of capital with labor. Employment falls on average by 0.1% in the RCP2.6 in the RCP8.5 (see **Figure 11.32**).

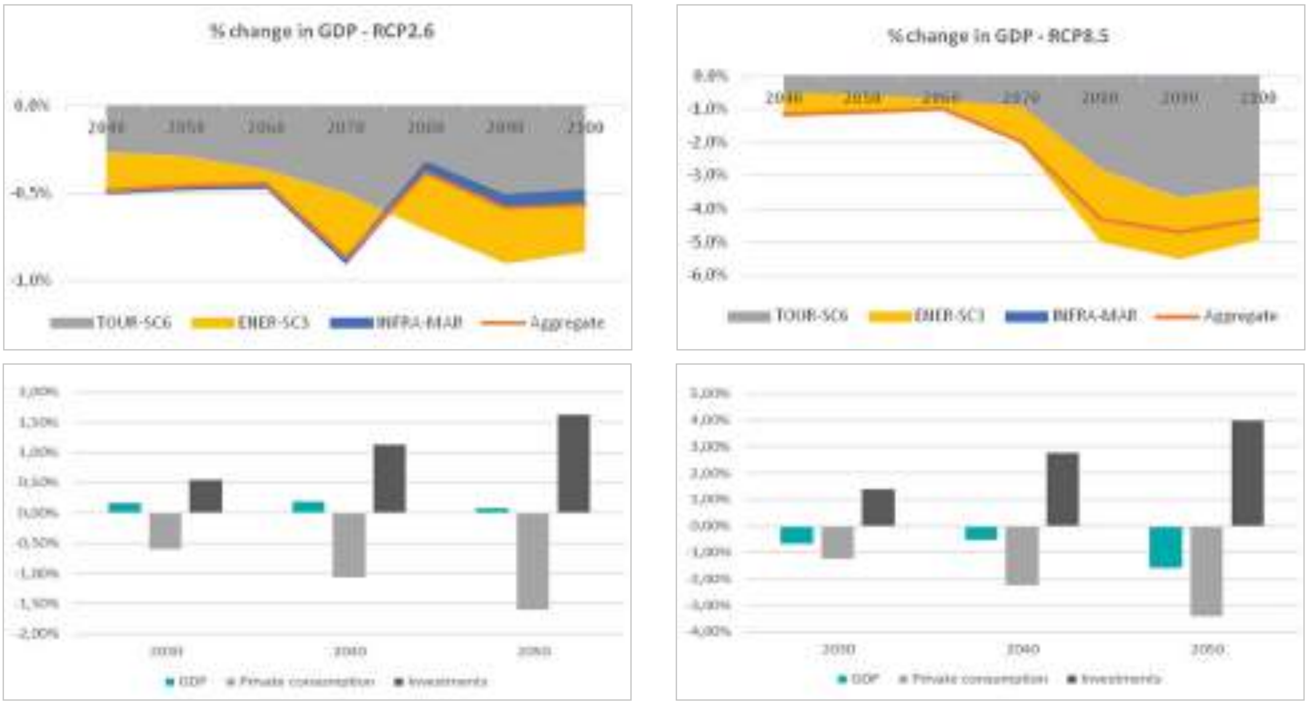


Figure 11.30. Percentage change in GDP. GEM-E3-ISL results (above), GINFORS (below).
Source: own calculation.

