Tunisia-Italy Power Interconnector Project

Environmental and Social Impact Assessment (ESIA)

Section 12

Climate change report

Draft for Consultations

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1. BASELINE CLIMATE CHANGE IN THE MEDITERRANEAN

1.2 Sources

This chapter uses information, specific data, and graphs from the following sources:

[1] MedECC (2020) *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future*. First Mediterranean Assessment Report [Cramer, W., Guiot, J., Marini, K. (eds.)] Union for the Mediterranean, Plan Bleu, UNEP/MAP, Marseille, France, 632pp

[2] IPCC (2021) *Climate Change 2022: Impacts, Adaptation and Vulnerability – Cross-Chapter Paper 4: Mediterranean Region (final draft)*. WGII Sixth Assessment Report [Ali, E., Cramer, W. (leads)] Intergovernmental Panel on Climate Change.

[3] IPCC (n.d.) *IPCC WGI Interactive Atlas: Regional information (Advanced).* Retrieved July 18, 2022, from (link)

1.3 Context and Methodology

1.3.1 Methodology

The main data used throughout this report are science-based information obtained from the analysis of present and future scenarios, as presented in the latest IPCC report, the most reliable source in this field. These data are supported by further documents and sources describing the climate baseline and impact of climate change on the areas within the project boundaries.

1.3.2 Spatial perimeter

The Mediterranean Region "comprises the semi-enclosed Mediterranean Sea and the countries and regions bordering it, which belong to Europe, Asia and Africa" [2].

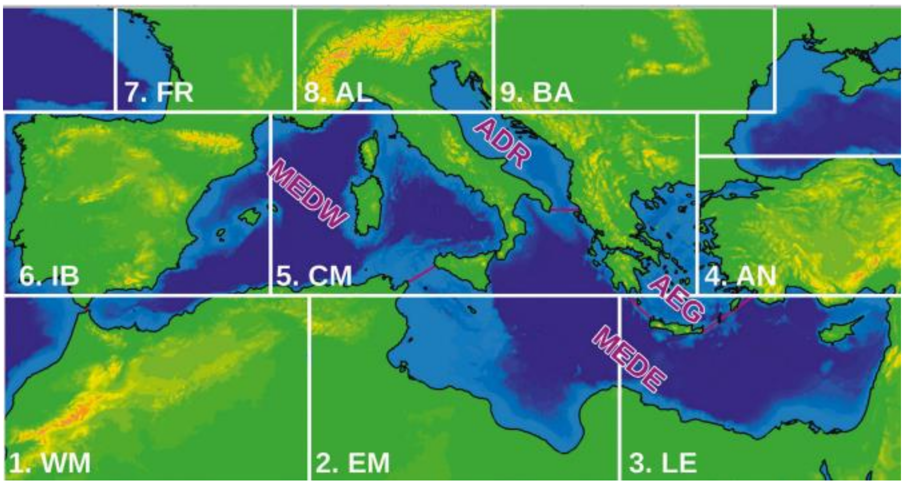

Figure 1.1: Mediterranean coastline, topography over land and bathymetry over the sea – [1]

This project will analyze the Mediterranean area corresponding to the IPCC definition reported above, as it comprehends both the Italian and Tunisian project areas. It will thus be possible to provide a general overview of how climate change impacts the project area in its wider definition. A more detailed analysis at a regional level will be provided in the next chapters.

1.4 Impacts of climate change on the Mediterranean

The Mediterranean Basin is highly vulnerable to climate change, which is already widely impacting the local climate and territory. Since the Mediterranean Region (with the boundaries above depicted) comprises a wide area with different climates, landscapes, and ecosystems, it is important to note that climate change is affecting the region unevenly. Indeed, different agricultural and farming practices, urbanization levels, and coastal development are crucial factors that determined how the impacts manifested in the basin, especially between the northern and southern shores.
The main climate change risks present in the Mediterranean Region are coastal flooding, erosion, water acidification, longer and more intense heat waves, wildfires, water scarcity (mainly in the South and East) and droughts (in the North) [2].
Solar radiation is the principal element determining how climate changes in different areas of the world, clouds and aerosols are instead responsible for the variability in time of the surface solar radiation reaching the Mediterranean. Data on long-term solar radiation at a global level showed highly variable values that followed a dimming/brightening pattern, with a decrease of surface solar radiation between the 1950s and 1980s (dimming) and a consequent slight increase (brightening) in more recent years [1]. The Mediterranean presents this same pattern, and climate model simulations have estimated a decline in radiation between -3.5 and -5.2 W m^2 per decade between 1953 and 1968 (the dimming period) [1]. A rise of +0.9 to +4.6 W m^2 per decade has instead been detected for the period 1989-2004, the brightening period. More specifically, the increase between 1980 and 2012 was of +2.3 W m^2 per decade [1].
This phenomenon of dimming/brightening in the Mediterranean is considered to be mostly caused by increasing and decreasing concentration levels of aerosols such as sulphate, produced by anthropogenic activities. Data show a growth in the concentration of aerosols during the dimming phase, and a drop during the brightening phase [1]. Similar trend patterns occur in the Mediterranean Region’s cloud coverage (mainly in low and mid cloud layers), with a decline of 0.63% of the coverage per decade since 1970s in concurrence with the brightening period, thus suggesting a possible influence of the cloud coverage on surface solar radiation [1].

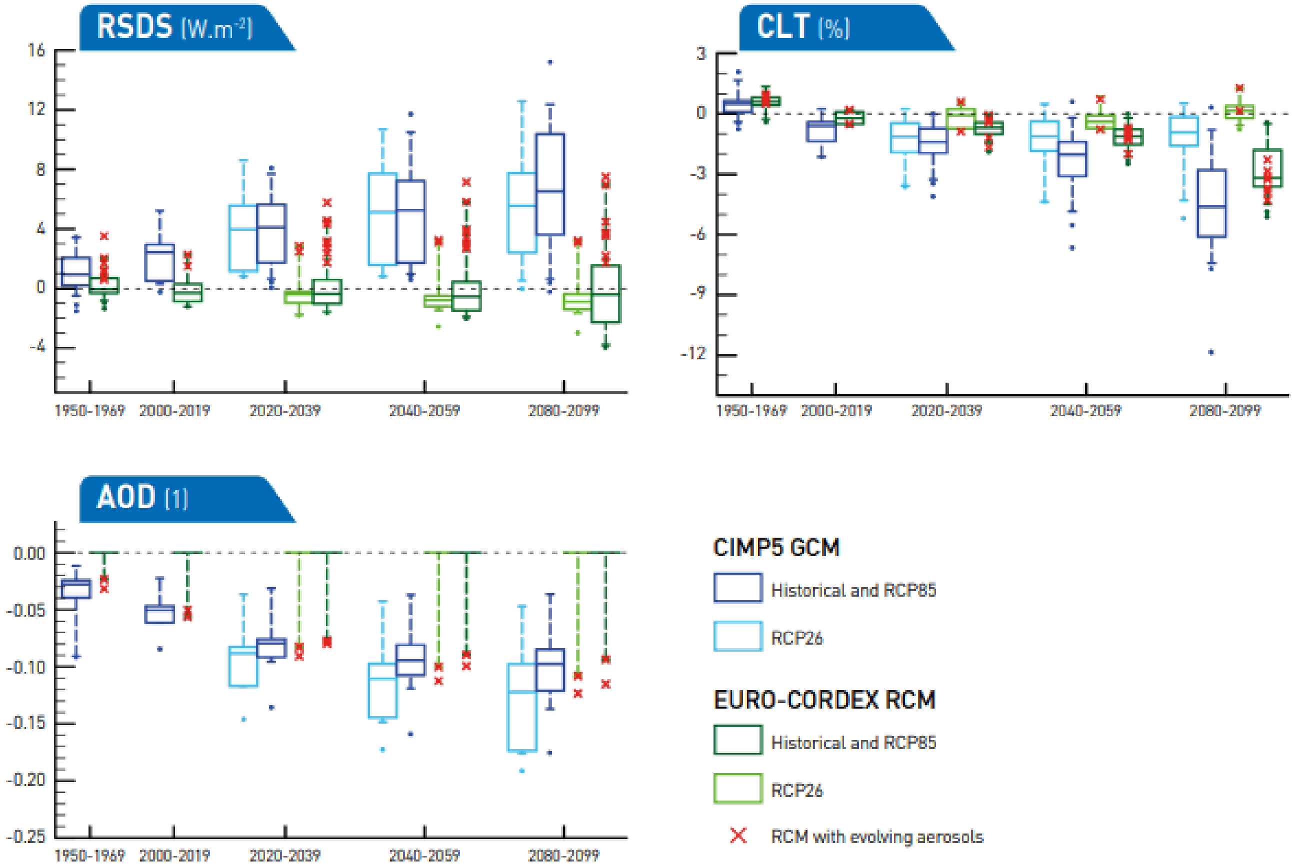

Figure 1.2: Past and Future Evolution of Surface Downwelling Shortwave Radiation (RSDS in W m²), Total Cloud Cover (CLT in %) and Aerosol Optical Depth (AOD) from 1950 to 20100 averaged over the Mediterranean – [1]

