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AquaBioTech Group

SOCLIMPACT

SoClimPact project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 77661

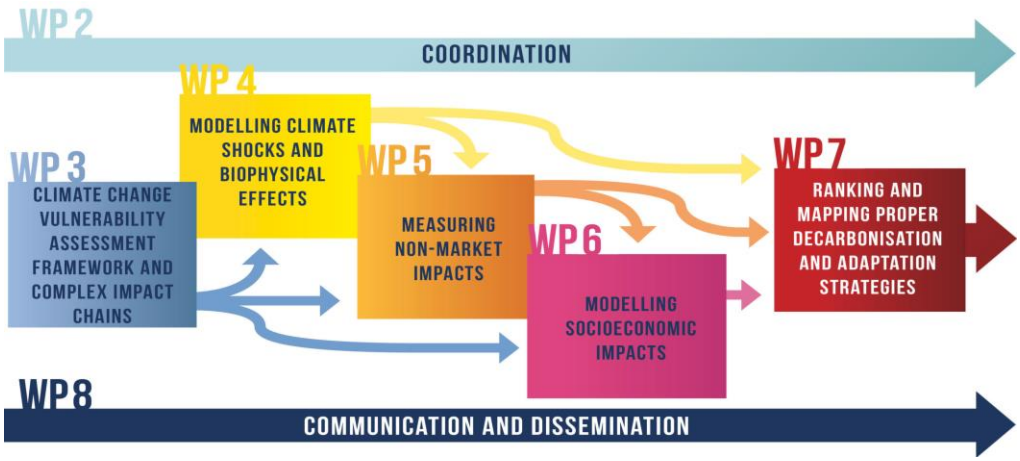
Climate Change Projections for Malta

The SOCLIMPACT Project

Downscaling climate impacts and decarbonisation pathways in EU islands, and enhancing socioeconomic and non-market evaluation of climate change for Europe, for 2050 and beyond.

CONSORTIUM: A multidisciplinary consortium of 24 partners
COORDINATOR: Universidad of Las Palmas de Gran Canaria
PROGRAMME: H2020-SC5-06-2017
DURATION: December 2017-March 2021
TOTAL COST: € 4,481,340.00
EU CONTRIBUTION: € 4,481,340.00

The project aims at modelling and assessing downscaled Climate Change impacts and low carbon transition pathways in European islands and archipelagos for 2030-2100, complementing current available projections for Europe, and nourishing actual economic models with non-market assessment. The project developed a thorough understanding on how Climate Change will impact the EU islands located in different regions.



Project Objectives

- Contributing to the improvement of the economic valuation of climate impacts and related policies for the EU´s Blue Economy sectors, by adopting revealed and stated preference methods.
- Increasing the effectiveness of the economic modelling of climate impact chains, through the implementation of an integrated methodological framework (GINFORS, GEM-E3 and non-market indicators), in the analysis of climate-induced socioeconomic impacts in 12 EU islands case studies, under different climate scenarios.
- Facilitating climate-related policy decision making for Blue Growth, by ranking and mapping the more appropriate mitigation and adaptation strategies.
- Delivering downscaled and accurate information to policy makers, practitioners and other relevant stakeholders, about the environmental and socio-economic consequences of global Climate Change in the EU Blue Economy.

SOCLIMPACT in Malta

Malta is one of the islands of the SOCLIMPACT project and was represented by the project partner AquaBioTech Group, which is an independent aquaculture, fisheries, biotechnology and environmental testing/ research, engineering, consulting, development, and training company with its own dedicated research and marine survey facilities in Malta. Within the SOCLIMPACT Project, AquaBioTech Group was involved in a variety of tasks:

- Act as the Island Focal Point for the Maltese islands and carry out a case study, which includes setting up a local work group, data mining, and field work to gather data to measure non-market costs of Climate Change
- Co-chair for the sector modelling group for Aquaculture, one of the Blue Growth sectors identified by the European Commission
- Lead the task to identify packages of adaptation, mitigation and risk management options for the island
- Assist other Island Focal Points regarding the aquaculture activities (impact chains, identification of indicators) for their islands

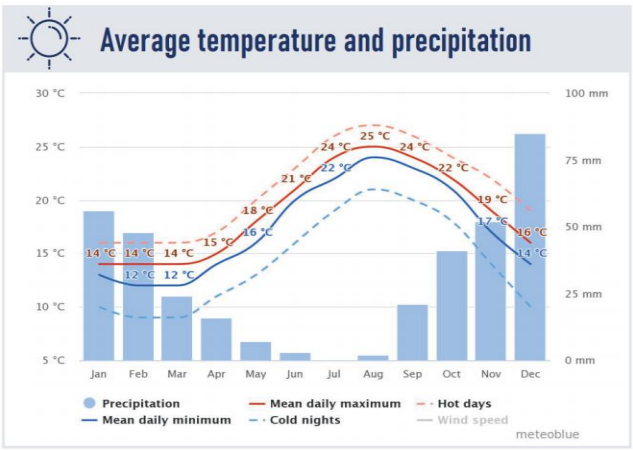
SoClimPact project has received funding from the European Union´s Horizon 2020 Research and Innovation Programme under Grant Agreement No 776611