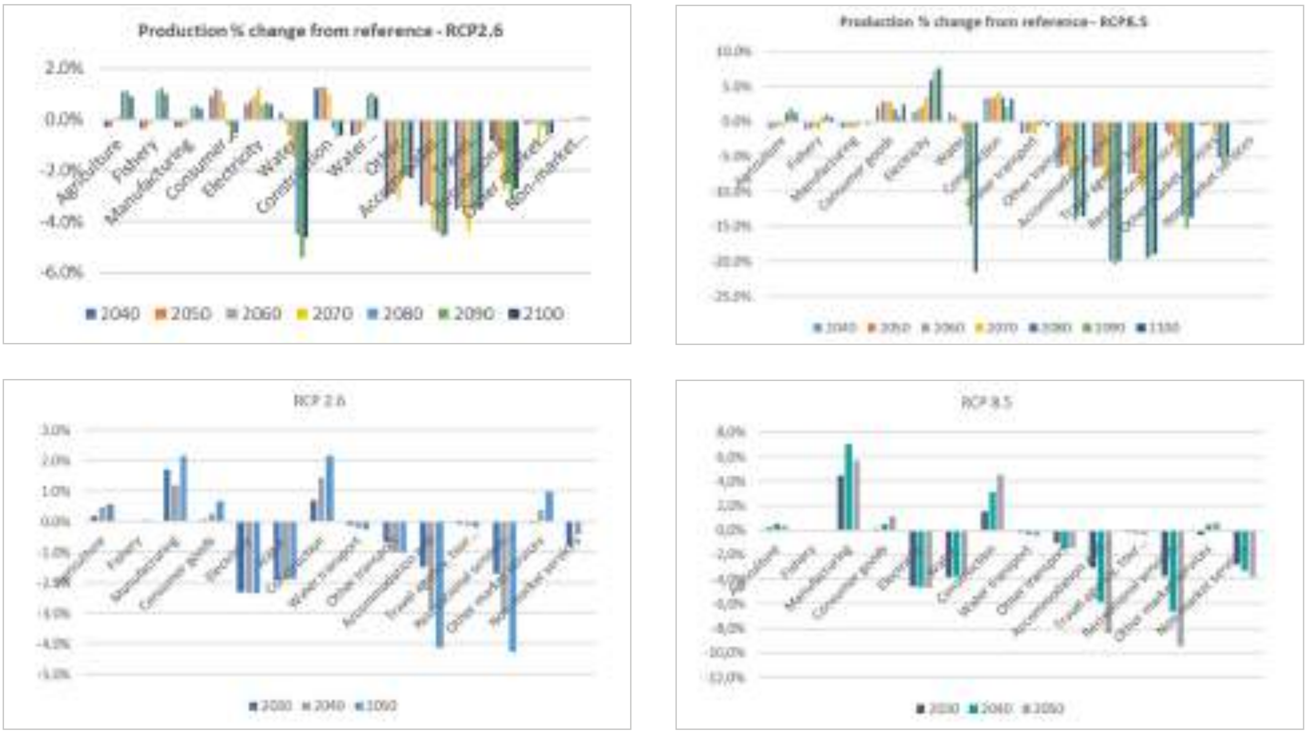


Figure 11.31. Production percentage change from reference. GEM-E3-ISL results (above), GINFORS (below).
Source: own calculation.

Figure 11.32. *Employment percentage change from reference.* GEM-E3-ISL results (above), GINFORS (below).
Source: own calculation.

11.7. Towards Climate Resiliency

Over the last few years, the country has been dedicated to support and provide a robust analytical basis for the National Integrated Energy and Climate Plan (2018):

- A BASE scenario that describes an evolution of the energy system with current policies and measures;
- A PNEC scenario that quantifies the strategic objectives of the plan. The PNEC tables illustrate the main objectives of the 2030 plan on renewables, energy efficiency and greenhouse gas emissions as well as the main measures envisaged to achieve the objectives of the plan.

The National Strategy for Adaptation to Climate Change (SNAC) was approved and adopted in 2015. The latest has been the National Plan of Adaptation to Climate Change (PNACC) (July 2017), which identifies and discusses the main objectives to be pursued, as well as the necessary steps, for each one of the socio-economic and environmental sectors of interest, based on the climatic and impact analyses to face the effects of the expected climate changes. From the sector analysis, over 350 actions emerged that were collected in a single database that contains detailed analytical information for each individual action and different selection keys for the actions to allow easy search and consultation.

Lately, in 2020, Sicily was selected among some mediterranean islands, together with Crete and Cyprus, to simulate the impacts of climate change on crop production and the effectiveness of selected adaptation options in decreasing vulnerability to climate change of three Mediterranean islands. This project, Adaptation to Climate Change Impacts on the Mediterranean Islands' Agriculture –ADAPT2CLIMA– (2020), aims to facilitate the development of adaptation strategies for agriculture by deploying and demonstrating an innovative decision support tool. The islands were selected for two reasons. Firstly, they figure among the most important cultivation areas at national level. Secondly, they exhibit similarities in terms of location (climate), size, climate change threats faced (coastal agriculture, own water resources), agricultural practices, and policy relevance.