The increased surface radiation of the brightening period can be connected to the acceleration of climate warming started in the last decades. Indeed, both large volcanic eruptions and solar forcing have strongly influenced the temperature variability of the Mediterranean during the last centuries [1].
The annual mean temperatures across the basin are currently 1.5°C higher than in the late 1800s [1], furthermore, the regional climate warming started during the 1980s and then accelerated at a higher pace than the global average [1]. While the climate warming process was found to be consistent over the Mediterranean, temperature trends varied depending on the region or country considered, on the season analyzed and on the type of data set investigated. A study considering data from different sources and reconstructions was able to recover temperature trends of the Mediterranean over the last 500 years and observed the recurrence of warming-cooling cycles [1]. This data highlighted that the temperatures of the 20th century were only slightly warmer than those of previous warming periods. The last three decades were instead anomalous, presenting temperatures consistently warmer than the average, this thirty-years period was in fact the warmest of the last centuries [1]. Indeed, it was possible to recognize clear trends of +0.1 to +0.5°C per decade since the 1980s [1].

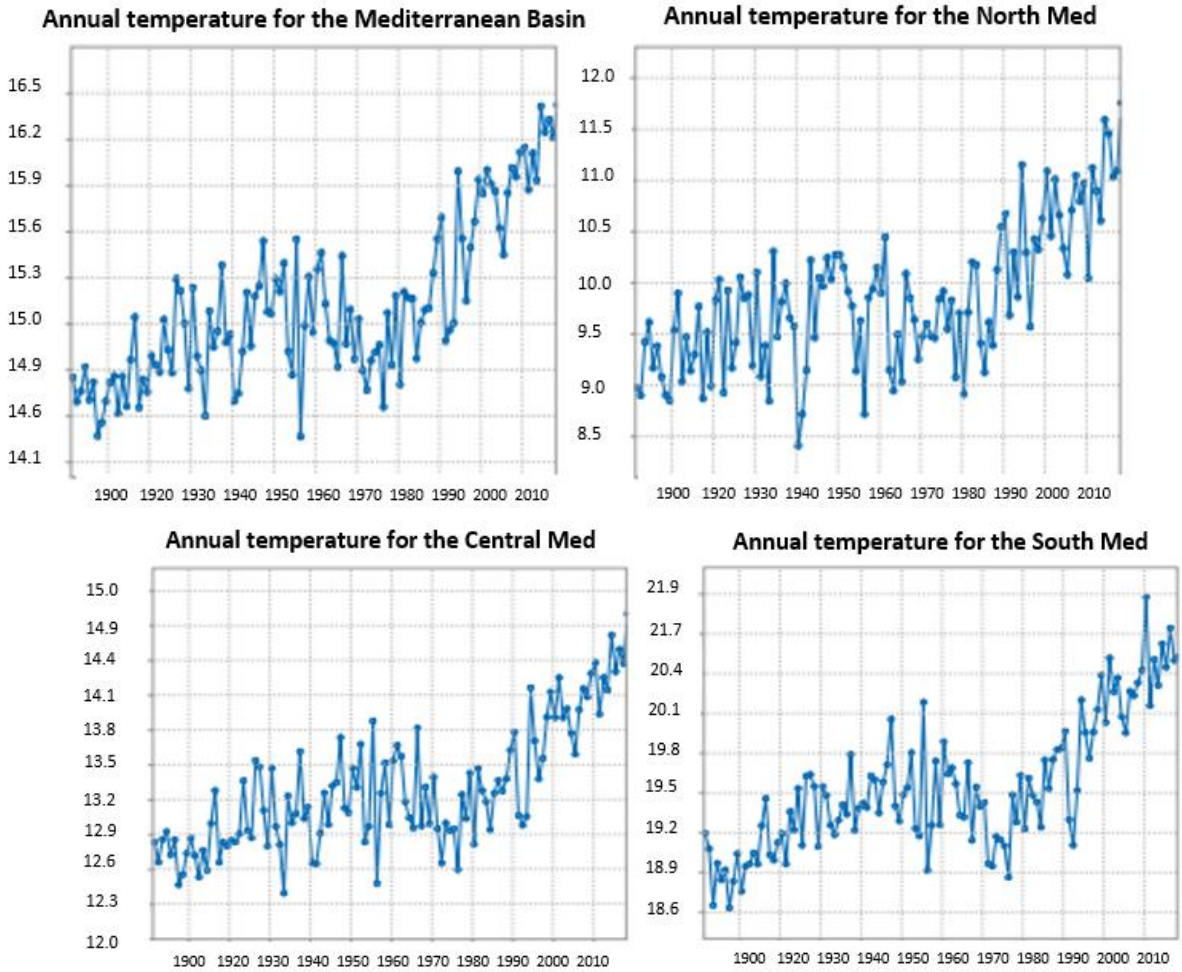

Figure 1.3: Temperature Over Land for the Mediterranean - [1]

It is also possible to observe the aggravation of climate warming in the Mediterranean basin in the warmer hot and cold extremes, in the more frequent and intense heat waves, in the higher incidence of warm and tropical nights in many countries of the region and in the occurrence of severe climate events linked to extreme heat in the summer period [1].

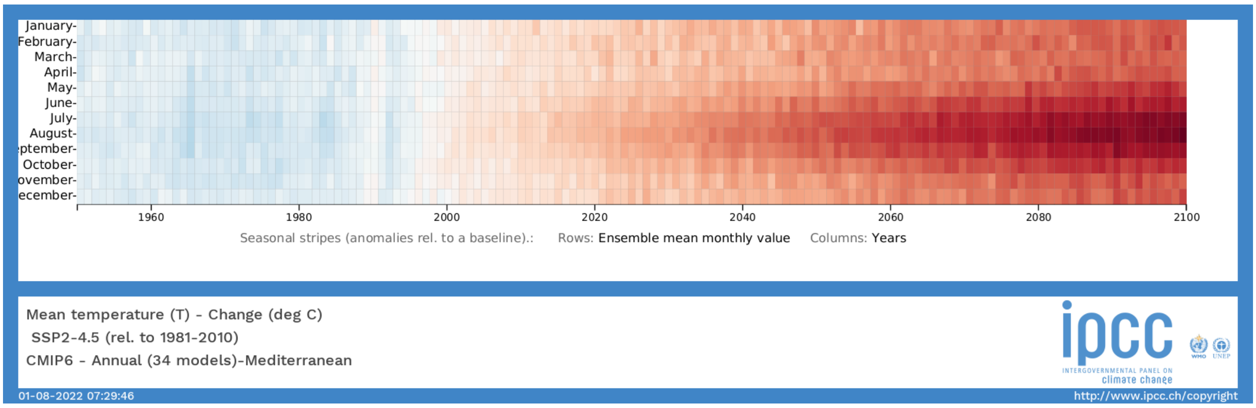

Figure 1.4: Mean temperature (T) Change deg C - SSP2-4.5 (rel. to 1981-2010) [4]

These warmer temperatures and heatwaves are contributing to the growing frequency of droughts and wildfire hazards, since they extend the duration of fire seasons increasing the risks of severe

fires. Nevertheless, forest fires are decreasing in the European areas of the Mediterranean that have implemented a more efficient risk management method [2].
The Mediterranean Region is one of the world's major cyclogenetic areas, presenting many of the high-impact weather characteristic of cyclonic structures [1]. Although in recent years there hasn't been a strong presence of cyclones (insufficient monitoring prevented the formulation of more specific data), the ones that were detected were mostly harmful [2].
One of the variables contributing to the creation of cyclones is the presence of strong winds, which characterize some tracts of the Mediterranean Basin. Unfortunately, there is a lack of conclusive information on the long-term wind patterns of the area: in fact, surface wind trends are not easily monitored as they are the result of various driving and drag forces created by several variables [1].
Precipitation trends in the Mediterranean basin are extremely variable in time and across the territory, and this characteristic conceals the eventual influence of climate warming on the phenomenon [1]. It is however possible to notice a decrease of winter precipitation in the southern and central areas of the region since the 1950s.