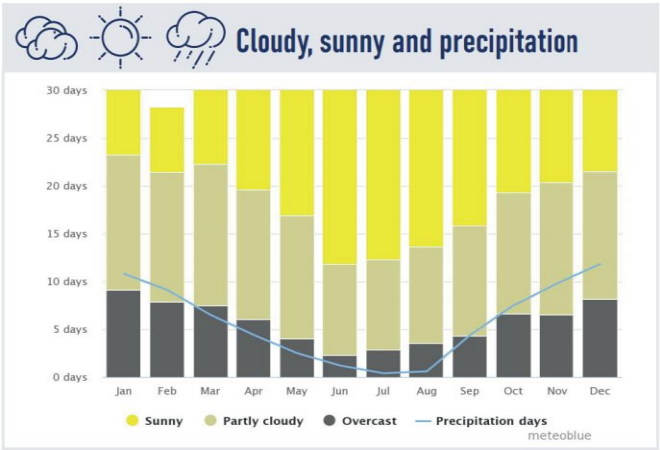
Current Climate Situation in Malta

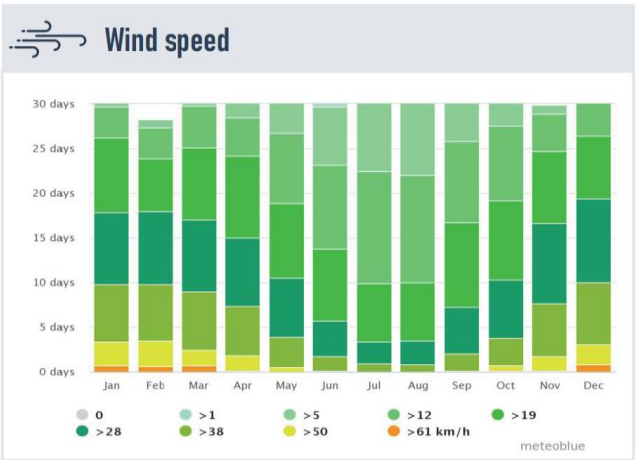
Malta has a typical Mediterranean dimate with mild rainy winter and dry hot summers. The mean temperature for the summer months is 35°C while the lowest average monthly temperature is 11°C in winter. The presence of the surrounding water mass shapes the dimate of the Maltese islands significantly. The general weather is often cooler and more humid (75% average) compared to larger inland areas.

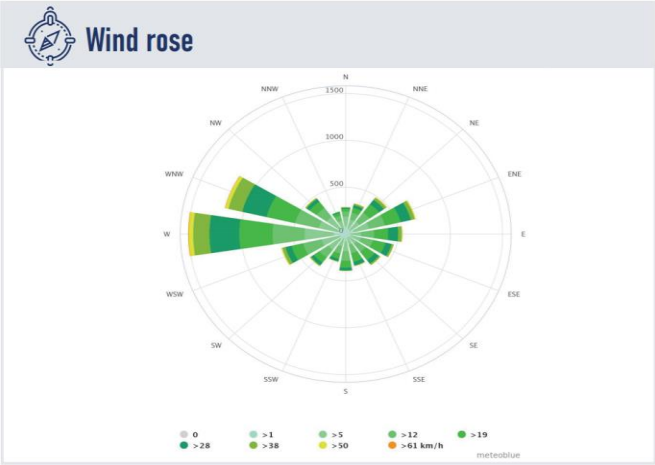
The high thermal capacity of the sea provides a more stable ambient temperature on the islands. However, when colder air comes from the north at the end of summer, combined with the warmer waters, this creates weather instability, heavy thunderstorms and intense rainfall. One of the highest in Europe, Malta has an average of 3,000 hours of sun per year. The average sea water temperature is 20°C. Summer is mostly dry, while rain falls mostly in winter in the form of heavy showers.

Current dimate-related risks in Malta are mostly associated with coastal flooding, extreme weather events and increasing air temperatures, especially heatwaves. Significant dimate events in the past years were storms in October 2018 and February 2019, resulting in coastal flooding and damage to infrastructure.









RCP Climate Scenarios

A Representative Concentration Pathway (RCP) represent different emissions, concentration and radiative projections forcing of global warming levels. The pathways show different possible dimate futures, depending on the volume of greenhouse gases emitted in the coming years. The RCP values refer to radiative forcing in Watt/m^2. The relevant radiative forcing levels for the Paris Agreement are 2.6 W/m2 leading to warming of well below 2 °C by the end of the century.

For the climate projections for **Malta** in the SOCLIMPACT project, **a low emission scenario (RCP2.6)** and a **high emission scenario (RCP8.5)** were selected.