There are 13 cross-cutting actions that are common to all the sectors analyzed and which have a national value, together with more specific actions for each sector. The actions identified for each sector are associated with the impacts detected in the previous analyzes, the adaptation targets to be pursued and the homogeneous climatic areas of implementation, suggested on the basis of the RCP4.5 climate scenario identified as the reference scenario.

Nevertheless, different limitations and barriers, respectively experienced by individuals, organizations and local governments have been identified. Research on climate change impacts has so far been limited to general conclusions at the national level, without focusing on regional and local climate change and its impact. Even less progress has been made in the field of adaptation, as no adaptation plans have been put in place to identify necessary and specific measures for the local context. From the point of view of individuals, a general low personal understanding of climate change and its impacts exists.

Considering organizations (both private and public), we can highlight different barriers:

- Inadequate funds for adaptation, especially the financial ones.
- Uncertainty around the scale of the climate changes and the concrete risks.
- Lack of locally relevant and practical information about potential climate impacts.
- Limited financial resources both for medium sized organizations and local governments.
- Culture of the organization.

Specifically for local governments, planning seems to be a difficult task.

Furthermore, there is a lack of reliable statistics and information related to exposure and vulnerability of the island to climate change. These are important components that worsen climate risks and respond to human interventions (more pressure). The island's adaptation focus should be, first, the development of reliable information systems for the periodic monitoring of these components.

11.7.1. Policy Recommendations

A stakeholders consultation process was carried out in the island, aiming to propose, analyse and rank alternative adaptation measures for the island. The profile of the individuals participating in these focal groups involved policy and decision-makers, practitioners, non-governmental and civil society organisations, science experts, private sector, business operators and sector regulators at island level.

The main aim of these meetings was:

1. Identify and present the characterized packages of adaptation and risk management options for the island.
2. Develop detailed integrated adaptation pathways, in three timeframes: Short term (up to 2030), Mid-century (up to 2050) and End-century (up to 2100).
3. Evaluate and rank adaptation options for 4 blue economy sectors in the island (energy, maritime transport, aquaculture and tourism).
4. To this aim, stakeholders utilized five evaluation criteria to rank the proposed measures:

- Cost efficiency: Ability to efficiently address current or future climate hazards/risks in the most economical way.
- Environmental protection: Ability to protect the environment, now and in the future.
- Mitigation win-wins and trade-offs: Current ability to meet (win-win) or not (trade-off) the island / archipelagos mitigation objectives.
- Technical applicability: Current ability to technically implement the measure in the island.

- Social acceptability: Current social acceptability of the measure in the island.

Four scenarios of intervention were analysed, called Adaptation Policy Trajectories (APT), which are different visions of future policy adaptation choices:

- APT A Minimum Intervention - Low investment, low commitment to policy change.
- APT B Economic Capacity Expansion - High investment, low commitment to policy change.
- APT C Efficiency Enhancement - Medium investment, medium commitment to policy change
- APT D System Restructuring - High investment, high commitment to policy change.

It was assumed that adapting to climate change may range from minimal to high cost, and from requiring a small or incremental change to a significant transformation from the *status quo*. However, not all APT scenarios were considered in all islands, especially when their stakeholders had a clear vision on the types of measures with greatest viability. Therefore, the final set of proposed adaptation measures are framed in the islands' socio-economic and political context, have a sectoral perspective, and respond to the islands' future scenarios of climate change. At the same time, the involvement of regional stakeholders in policy design allows them to engage in the effective implementation of climate actions on their island.

In Appendices from K to N, a brief explanation of each adaptation option can be found, classified by type or class: Vulnerability Reduction, Disaster Risk Reduction, Social Ecological Resilience, and Local Knowledge. The latest group refers to very specific measures proposed by stakeholders in each island to ratify the needs.

11.7.1.1. Tourism

Overall, the adaptation pathways for the tourism sector in Sicily are characterized by a significant heterogeneity across the four potential Adaptation Policy Trajectories (APTs) and across adaptation objectives.

The main measures selected to address vulnerability reduction indicate that the region is initially centred on the development of sustainable approach in short, medium, and long term. Indeed, especially in APT C, the goal is address a circular economy system and sustainable economic activities. But the priority is for the natural, social, physical and human capital rather than the financial one. This last one is considered residual in this class and mainly for the short and long term in APT B and D. The selection of the financial incentives to retreat in the end of the century is related with the perception that the risks will continue or increase over time. The diversification of the activities and products are the desired option for all timeframes and APTs.