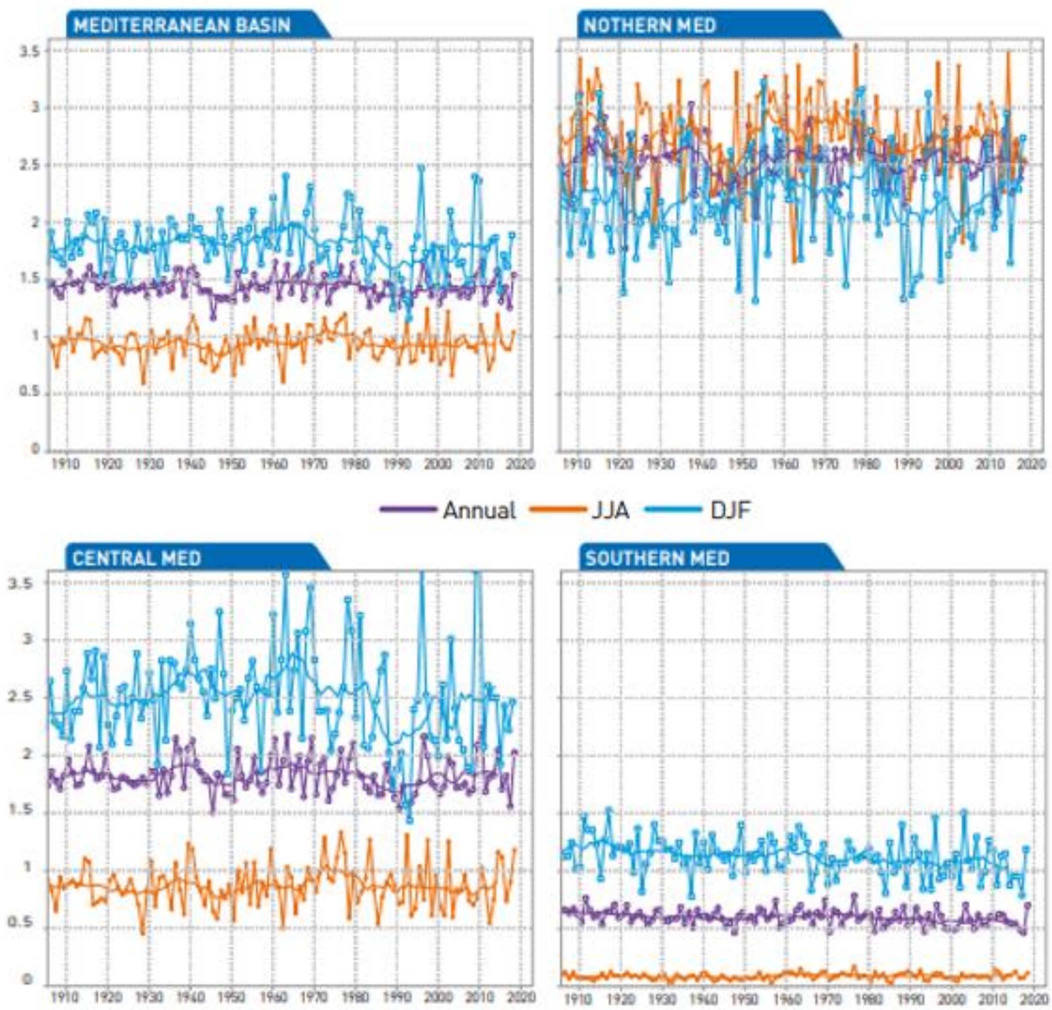

Figure 1.5: Annual and Seasonal Precipitations - [1]

Overall, in the last century, annual precipitation remained fairly stable, with more abundant rain during winter and a dry tendency during summer. Although, the North of Europe is distanced by this regional average by positive peaks between June and August and negative ones from December to February.

Nevertheless, the number of consecutive dry days of the region has fluctuated in the last years, with a current change of about three days from the pre-industrial age, after the peaks of 6.2 and 7.5 days of change respectively of 2019 and 2020 [3].

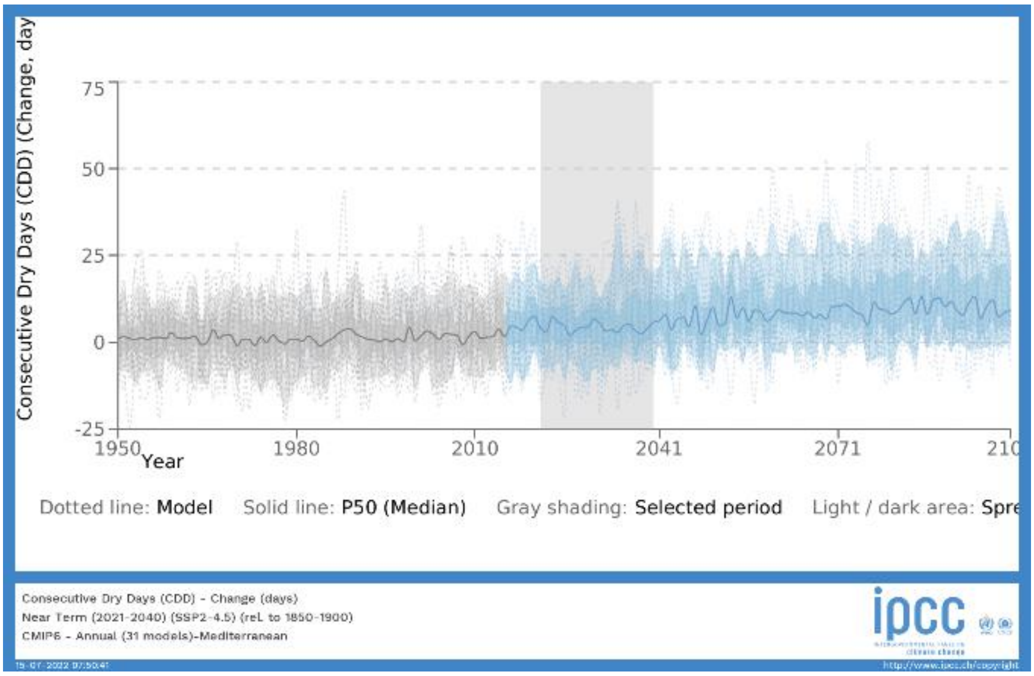

Figure 1.6: CMIP6 - Consecutive Dry Days (CDD) Change days - Near Term (2021-2040) SSP2-4.5 (rel. to 1850-1900) - Annual (31 models)-MED timeseries – [3]

Changes in precipitation and temperature trends affect the evaporation rates of the Mediterranean, and their increase, coupled with a decreased river runoff, can lead to regional water losses and land dryings in the summertime. Indeed, the basin's inter-annual variability of rainfall has always caused frequent droughts and since the 1970s their incidence has risen [1]].

Estimates based on observations showed minimum levels of evaporation between 1965 and 1975, which then increased in early winter periods by about 10% decade^{-1} [1] with peaks during the 1990s, especially in the Ligurian and Adriatic Sea and in the south-eastern Mediterranean. Between 1958 and 2006, the region's approximate rate of evaporation linked to climate change was about 0.7 mm day^{-1} K^{-1} [1].

Moreover, land evapotranspiration is affected both by increased temperatures and changes to regional precipitation trends, which diminish the soil moisture availabilities and therefore the evapotranspiration, causing drought tendencies in the region. Evapotranspiration trends are variable across the regions, and changes of about 0.1 mm yr^{-1} have been detected in the Mediterranean between 1982-2008 [1], with an overall tendency to rise during winter since 1970 and to decrease during summer.