RCP (Forcing in W/m^2)	Temperature (°C)	Emission Trend
1.9	-1.5	Very Strongly Declining Emissions
2.6	-2.0	Strongly Dedining Emissions
4.5	-2.4	Slowly Declining Emissions
6.0	-2.8	Stabilising Emissions
8.5	-4.3	Rising Emissions

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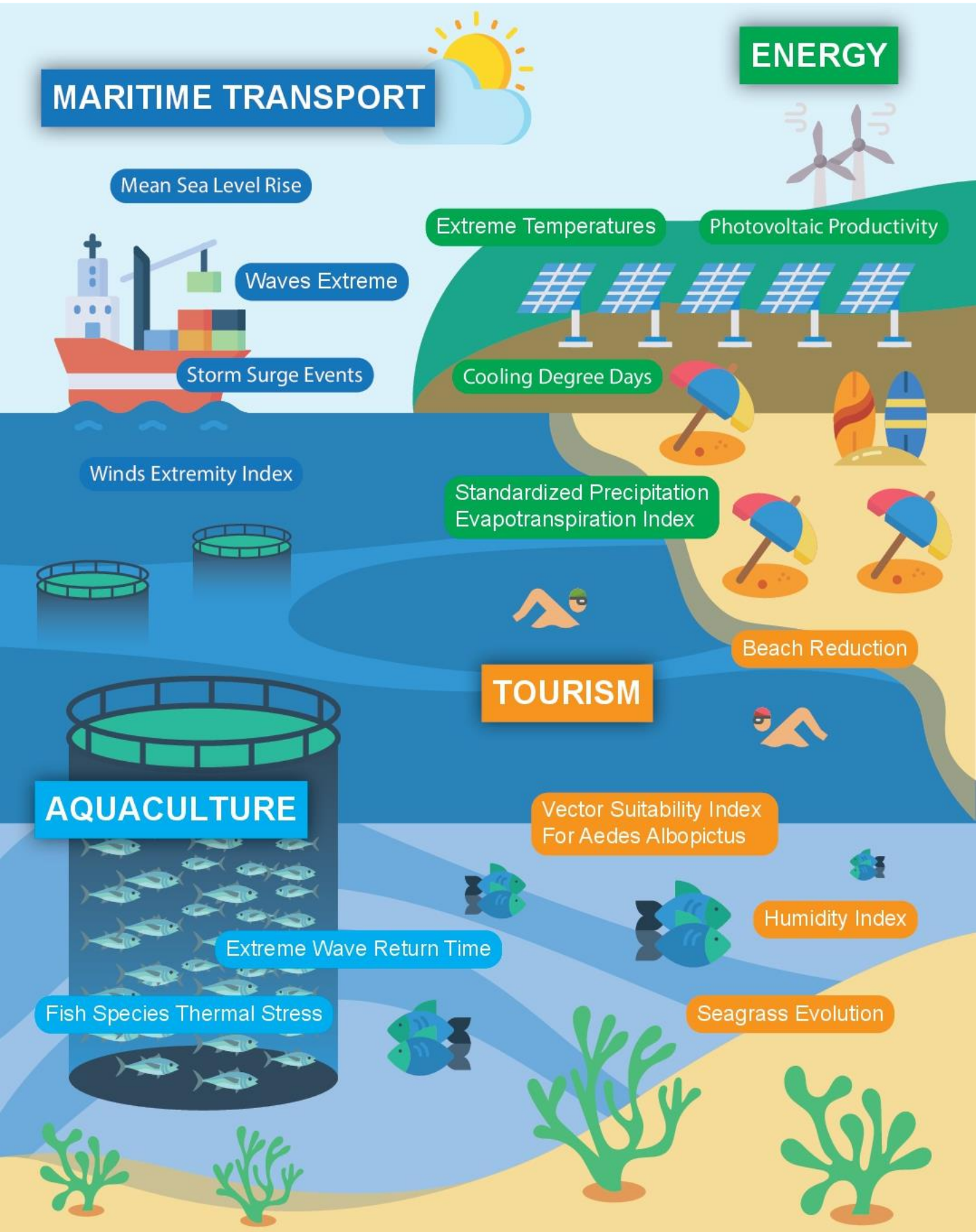
Climate Projections for Malta's Blue Economy Sector Indicators



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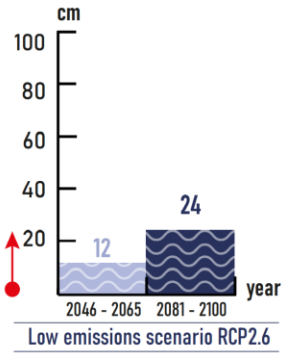
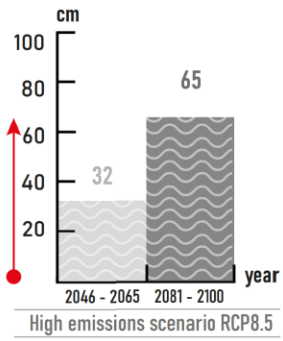
MARITIME TRANSPORT

MEAN SEA LEVEL RISE
(in cm) with respect to the present (1986-2005)

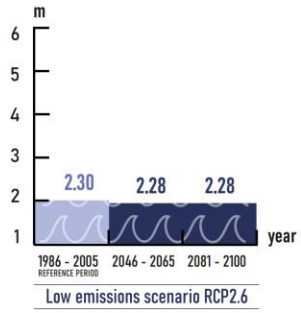
Sea level rise can trigger floods at ports, cause damage to port's infrastructure and equipment and increase the number of operational steps in maritime transport operations. This hazard also leads to users' risk perception leading to lower rates of moorings and turnover and increased costs of maintenance in nautical installations and equipment. For Malta the mean sea level rise ranges from 24 cm (RCP2.6) to 65 cm (RCP8.5) at the end of the century.