For Disaster Risk Reduction, and to manage long term risk, the decisions need to be sensible to the level of investment and reflect the climate change risk identified for the region. Pre-disaster early recovery planning is a priority for the region in the opposite scenarios, that is APT A and D, for the medium and long term. In general, for this class, the options are selected for the medium or long term and with a preference for the planning tools. This result highlights a great attention towards a better management with a long-term planning. In the other case, a different combination of investment and commitment is considered in respect of the first two options.

In Social-Ecological Resilience, the most selected option that is adaptive management of natural habitats, included in the cultural services. This measure is in APT C for all the times, then is considered a priority, now and in the future, but only with low investments and a medium level of commitment in this direction. All the measures of this class are mainly selected for the medium and long term and with a certain combination of investment and commitment, then often for APT B and C. The actions concerning the rivers represent a priority in respect of those ones on the sea, and there is a special attention to the planning and monitoring activities. This indicates that the need to prevent negative effects is considered urgent (see **Table 11.7**).

Table 11.7. Proposed adaptation options for tourism in Sicily.

APT A – Pathway	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
Minimum Intervention low investment, low commitment to policy change — This policy trajectory assumes a no-regrets strategy where the lowest cost adaptation policies are pursued to protect citizens from some climate impacts	Public awareness programmes	Activity and product diversification	
	Coastal protection structures	Drought and water conservation plans	
	Fire management plans	Health care delivery systems	
	Post-disaster recovery funds	Pre-disaster early recovery planning	
	Adaptation of groundwater management		Monitoring, modelling and forecasting systems

Table 11.7 (Cont.). Proposed adaptation options for tourism in Sicily.

APT B – Pathway	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
Economic Capacity Expansion high investment, low commitment to policy change	Economic Policy Instruments (EPIs)	Financial incentives to retreat from high-risk areas	
This policy trajectory focuses primarily on encouraging climate-proof economic growth but does not seek to make significant changes to the current structure of the economy	Public awareness programmes	Activity and product diversification	
	Beach nourishment		Desalination
	Coastal protection structures	Drought and water conservation plans	
	Adaptation of groundwater management	Monitoring, modelling and forecasting systems	
	Dune restoration and rehabilitation	River rehabilitation and restoration	

APT C – Pathway	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
Efficiency Enhancement medium investment, medium commitment to policy change	Activity and product diversification		Public awareness programmes
This policy direction is based on an ambitious strategy that promotes adaptation consistent with the most efficient management and exploitation of the current system	Local circular economy		Tourist awareness campaigns
	Local sustainable fishing		
	Coastal protection structures		Drought and water conservation plans
	Mainstreaming Disaster Risk Management		Using water to cope with heat waves
	Adaptation of groundwater management	Monitoring, modelling and forecasting systems	
	Dune restoration and rehabilitation	River rehabilitation and restoration	
	Adaptive management of natural habitats		Ocean pools

APT D – Pathway	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
System Restructuring high investment, high commitment to policy change	Economic Policy Instruments (EPIs)	Financial incentives to retreat from high-risk areas	Economic Policy Instruments (EPIs)
This policy direction embraces a pre-emptive fundamental change at every level in order to completely transform the current social-ecological and economic systems	Activity and product diversification		Public awareness programmes
	Local sustainable fishing		Water restrictions, consumption cuts and grey-water recycling
	Coastal protection structures	Drought and water conservation plans	
	Post-disaster recovery funds	Pre-disaster early recovery planning	
	Adaptation of groundwater management	Monitoring, modelling and forecasting systems	

Vulnerability Reduction | *Disaster Risk Reduction* | *Socio-Ecological Resilience* | *Local Knowledge (provided by local stakeholders)*

Source: SOCLIMPACT Deliverable Report – D7.3. Workshop Reports.

11.7.1.2. Maritime transport

The Sicilian maritime transport sector adaptation pathways are characterized by a significant heterogeneity across the four potential Adaptation Policy Trajectories (APTs). In general, a certain combination of investment and commitment, then a certain level of concrete involvement emerge for this sector.