Overall, climate change is increasing the frequency of droughts in the Mediterranean, and even groundwater availability is quickly diminishing in the region, due to intense rates of withdrawals for agricultural usage and tourism.

Climate warming is also heavily impacting the sea water temperature and level. In fact, evidence shows that the upper layers of the Mediterranean's waters have been warming up since 1980s [1] with an increasingly fast pace, and at an average rate between +0.29 and +0.44°C decade^{-1} [1]. In addition, between 2000 and 2017, the Mediterranean's seas have increased their temperature of a minimum of +0.2°C since the previous two decades, especially in the Eastern area where the water was +1.2°C warmer than in the beginning of the century [1]. Moreover, the occurrence of "marine heat waves" characterized by abnormal sea water temperatures have increased their frequency, intensity, and spatial extension during the last decades, passing from two marine heat waves between 1982-1991 to 14 between 2008-2017 [1].

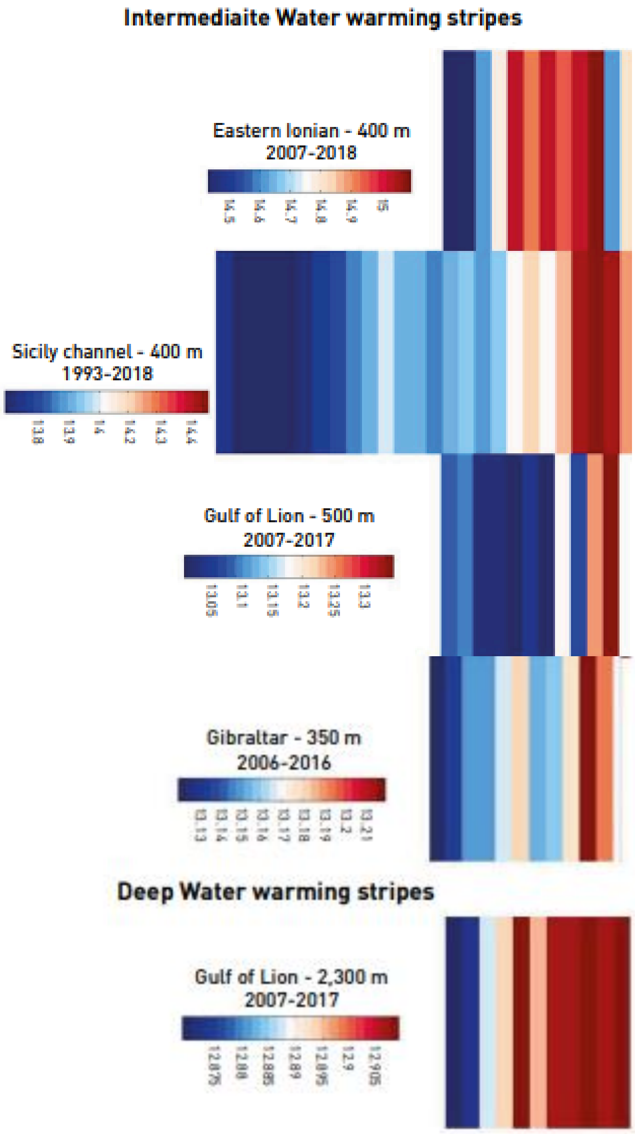

Figure 1.7: Warming Stripes in the Intermediate Water (from East to West) and the Deep Water (Gulf of Lion) – [1]

As for the sea levels, the Mediterranean Basin shows a trend of a -1.4 mm yr^{-1} decrease [1], which can be linked to interannual and decadal variabilities, masking the overall sea level increase observed over the last century. An example is the lowering of the regional sea levels that took place between 1960-1980 [1], provoked by an unusually high atmospheric pressure; once the pressure had settled to its typical values, the sea levels started increasing following the global trends. Data on the Mediterranean waters from satellite altimetry exhibit a sea level increase of about 2.8 ± 0.1 mm yr^{-1} in the period of 1993-2018 [1], in line with the global trend of 3.1 ±0.4 mm yr^{-1} [1]. This rise in the medium sea levels is causing a growth in the extent and duration of extreme sea level events in the basin and originates risks such as flooding at high-tide for low-laying areas as well. In fact, coastal regions are currently facing high risks of erosion and flooding, growing in importance as urban development brings inhabited areas closer and closer to the coasts, narrowing the beaches and not leaving adaptation options.

Indeed, floods represent the deadliest and most frequent natural disaster in the Mediterranean. Fortunately, their incidence seems to be decreasing in the European area, with diminished mean annual flood discharge in the North and East from 1960 to 2010 [1]. Possible drivers for this negative trend can be changes in rainfall-runoff processes or in land use and to structural flood protection measures. On the other hand, the largest Mediterranean rivers present the occurrence of late winter floods with increased magnitude and decreased frequency. The incidence of flash floods is also growing, especially in coastal areas and, since 1981, in some parts of Italy, France and Spain [1]; the main cause being sealed surfaces in urban areas and poor storm-water management systems.

2. TUNISIA, CLIMATE AND PROJECT AREAS

2.1 Sources

This chapter uses information, data and graphs or figures from the following sources:

[4] The World Bank (2021). *Climate Risk Profile: Tunisia*. Retrieved July 19, 2022 from (link)
[5] USAID (2018). *Climate Risk Profile – Tunisia*. Retrieved July 19, 2022, from (link)
[6] Tunisia (2019). Tunisia's Third National Communication – as Part of the United Nations Framework Convention on Climate Change. Retrieved on July 19, 2022, from (link)
[7] Société Tunisians de electricity et du Gaz (2009). Carbon Finance (CBF) Sidi Daoud Wind Farm Project: environmental assessment (Vol. 2): Réalisation d'une ligne électrique aérienne 90 KV/ Sidi Daoud_Menzel Temime. World Bank Group. Retrieved July 20, 2022 from (link)
[8] Simulated historical climate & weather data for Kélibia. (n.d.) Meteoblue. Retrieved on July 22, 2022, from (link)
[9] Simulated historical climate & weather data for Menzel Temime. (n.d.) Meteoblue. Retrieved on July 20, 2022, from (link)
[10] Climate Change Menzel Temime. (n.d.) Meteoblue. Retrieved on July 21, 2022, from (link)
[11] Climate in Tunis (Tunisia). (n.d.) WorlData. Retrieved on July 21, 2022, from (link)
[12] Climate – Tunis (Tunisia). (n.d.) Climates to Travel. Retrieved on July 21, 2022, from (link)
[13] Simulated historical climate & weather data for Tunis. (n.d.) Meteoblue. Retrieved on July 22, 2022, from (link)
[14] Climate Change Tunis – Carthage Airport. (n.d.) Meteoblue. Retrieved on July 21, 2022, from (link)
[15] Compare the Climate and Weather in Kélibia and Tunis. (n.d.) Weather Spark. Retrieved on July 21, 2022 from (link)
[16] Menzel Temime. (n.d.) ThinkHazard. Retrieved on July 21, 2022, from (link)
[17] Kelibia (n.d.) Thinkhazard. Retrieved on July 21, 2022, from (link)
[18] Sidi Hassine. (n.d.) Thinkhazard. Retrieved on July 21, 2022, from (link)
[19] Tunisia- Climate Projections > Mean Projections. (n.d.) Climate Change Portal. Retrieved on July 21, 2022, from (link)

2.2 Introduction

Tunisia is located in North Africa, on the southern shore of the Mediterranean Sea among the eastern and western Mediterranean basins. The country is split in two geographical areas by aligned low points passing from West to East, which are occupied by the Chotts El Gharsa, Djerid and Fedjej [4].

The territory is extremely varied across the regions and passes from the desert of the Sahara in the South to highlands and mountains in the Centre, steppe on the eastern coast and the mountainous landscape of the North. While being the smallest country in the North of Africa, Tunisia is characterized by five different climate zones due to its high latitude and North-South expansion: Saharan in the South, arid in the center, semiarid in the Northwest and part of the Nabeul region, subhumid and humid in the North [4].