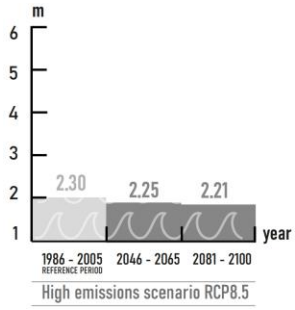




WAVES EXTREME
99th percentile of significant wave height averaged

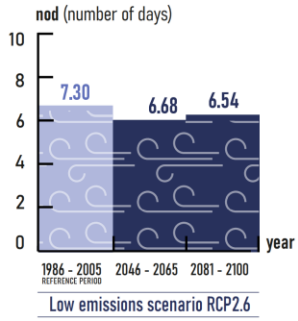
High waves and storms can have a negative impact on maritime transport, among other activities. To illustrate this impact, the 99th percentile of significant wave height averaged has been chosen. A slight decrease in the extreme wave height is found in Malta, being minimally larger under scenario RCP8.5.

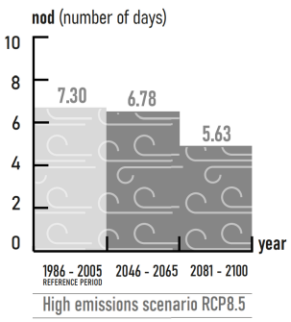




WINDS EXTREMITY INDEX

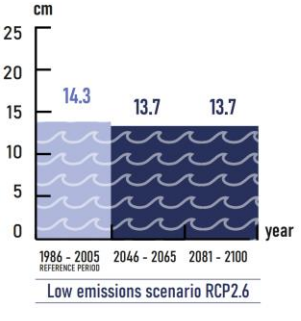
The wind extremity index NWIX98 is defined as the number of days per year exceeding the 98th percentile of mean daily wind speed. Increased frequency and intensity of winds lead to increased costs for new investment and insurance, less turnover from maritime transport activities and disruption costs. For Malta, the index decreases with a stronger value under RCP8.5 (-23 %).

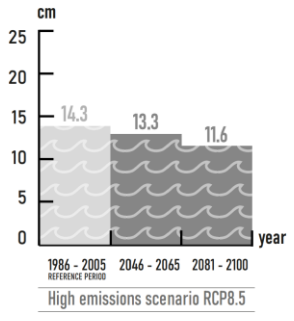




STORM SURGE EVENTS
99th percentile of atmospherically forced sea level in cm for the reference Period and relative change (in %) for mid and end of century

Storm surge events are characterised 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. A decrease is estimated in Malta, being larger under scenario RCP8.5, in agreement with the projections of extreme wave heights. Nevertheless, it is worth noting that the Mean Sea Level Rise is expected to be critically larger in this same period and scenario.





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AQUACULTURE

FISH SPECIES THERMAL STRESS

Number of days exceeding the sea surface temperature threshold adopted (in the period)

Temperature changes in seawater trigger physical impacts; 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, these impacts lead to socio-economic implications among them; changes in production levels and an increase in fouling and pests. In order to assess the impact of thermal stress on the aquaculture sector in Malta, changes of sea surface temperature and thresholds of farmed species according to the farming and feeding necessities were examined. The fish species thermal stress indicator was finally defined as the number of days exceeding the sea surface temperature threshold for different aquaculture species. In Maltese waters under RCP8.5, the threshold temperature of seabream is exceeded during 2.5 month per year in mid-century and 3 month at the end of the century. The threshold for tuna and sea bream is expected to be exceeded during 3 month in mid-century and 4 month at the end of the century which can have severe impact on the aquaculture production of the island.

	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)	152 days	62 days	43 days
RCP 8.5 - mid century (2046-2065)	175 days	95 days	72 days
RCP 8.5 - end century (2081-2100)	201 days	123 days	98 days

Species	Thershold (°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

EXTREME WAVE RETURN TIME

Extreme weather events can cause direct damage to marine aquaculture facilities and structures and lead to the loss of stock which can overall result in increased fragility of aquaculture activity. In order to analyse the occurrence and impact of extreme weather events, return times for a threshold of 7 m significant wave height were computed. This significant height has been identified by stakeholders as the critical limit for severe damages to assets at sea. For Malta, at the end of this century, under RCP8.5, the extreme wave return time will decrease or not show any significant change depending on the type of model.

Adaption Measures for the Aquaculture Sector

In order to minimise the risk of changes in production and increased fragility of the marine aquaculture activities in Malta, the sector needs to adapt to dimate change impacts. A variety of adaption options in the dasses 'disaster risk reduction', 'addressing drivers of vulnerability' and 'socio-ecological resilience' were scored and ranked within the scope of the SOCLIMPACT project and the measures with the highest ranking are presented.