As in the tourism sector, the most selected option for maritime transport is in the class of the Social-Ecological Resilience and it is considered the best for all the timeframes and with a combination of medium investment and commitment (APT B and C). For this class, there is a certain availability in investment for the medium and long term, mainly concerning the coastal protection, which represent a priority also in respect of alternative and sustainable propulsions for ships. These ones are selected as long-term option in APT B and C. Ocean pools are not considered a measure to implement in Sicily. The orientation is toward the improvement of the infrastructures with medium long-term strategies and investments.

In the context of Risk Reduction class of adaptation, the selection of the different measures is different both in terms of timeframes and in terms of combination among investments and commitment. The most selected measures concern the creation of an Intelligent transport system but in APT A, then with low investment and low commitment. The other options are the post disaster recovery (APT A low investment and commitment) to react to the impacts and the prevention systems to avoid negative effects (APT C – low investments and medium commitment). The two risk mitigation options are considered equally desirable. Preparing for service delays or cancellations, instead, is not considered as a priority and could be a strategy only in the short time under APT C and D.

For the Vulnerability Reduction, among the financial instruments available, the insurance mechanisms fit well in the mid and long term, while the financial incentives are considered useful in the short term, in APT B and D (see **Table 11.8**).

Table 11.8. Proposed adaptation options for maritime transport in Sicily.

<table>
<tr><td rowspan="6">APT A – Pathway
—
Minimum Intervention
low investment, low commitment to policy change
—
This policy trajectory assumes a no-regrets strategy where the lowest cost adaptation policies are pursued to protect citizens from some climate impacts</td><th>Short-term (up to 2030)</th><th>Mid-century (up to 2050)</th><th>End-of-century (up to 2100)</th></tr>
<tr><td colspan="2">Awareness campaigns for behavioural change</td><td>Social dialogue for training in the port sector</td></tr>
<tr><td colspan="2">Climate proof ports and port activities</td><td>Consider expansion/retreat of ports in urban planning</td></tr>
<tr><td colspan="2">Intelligent Transport Systems (ITS)</td><td>Prepare for delays or cancellations</td></tr>
<tr><td colspan="2">Backup routes and infrastructures during extreme weather</td><td>Post-disaster recovery funds</td></tr>
<tr><td>Marine life friendly coastal protection structures</td><td colspan="2">Combined protection and wave energy infrastructures</td></tr>
<tr><td rowspan="7">APT B – Pathway
—
Economic Capacity Expansion
high investment, low commitment to policy change
—
This policy trajectory focuses primarily on encouraging climate-proof economic growth but does not seek to make significant changes to the current structure of the economy</td><th>Short-term (up to 2030)</th><th>Mid-century (up to 2050)</th><th>End-of-century (up to 2100)</th></tr>
<tr><td colspan="2">Financial incentives to retreat from high-risk areas</td><td>Insurance mechanisms for ports</td></tr>
<tr><td>Awareness campaigns for behavioural change</td><td colspan="2">Social dialogue for training in the port sector</td></tr>
<tr><td>Sturdiness improvement of vessels</td><td colspan="2">Increase operational speed and flexibility in ports</td></tr>
<tr><td colspan="2">Consider expansion/retreat of ports in urban planning</td><td>Climate proof ports and port activities</td></tr>
<tr><td>Marine life friendly coastal protection structures</td><td colspan="2">Combined protection and wave energy infrastructures</td></tr>
<tr><td>Coastal protection structures</td><td colspan="2">Hybrid and full electric ship propulsion</td></tr>
<tr><td rowspan="9">APT C – Pathway
—
Efficiency Enhancement
medium investment, medium commitment to policy change
—
This policy direction is based on an ambitious strategy that promotes adaptation consistent with the most efficient management and exploitation of the current system</td><th>Short-term (up to 2030)</th><th>Mid-century (up to 2050)</th><th>End-of-century (up to 2100)</th></tr>
<tr><td>Awareness campaigns for behavioural change</td><td colspan="2">Social dialogue for training in the port sector</td></tr>
<tr><td>Climate resilient economy and jobs</td><td colspan="2">Diversification of trade using climate resilient commodities</td></tr>
<tr><td>Restrict development and settlement in low-lying areas</td><td colspan="2">Refrigeration, cooling and ventilation systems</td></tr>
<tr><td>Climate proof ports and port activities</td><td colspan="2">Consider expansion/retreat of ports in urban planning</td></tr>
<tr><td>Reinforcement of inspection, repair and maintenance of infrastructures</td><td colspan="2">Early Warning Systems (EWS) and climate change monitoring</td></tr>
<tr><td colspan="2">Marine life friendly coastal protection structures</td><td>Combined protection and wave energy infrastructures</td></tr>
<tr><td colspan="2">Coastal protection structures</td><td>Hybrid and full electric ship propulsion</td></tr>
<tr><td colspan="3">Integrate ports in urban tissue</td></tr>
<tr><td rowspan="7">APT D – Pathway
—
System Restructuring
high investment, high commitment to policy change
—
This policy direction embraces a pre-emptive fundamental change at every level in order to completely transform the current social-ecological and economic systems</td><th>Short-term (up to 2030)</th><th>Mid-century (up to 2050)</th><th>End-of-century (up to 2100)</th></tr>
<tr><td>Financial incentives to retreat from high-risk areas</td><td colspan="2">Insurance mechanisms for ports</td></tr>
<tr><td>Awareness campaigns for behavioural change</td><td colspan="2">Social dialogue for training in the port sector</td></tr>
<tr><td>Restrict development and settlement in low-lying areas</td><td colspan="2">Refrigeration, cooling and ventilation systems</td></tr>
<tr><td>Consider expansion/retreat of ports in urban planning</td><td colspan="2">Climate proof ports and port activities</td></tr>
<tr><td>Post-disaster recovery funds</td><td>Backup routes and infrastructures during extreme weather</td><td>Post-disaster recovery funds</td></tr>
<tr><td>Marine life friendly coastal protection structures</td><td colspan="2">Combined protection and wave energy infrastructures</td></tr>
</table>