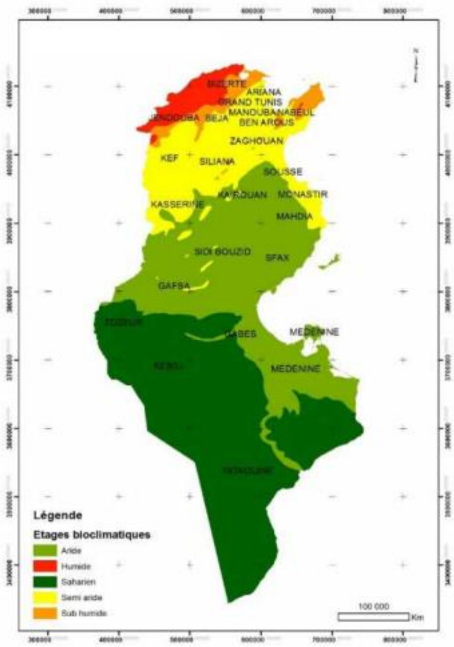

Figure 2.1: Map of Bioclimatic Regions – [6]

The main factors influencing the country's climate are the Atlas Mountains and the Mediterranean Sea. The mountain chain gives a typical Mediterranean climate to the North, while the influence of the Mediterranean mitigates the steppe climate of the eastern coast.
Overall, Tunisia is highly vulnerable to climate change with the main risks being Increased temperatures, varied precipitations causing water scarcity and droughts as well as floods, rise of the sea levels.
The areas of interest for the project are Cap Bon and Mornaguia but it was not possible to find accurate climate data on these two specific locations. In fact, because of the country's highly fragmented climate the territory, and since the Nabeul governorate is itself characterized by two types of climates, to provide a description of the climate at a country or regional level would not be useful for the scope of this document. Thus, in order to provide an analysis of how climate change impacts the two sites, the next pages will analyze the climate of the closest cities: Menzel Temime and Kelibia (in the Cap Bon peninsula) and Tunis (close to Mornaguia).

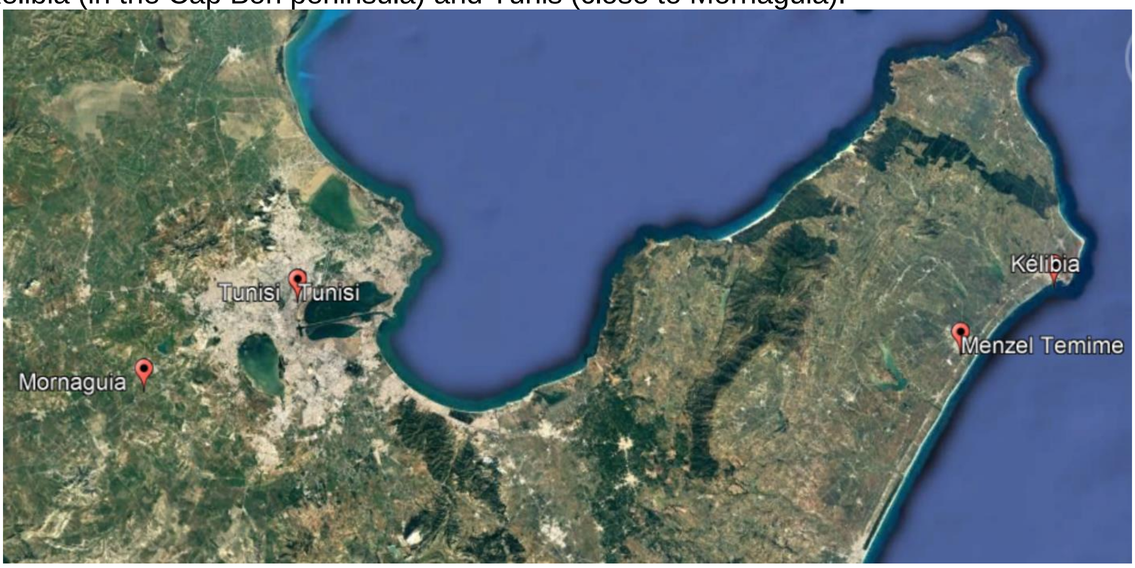

Figure 2.2: Project Area - Google Earth

2.3 The Cap Bon peninsula: Menzel Temime and Kelibia

The Tunisian conversion station will be positioned in Mlaâbi, located close to Menzel Temime in the Cap Bon peninsula. Since there is no data available for that specific site and not enough information on Menzel Temime to provide a complete overview, this section will describe the climate and climate risks of the nearby town Kélibia as well.
Kélibia is situated between the lower-subhumid and the semi-arid climate zone, characterized by average annual precipitations of 591 mm, annual average annual relative humidity of 73% [7], and a semi-arid vegetation.

Table 2.1: Average Precipitation in Kélibia (1994 - 2003) – [7]

Pluviométrie	Jan	Fév	Mar	Avr	Mai	Jun	Jul	Aou	Sep	Oct	Nov	Dec	**Annuelle**
En millimètre	78	71	40	43	18	9	2	6	51	100	83	90	**591**

Both Kélibia and Menzel Temime present a warm climate with temperatures spanning from an average maximum of 34°C in August and an average minimum of 7°C in February [8].

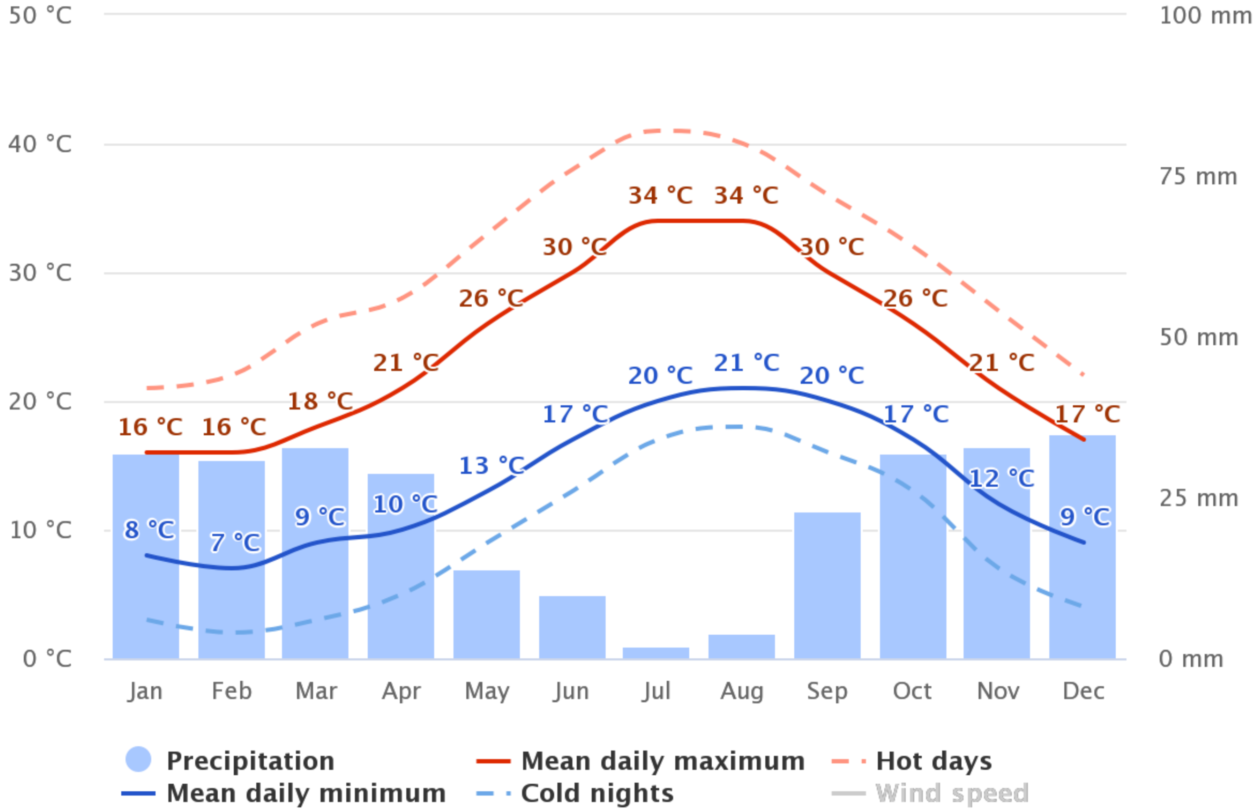

Figure 2.3: Average Temperatures and Precipitation in Kélibia – [8]

The area comprising the two towns thus experiences mild to warm winter and summer temperatures compared to the rest of the Cap Bon peninsula, this because of the mitigative effect of the South-East wind Chlouk coming from the Gulf of Hammamet [7].
Historical data from the area of Menzel Temime and Kélibia show an overall warming trend that increased the mean temperatures of more than 1°C since 1979 [10]. The region presents cooling-warming cycles up to 1998, from when it is possible to observe the beginning of the climate warming period, which accelerated from 2006 onwards.