Addressing Drivers of Vulnerability
- Efficient feed management
- Financial schemes, insurances and loans
- Integrated multi-trophic aquaculture (IMTA)
- Submersible cages

Social-Ecological Resilience
- Best management practices
- Species selection
- Educational visits

Disaster Risk Reduction
- Environmental monitoring and Early Warning Systems (EWS)
- Mainstreaming Disaster Risk Management (DRM)
- Risk-based zoning and site selection

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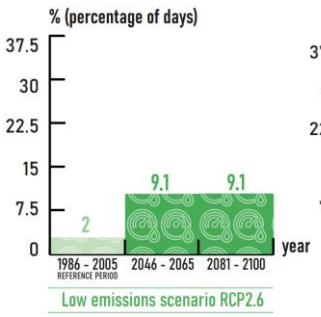
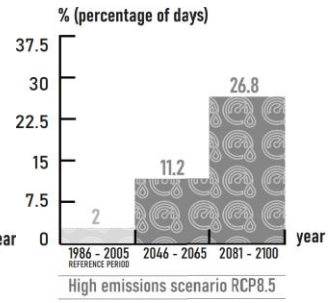
ENERGY

EXTREME TEMPERATURES
(Percentage of days per year when T > 98th percentile - T98p)

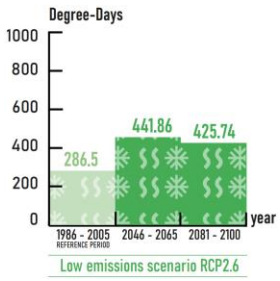
Extreme temperatures are displayed as the percentage of time where the daily temperature is above 98th percentile of mean daily temperature calculated for the reference period. In Malta under RCP2.6, the indicator will reach almost 10% by the end of the century, while under RCP8.5 this value will rise up to more than 26% which is equal to 94 days per year.

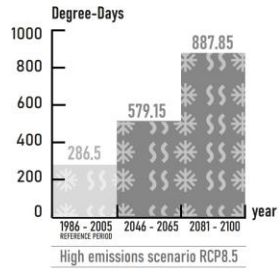




COOLING DEGREE DAYS

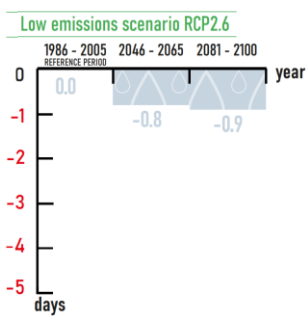
Climate change may impose welfare reductions to the Malta's society by affecting thermal comfort. Cooling Degree Days (CDD) are a measure of how much (in degrees), and for how long (in days), outdoor air temperature is higher than 18°C. The analysis of the RCP8.5 provides a devastating picture as the number of CDD are expected be almost four times larger than the reference period.

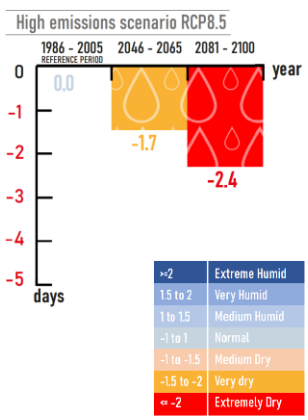




STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX

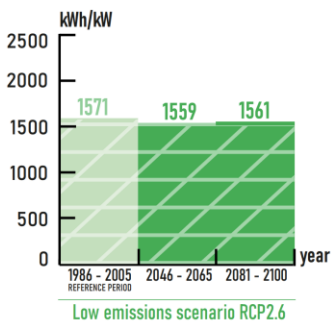
The Standardized Precipitation-Evapotranspiration Index is used as an indicator for water availability. This hazard index can serve as a representative indicator for increases in water demand for Malta's residents, tourists and agriculture, while it also provides an indication on the available water stored. In a drier future, which is the likely case, this will lead to additional increases in desalination and water pumping needs, a scenario which will substantially increase the cost for adaptation.

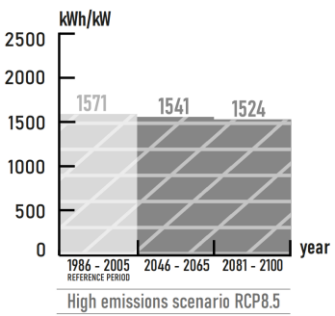




PHOTOVOLTAIC PRODUCTIVITY (LAND)

Among the different renewable energy sources, solar PV has been selected as a relevant indicator for the island, due to its potential to foster technological development and its comparatively low cost. Photovoltaic productivity projected for Malta is expected to remain relatively stable for both scenarios and periods.





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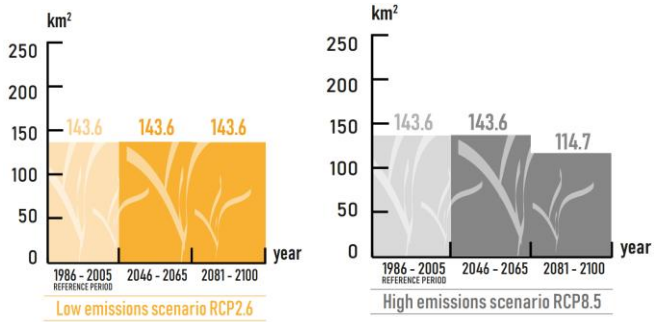
TOURISM