Vulnerability Reduction *Disaster Risk Reduction* *Socio-Ecological Resilience* *Local Knowledge (provided by local stakeholders)*

Source: SOCLIMPACT Deliverable Report – D7.3. Workshop Reports.

11.7.1.3. Energy

In general, the energy sector in Sicily is characterized by heterogeneity concerning the selection of adaptation options in all Adaptation Policy Trajectories (APTs). APT C is the prevailing combination of investment and commitment, highlighting as there is a wide awareness about the need to do something concretely improving the medium and long-term scenarios.

Across all ATPs, for vulnerability reduction, pathways mainly rely on energy storage and green jobs. Both options are considered at least for the mid and long-term. In contrast, public information on climate action (also human capital; APT B and C) is not a priority, since it is assumed that there is and will be a sufficient level of public information in the island for it to pursue climate action. In the same way, the collection of forest fuel loads is part of pathways D for the short term, but it relies as the last option. Moreover, the financial capital is considered necessary, almost with equal intensity, and with a certain combination of investment and commitment, in APT B and D.

For Disaster Risk Reduction, the grid reliability is the most selected option in APT C for the mid and long term. On the opposite, the early warning system is not a priority, chosen only in APT C as a short-term measure. The options within the classes risk mitigation, disaster response and Post-disaster recovery have the same distribution of preference. Particularly, the options with the higher percentage (56%) are valid for the short and the long term, instead the remaining ones are chosen for the medium timeframe. Moreover, reviewed building codes and generators are present in all the APTs for all the timeframes.

Regarding Social-Ecological Resilience, heated pools with waste heat from power plants is considered a priority in all the timeframes of APT C. Except for underground tubes and piping in urban planning, chosen for all the APTs, the other measures are characterized by a certain degree of investment and commitment (APT B and C). The options in the regulating and maintenance services class are considered equally relevant and with the same degree of priority. The educational gardens are not a priority, then it seems that there is enough awareness and knowledge about climate implication in the energy sector (see **Table 11.9**).

Table 11.9. Proposed adaptation options for the energy sector in Sicily.