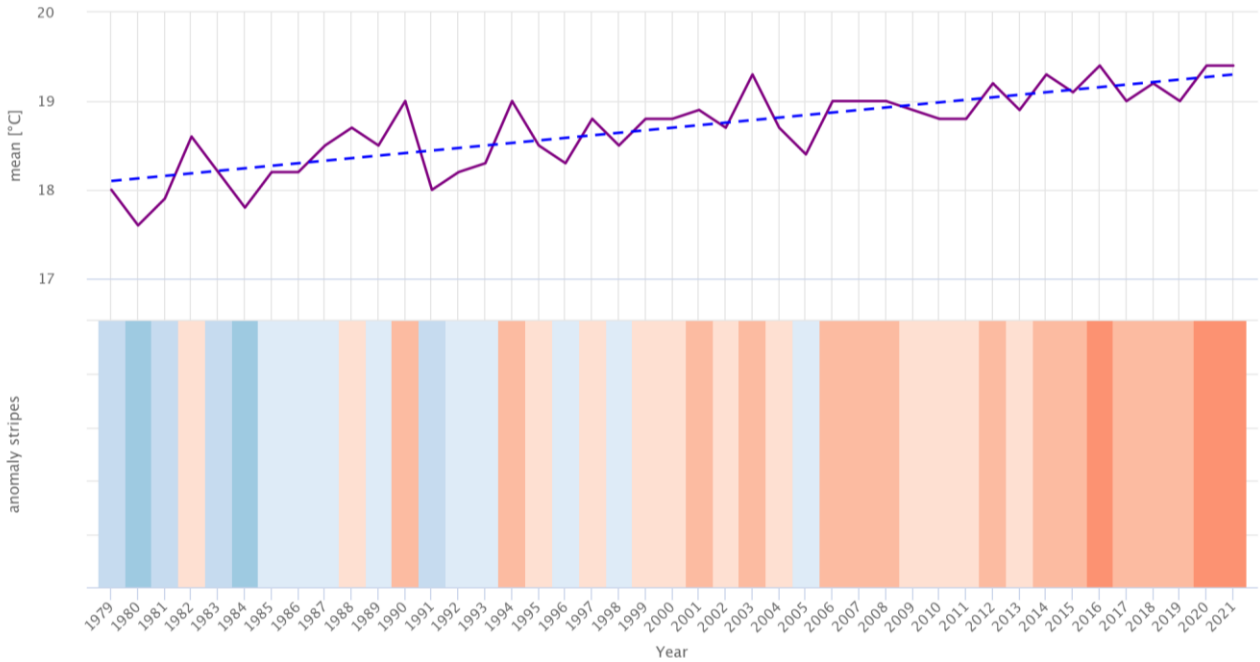

Figure 2.4: Mean Yearly Temperature, Trend and Anomaly, 1979-2022 for Menzel Temime - [10]

Droughts are an important issue in this site due to the long dry season, starting in April and lasting until September. Kélibia's water shortage, calculated comparing potential evapotranspiration with the precipitation value, show that about 42% of the potential water losses happen during summer [7].

The precipitation trends of the last 40 years are highly variable and show a couple of anomalies on each extreme such as a remarkably dry year in 2001 (precipitation anomaly of -191.6 mm) and a period of heavy rain and flood just one year apart in 2003 (anomaly was of +404.5) [10]. From 2003 started a five-year period characterized by abundant precipitations, after which the trends kept varying slightly from negative to positive.

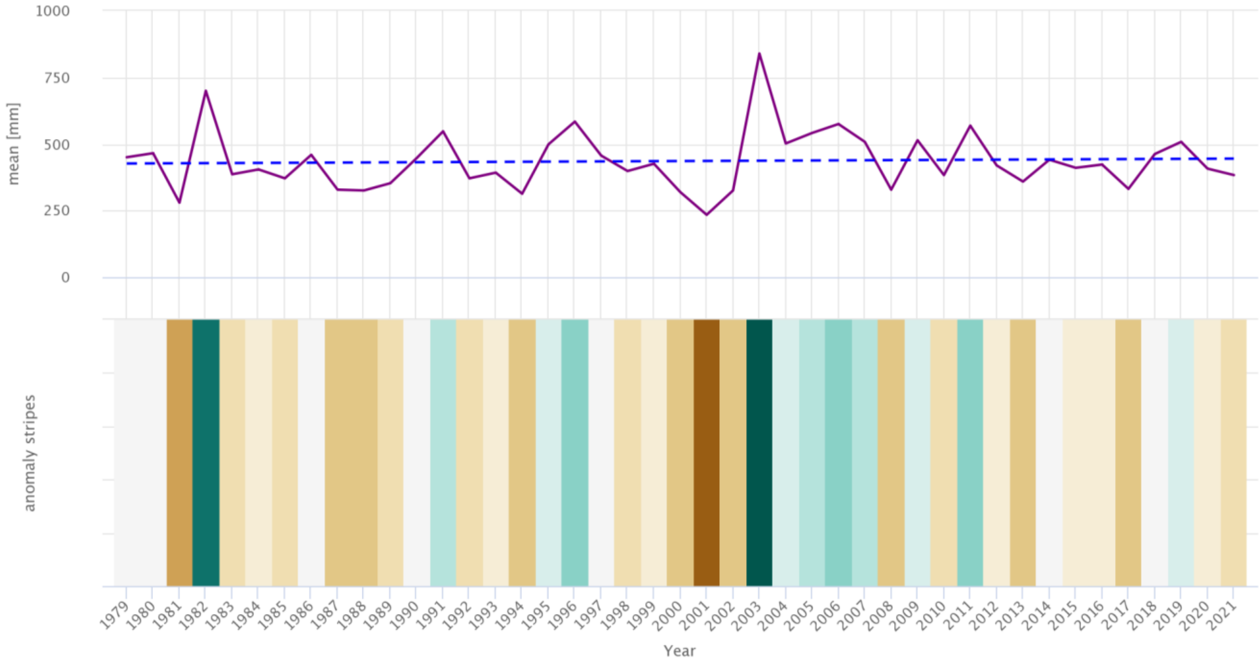

Figure 2.5: Mean Yearly Precipitation, Trend and Anomaly, 1979-2022 for Menzel Temime - [10]

Wind is almost constantly present in the peninsula of Cap Bon, in Kélibia only 12% of the observations carried out for 20 years showed an absence of wind, which is also considerably violent and in the proximities of the town can reach a maximum velocity of 20m/s [7]. Likewise, Menzel Temime displays the incidence of strong winds, exceeding 61 km/h in the winter months (December to March) and slowing down slightly in summer, when it usually stays under 50 km/h [9].