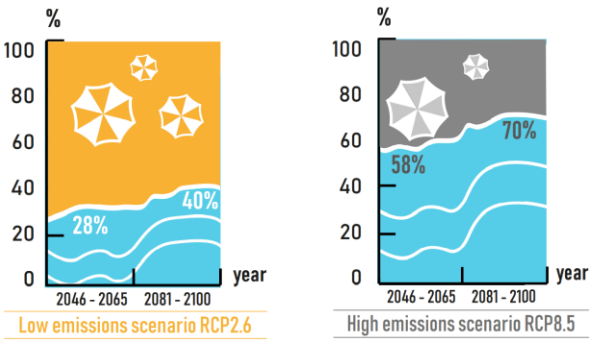
SEAGRASS EVOLUTION (Posidonia)

Posidonia oceanica seagrass is a keystone species in Mediterranean waters, providing important ecosystem services. These include the provision of habitat, water filtration, natural coastal protection and a variety of cultural ecosystem services such as opportunities for recreational activities and tourism. The results suggest that noticeable seagrass losses could be expected in Malta under scenario RCP8.5 by the end of the century. Although the projected reduction may seem moderate, it has to be kept in mind that the losses will be localized in the nearshore areas, which can impact water transparency in beach areas and a loss of ecosystem services e.g., for tourism activities such as SCUBA diving.



BEACH REDUCTION

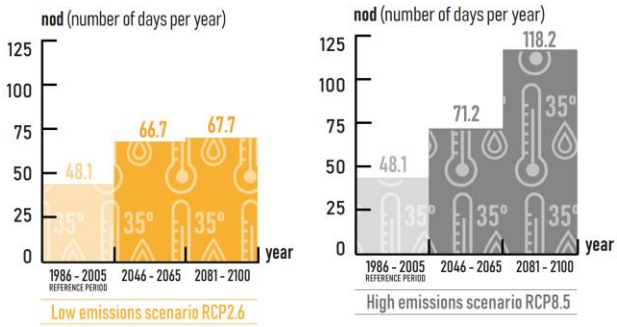
One of the consequences of sea level rise is the flooding of coastal areas. This includes sand beaches, which are an important asset for tourism activities in Malta. Besides sea level rise, wind and waves were taken into account to accurately estimate beach reduction. For Malta, it is estimated that, under mean conditions, the total beach surface loss ranges from ~40% to ~70% at the end of the century.



HUMIDITY INDEX

Number of Days with discomfort level Humidex greater than 35°C

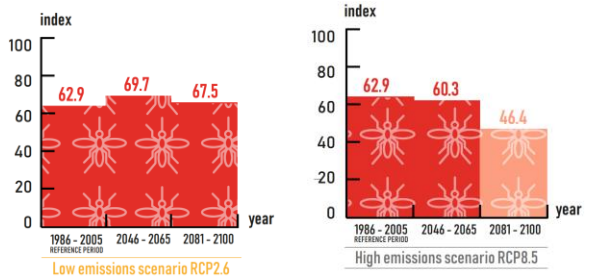
The number of days per year in which the Humidity Index is larger than 35°C was used as an indicator to assess thermal discomfort and imminent danger for humans. The present climate shows these discomfort conditions for 1.5 month per year, while in both scenarios this value increases to more than 2 month per year. By the end of the century under RCP8.5 it is expected to rise to almost 4 month per year.



VECTOR SUITABILITY INDEX FOR AEDES ALBOPICTUS (ASIAN TIGER MOSQUITO)

Climate change can influence the transmission of vector-borne diseases through altering the habitat suitability of insect vectors. This is mainly controlled by increases of ambient air temperature and changes in the hydrological cycle. The Asian tiger mosquito, a vector of viral pathogens and infectious agents, is native to Southeast Asia, however, in the past decades this specis has spread to many countries. For Malta, regional simulations suggest a transition from medium to low habitat suitability under a strong emission scenario (pathway RCP8.5).

80 - 100	High Suitability
60 - 80	Medium Suitability
40 - 60	Low Suitability
< 40	No Suitability