<table>
<tr><td rowspan="7">APT A – Pathway
—
Minimum Intervention
low investment, low commitment to policy change
—
This policy trajectory assumes a no-regrets strategy where the lowest cost adaptation policies are pursued to protect citizens from some climate impacts</td><td>Short-term (up to 2030)</td><td>Mid-century (up to 2050)</td><td>End-of-century (up to 2100)</td></tr>
<tr><td colspan="3">Green jobs and businesses</td></tr>
<tr><td>Review building codes of the energy infrastructure</td><td>Upgrade evaporative cooling systems</td><td>Review building codes of the energy infrastructure</td></tr>
<tr><td>Study and develop energy grid connections</td><td>Energy-independent facilities (generators)</td><td>Study and develop energy grid connections</td></tr>
<tr><td colspan="3">Energy recovery microgrids</td></tr>
<tr><td colspan="2">Underground tubes and piping in urban planning</td><td>Energy efficiency in urban water management</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="7">APT B – Pathway
—
Economic Capacity Expansion
high investment, low commitment to policy change
—
This policy trajectory focuses primarily on encouraging climate-proof economic growth but does not seek to make significant changes to the current structure of the economy</td><td>Short-term (up to 2030)</td><td>Mid-century (up to 2050)</td><td>End-of-century (up to 2100)</td></tr>
<tr><td>Financial support for smart control of energy in houses and buildings</td><td colspan="2">Financial support for buildings with low energy needs</td></tr>
<tr><td>Public information service on climate action</td><td colspan="2">Green jobs and businesses</td></tr>
<tr><td>Demand Side Management (DSM) of Energy</td><td>Seawater Air Conditioning (SWAC)</td><td>Demand Side Management (DSM) of Energy</td></tr>
<tr><td>Review building codes of the energy infrastructure</td><td>Upgrade evaporative cooling systems</td><td>Review building codes of the energy infrastructure</td></tr>
<tr><td>Energy efficiency in urban water management</td><td colspan="2">Underground tubes and piping in urban planning</td></tr>
<tr><td>Biomass power from household waste</td><td colspan="2">Urban green corridors</td></tr>
<tr><td rowspan="9">APT C – Pathway
—
Efficiency Enhancement
medium investment, medium commitment to policy change
—
This policy direction is based on an ambitious strategy that promotes adaptation consistent with the most efficient management and exploitation of the current system</td><td>Short-term (up to 2030)</td><td>Mid-century (up to 2050)</td><td>End-of-century (up to 2100)</td></tr>
<tr><td>Public information service on climate action</td><td colspan="2">Green jobs and businesses</td></tr>
<tr><td colspan="3">Small scale production and consumption (prosumers)</td></tr>
<tr><td colspan="3">Energy storage systems</td></tr>
<tr><td>Review building codes of the energy infrastructure</td><td>Upgrade evaporative cooling systems</td><td>Review building codes of the energy infrastructure</td></tr>
<tr><td>Early Warning Systems (EWS)</td><td colspan="2">Grid reliability</td></tr>
<tr><td>Energy efficiency in urban water management</td><td colspan="2">Underground tubes and piping in urban planning</td></tr>
<tr><td>Biomass power from household waste</td><td colspan="2">Urban green corridors</td></tr>
<tr><td colspan="3">Heated pools with waste heat from power plant</td></tr>
</table>

Table 11.9 (Cont.). Proposed adaptation options for the energy sector in Sicily.

	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
APT D – Pathway — **System Restructuring** high investment, high commitment to policy change — This policy direction embraces a pre-emptive fundamental change at every level in order to completely transform the current social-ecological and economic systems	Financial support for smart control of energy in houses and buildings	Financial support for buildings with low energy needs	Financial support for smart control of energy in houses and buildings.
	Green jobs and businesses		
	Collection and storage of forest fuel loads	Energy storage systems	
	Review building codes of the energy infrastructure	Upgrade evaporative cooling systems	
	Local recovery energy outage capacity		Energy recovery microgrids
	Energy efficiency in urban water management		Underground tubes and piping in urban planning

Vulnerability Reduction · *Disaster Risk Reduction* · *Socio-Ecological Resilience* · *Local Knowledge (provided by local stakeholders)*

Source: SOCLIMPACT Deliverable Report – D7.3. Workshop Reports.

11.7.1.4. Aquaculture

In general, the aquaculture sector in Sicily is characterized by a heterogeneous selection of adaptation options in all Adaptation Policy Trajectories (APTs). APT A prevails in Disaster Risk Reduction class of adaptation and APT B and C are the prevalent choice in Social Ecological Resilience measures, while the Vulnerability Reduction is characterized by a certain combination of APT B, C and D. This shows the degree of commitment and investment associated to each class.