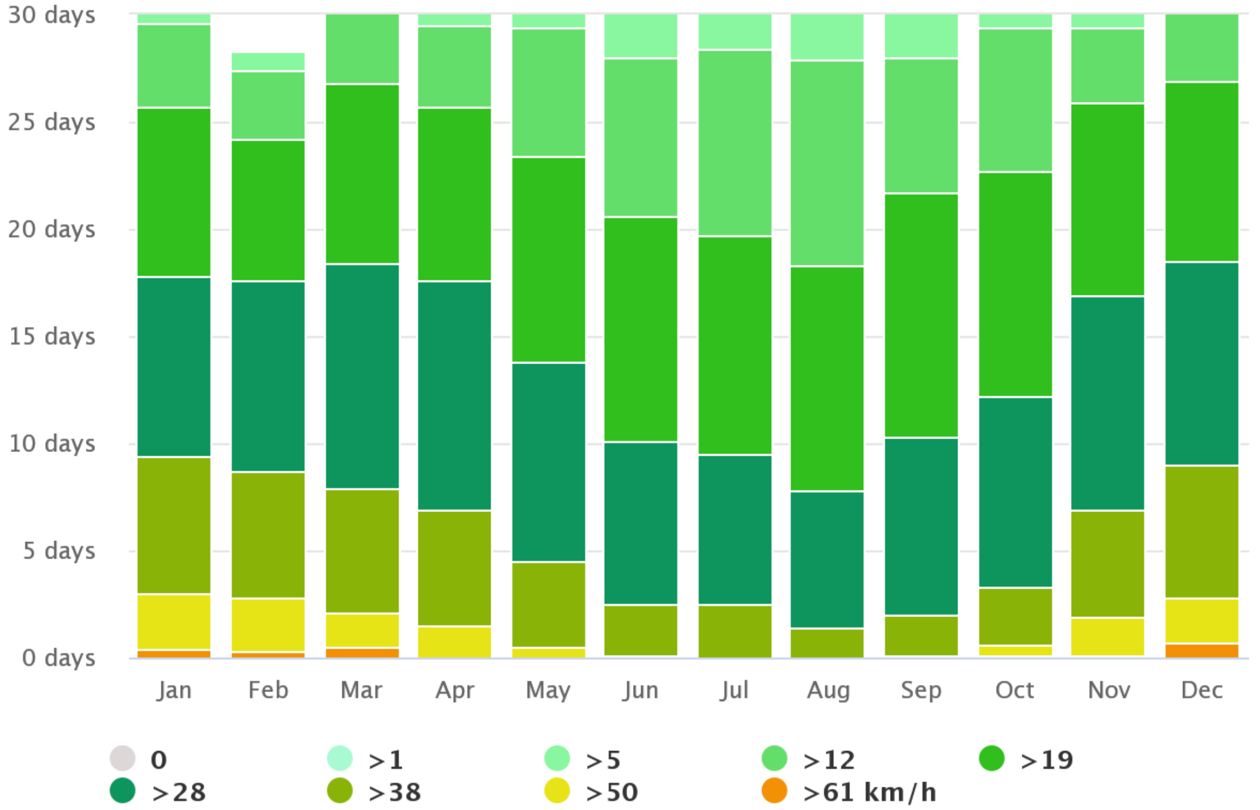

Figure 2.6: Mean Monthly Wind Speed for Menzel Temime – [9]

Overall, the Kélibia-Menzel Temime area presents mild to high temperatures, is prone to heat waves and climate warming, droughts and water scarcity, rare floods, and strong, persistent wind.

2.4 Tunis Area

Climate in the Tunis region is classified as semi-arid and is characterized by frequent rainfall and mild temperatures in winter, and by extremely warm and sunny weather in summer. The area is located on the Tunis gulf, but the main climate influence is the desert wind, responsible for the warm temperatures all year round. Indeed, the coldest month (January) has an average of 16°C, while the warmest (July) presents an average of 35°C [11].

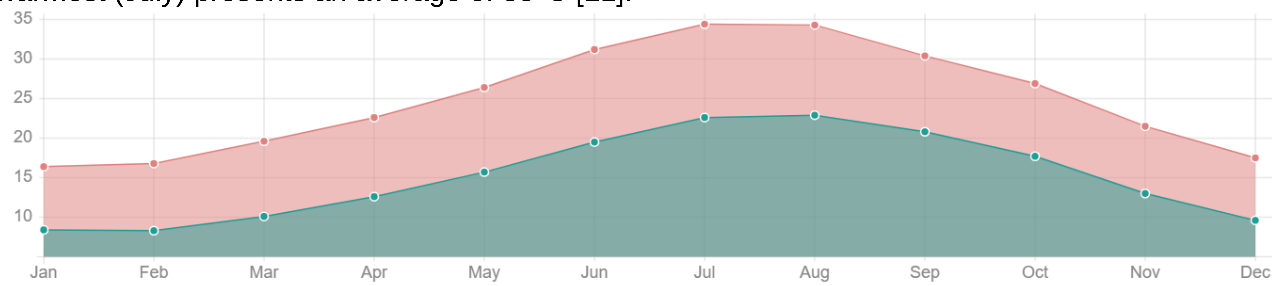

Figure 2.7: Average daytime and night-time temperatures for Tunis – [11]

Climate change strongly affected the local temperatures, which started increasing in 1999 and kept rising steadily with only a slight drop in 2005. In 2021, the average temperature was 19.5°C which indicates an increase of 2.3°C from the 1979 values of 17.8°C [14].

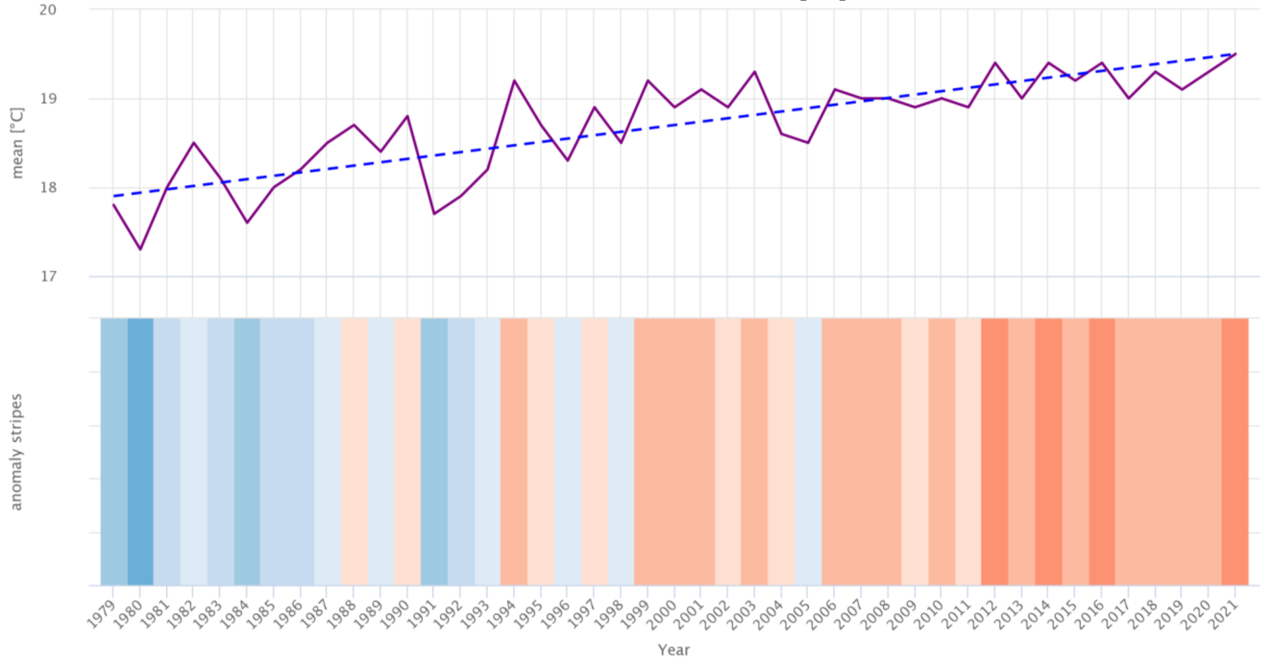

Figure 2.8: Mean Yearly Temperature, Trend and Anomaly, 1979-2022 for Tunis - [14]

The rainy season in Tunis is Between December and March, when there is an average of about 8 rainy days per month [11], while the maximum precipitations occur in September (about 2.2 mm/day) and December (2.4 mm/day) [11].