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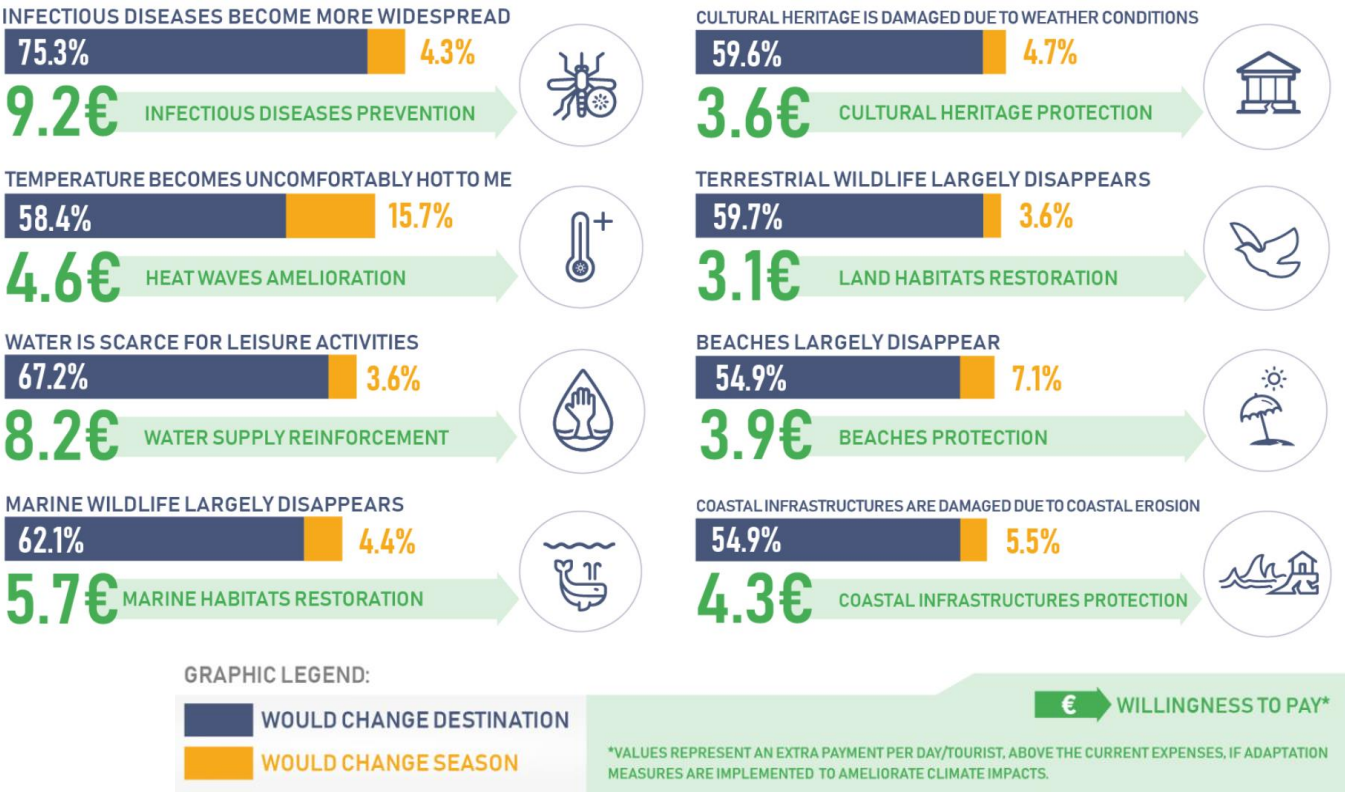
TOURISM

Tourist Behavioural Response to Climate Change Impacts and Related Policies

In order to assess the effects of climate change on tourist's behaviour surveys were conducted with 255 tourists in Malta during summer 2019. To evaluate tourists' preferences and decision-making facing climate change options, Discrete Choice Experiments (DCEs) were used as the surveying technique. These surveys provided an insight into economic values of changes in the marine and coastal ecosystem services due to climate change impacts and related policies.



Firstly, tourists had to indicate whether they would keep their plans to stay at 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 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 water is scarce for leisure activities (67.20%) or where marine wildlife has disappeared to a large extent (62.10%). On the other hand, policies related to the prevention of infectious diseases (9.2€/day), water supply reinforcement (8.2€/day), and marine habitats protection (5.7€/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.

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Socio-economic Projections

In order to assess the socio-economic impacts of biophysical changes for Malta, the GEM-E3-ISL and GINFORS models have been used. The former is multi-sectoral based on the principles of neo-classical theory, while the latter is a macroeconometric model based on the post-Keynesian theory.

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 and RCP8.5 scenarios. The impacts on these three factors have been used as input in the economic models, which then assess the effects on GDP, consumption, investments, employment, etc.
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 has an endogenous representation of labour market and trade flows etc.

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

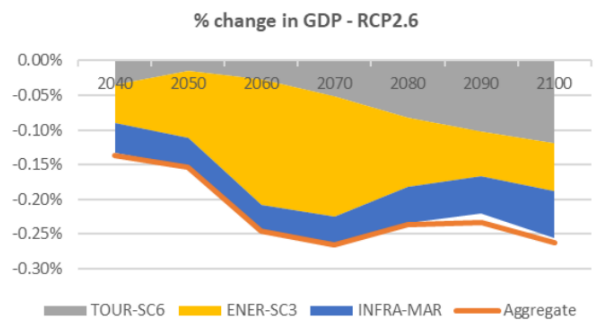
1. Tourism scenarios: these scenarios examine the reduction in tourism revenues due to changes in human comfort as captured by the hum-index, the degradation of marine environment, increased risk of forest fires and beach reduction

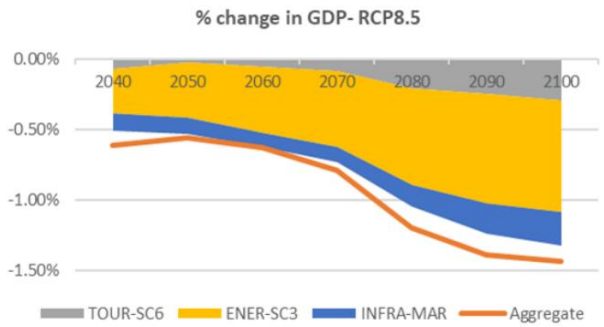
2. Energy scenarios: these scenarios examine the impacts of increased electricity consumption for cooling purposes and for water desalination