The most selected measures concern vulnerability reduction, that is recirculation aquaculture systems and integrated multi-trophic aquaculture. These options are selected for all the timeframes respectively in APT B for the first one and APT C and D for the other one. Since they are perceived as urgent, there is a certain degree of investment and commitment towards them. The measures concerning human and social capital are selected for all the ATPs and different timeframes and show the same share of preference within each class.

For Disaster Risk Reduction, the monitoring and the implementation of a warning plan are considered a priority option, showing that the prevention measures and tools are fundamental. All the measures included in this category of class of adaptation have a certain level of relevance for local experts, so they are in all the APTs and in all the timeframes.

Regarding Social-Ecological Resilience, the measures with the higher score are considered for all the timeframes within the single ATP in which they are selected. Promote aquaculture and better management practices consider a different combination of investment and commitment (ATP B and C), but they are considered valid in the short, medium, and long term. The feed production is the option universally selected for all the ATPs and timeframes. In this field, the need for measure addressing different aspect emerges (see **Table 11.10**).

Table 11.10. Proposed adaptation options for aquaculture in Sicily.

	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
APT A – Pathway — **Minimum Intervention** low investment, low commitment to policy change — This policy trajectory assumes a no-regrets strategy where the lowest cost adaptation policies are pursued to protect citizens from some climate impacts	Awareness campaigns for behavioural change	Efficient feed management	
	Climate proof aquaculture activities		Risk-based zoning and site selection
	Mainstreaming Disaster Risk Management	Contingency for emergency management, early harvest and/or relocation	
	Recovery Post-disaster plans		
	Species selection	Feed production	

Table 11.10 (Cont.). Proposed adaptation options for aquaculture in Sicily.

Pathway	Short-term (up to 2030)	Mid-century (up to 2050)	End-of-century (up to 2100)
APT B – Pathway — **Economic Capacity Expansion** high investment, low commitment to policy change — This policy trajectory focuses primarily on encouraging climate-proof economic growth but does not seek to make significant changes to the current structure of the economy	Tax benefits and subsidies		Financial schemes, insurance and loans
	Awareness campaigns for behavioural change		Efficient feed management
	Recirculation Aquaculture Systems (RAS)	Submersible cages	Recirculation Aquaculture Systems (RAS)
	Climate proof aquaculture activities	Risk-based zoning and site selection	
	Species selection	Feed production	
	Selective breeding	Best Management Practices	
APT C – Pathway — **Efficiency Enhancement** medium investment, medium commitment to policy change — This policy direction is based on an ambitious strategy that promotes adaptation consistent with the most efficient management and exploitation of the current system	**Short-term (up to 2030)**	**Mid-century (up to 2050)**	**End-of-century (up to 2100)**
	Awareness campaigns for behavioural change	Efficient feed management	
	Addressing consumer and environmental concerns at the local level	Promote cooperation to local consumption	
	Integrated multi-trophic aquaculture		
	Climate proof aquaculture activities	Risk-based zoning and site selection	
	Environmental monitoring Early Warning Systems (EWS)	Disease prevention methods	Environmental monitoring Early Warning Systems (EWS)
	Species selection	Feed production	
	Selective breeding	Best Management Practices	
	Create educational visits	Promote aquaculture cuisine	
APT D – Pathway — **System Restructuring** high investment, high commitment to policy change — This policy direction embraces a pre-emptive fundamental change at every level in order to completely transform the current social-ecological and economic systems	**Short-term (up to 2030)**	**Mid-century (up to 2050)**	**End-of-century (up to 2100)**
	Tax benefits and subsidies	Financial schemes, insurance and loans	
	Awareness campaigns for behavioural change	Efficient feed management	
	Integrated multi-trophic aquaculture		Short-cycle aquaculture
	Climate proof aquaculture activities	Risk-based zoning and site selection	
	Recovery Post-disaster plans		Recovery post-disaster funds
	Feed production	Species selection	Feed production

Vulnerability Reduction · *Disaster Risk Reduction* · *Socio-Ecological Resilience* · *Local Knowledge (provided by local stakeholders)*

Source: SOCLIMPACT Deliverable Report – D7.3. Workshop Reports.