3. Infrastructure scenarios: these scenarios examine the impacts of port infrastructure damages

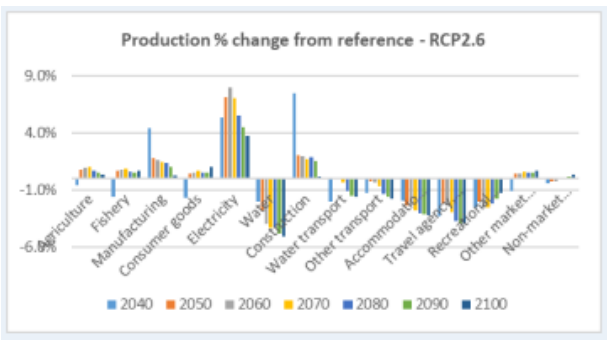
4. Aggregate scenarios: these scenarios examine the total impact of the previous-described changes in the economy

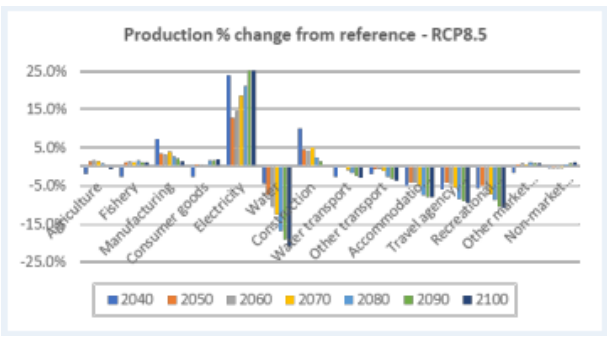
	Tourism revenues (% change from reference levels)	Electricity consumption (% change from reference levels)	Infrastructure damages (% of GDP)
RCP2.6 (2045-2060)	-10.31	6.9	-0.26
RCP2.6 (2080-2100)	-14.19	4.2	-0.29
RCP8.5 (2045-2060)	-20.03	14.0	-0.69
RCP8.5 (2080-2100)	-33.42	25.7	-0.77





With respect to GDP the estimated change compared to the reference case is between -0.15% and -1.8% in the RCP2.6 in 2050 and between - 0.55% and -4.0% in the RCP8.5. The cumulative change over the period 2040-2100 is estimated (by GEM-E3-ISL) to be equal to -0.2% in the RCP2.6 and -0.9% in the RCP8.5





With respect to sectorial impacts both models show a significant decrease in the activity of tourism related sectors and an increase in the activity of the manufacturing sector and to a lesser extent in the activity of the primary sectors of production.

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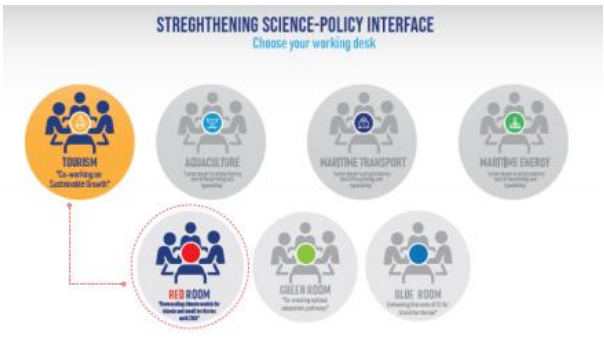
REIS Platform & Adaption Support Tool

The SOCLIMPACT consortium has decided to implement the "Regional Exchange Information System" (REIS platform) as a user-friendly tool for periodic exchange between EU islands, researchers, and regional policymakers. The REIS is an information system to support decision-making while filling research and data gaps for the EU islands between what climate researchers can provide and what decision-makers require. The REIS platform offers a great opportunity for networking to all European islands and their communities. Its aim is to stimulate debates, promote further research and joint projects, and intensively discuss to establish a benchmark for adaptation, encouraging resilient capacities of EU islands as well as the promotion of blue growth.

All the results of the project should be integrated in this platform with easy filter by island and sector:

- Risk assessment has potential to be induded
- Climate modelling and forecasts for all hazards
- Tourist reactions and willingness to pay for adaptation policies
- Climate change effects on aquaculture productivity, ports disruption and energy demand and productivity
- Macroeconomic assessment of CC impacts, interconnecting all the sectoral activities of the islands
- The rank of alternative adaptation pathways that can be implemented within the islands decision-making context, framed by the geographic, economic, and social context of each island, thanks to the regional stakeholders' views and contribution.

This tool supports each island's policy makers to select and form international and multidisciplinary groups for networking activities to the benefit of their islands, propose further development of the SOCLIMPACT research, and extend the results to other key areas and sectors. Furthermore, the platforms' **Networking Area** provides a space for the formation of international and multidisciplinary groups, open forums and proposals of new research projects and worktables with the experts presented in the platform's **Experts Panel**.



The REIS platform as an information system in support decision-making in the island context, and a huge opportunity for consultation of relevant and useful information networking, and stimulates debates, further research, future joint projects, and intensively discuss to establish a benchmark for adaptation for islands and coastal areas worldwide.

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