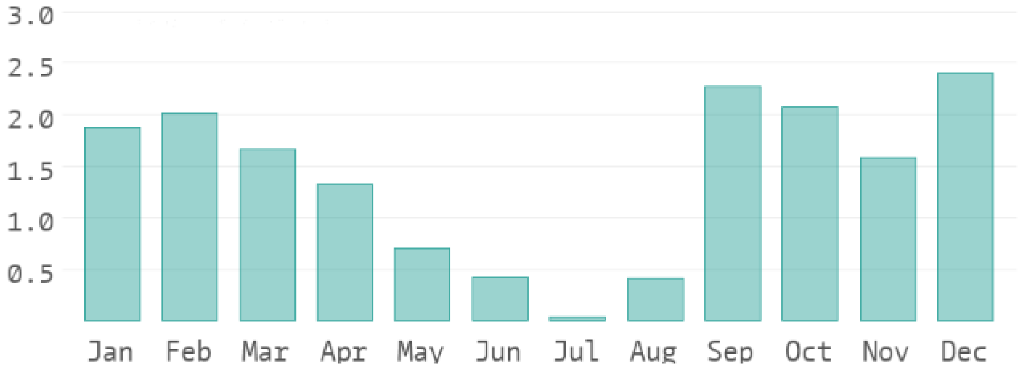

Figure 2.9: Precipitation in mm/day for Tunis – [11]

The precipitation trends have grown slightly between 1979 and 2021, with an increase of 30.9 mm [14]. During the years, the average precipitations have varied between positive values as in the last four years, and negative ones for sets of consequent years, the longest one being from 1998 to 2002. This unusually long dry period was followed by a year of heavy rain like in the Menzel Temime region (in 2003 there was an anomaly of 298.1 mm) [10], and then by other four years of abundant rain broken only by the precipitation average of 2008 [14].

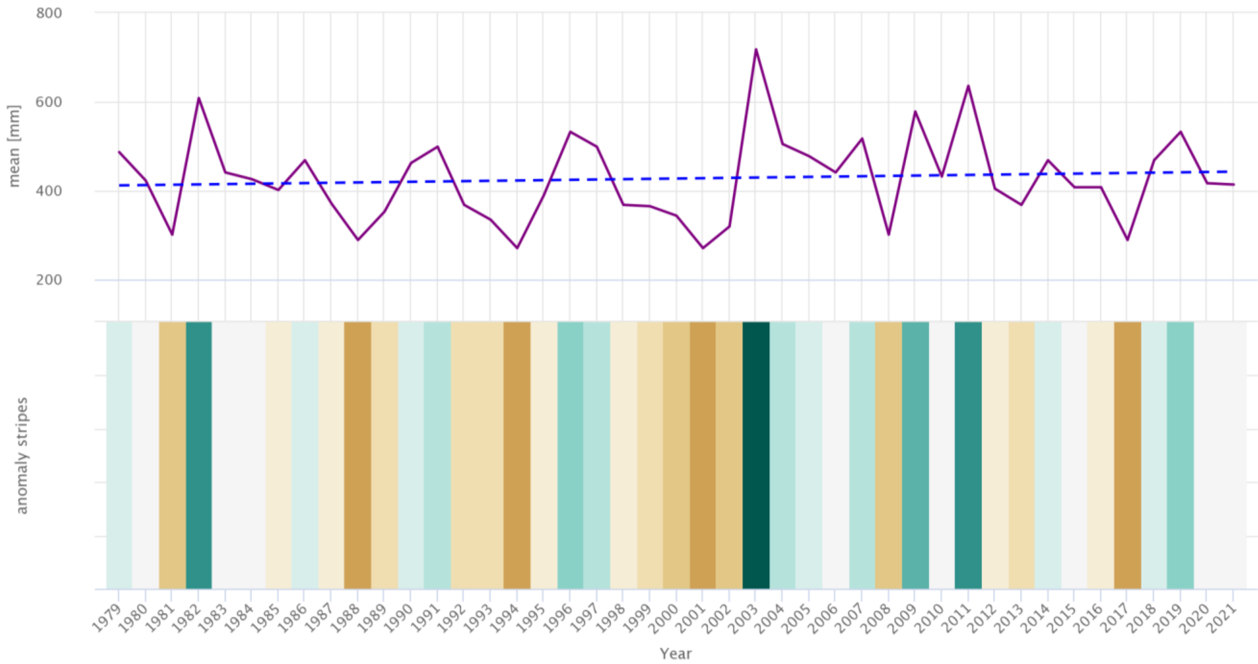

Figure 2.10: Mean Yearly Precipitation, Trend and Anomaly, 1979-2022 for Tunis – [14]

Tunis' climate is always rather humid, with an average relative humidity of 70% (78% in December), and the absolute humidity exceeding 14 g/m^3 from June to October, with a maximum peak of 19 g/m^3 in August [11].

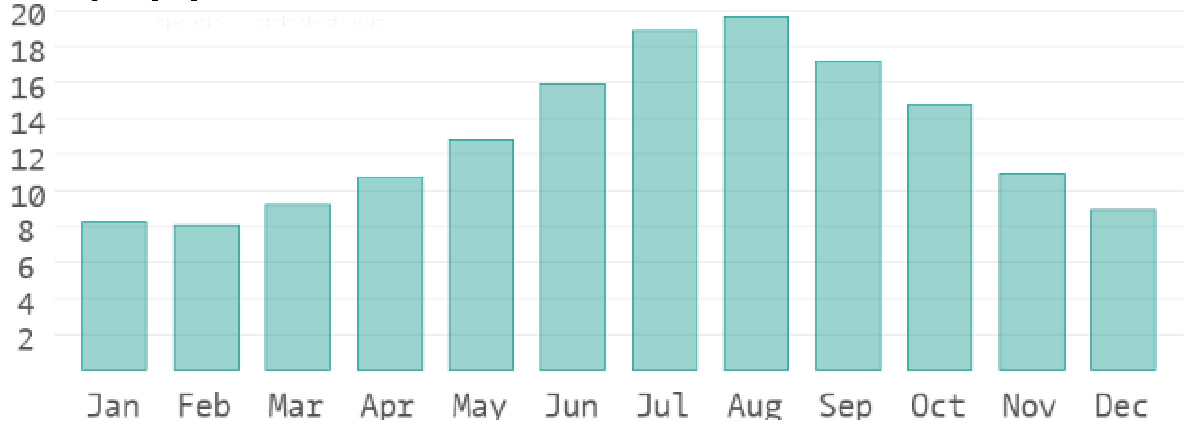

Figure 2.11: Absolute Humidity in g/m^3 – [11]

The wind in Tunis is also consistently present and it is stronger between December and March, while it stays under 50 km/h from July to September [13].

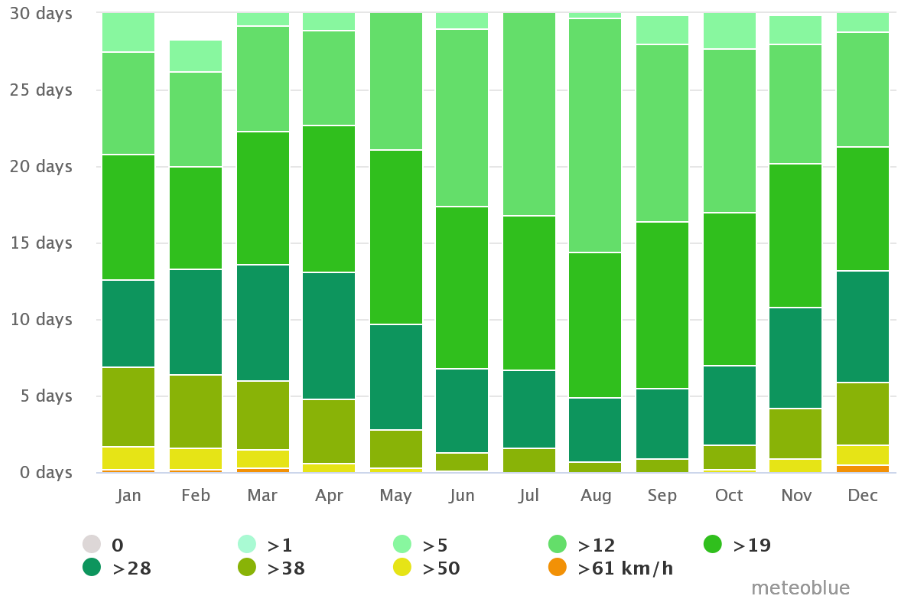

Figure 2.12: Average Monthly Wind Speed for Tunis – [13]

To sum up, Tunis has a warm and humid climate that is at risk of heatwaves and warming, and strong winds.
Comparing the climate baseline of the Kélibia/ Menzel Temime area with the Tunis area, it is possible to observe slightly higher temperatures in Tunis.

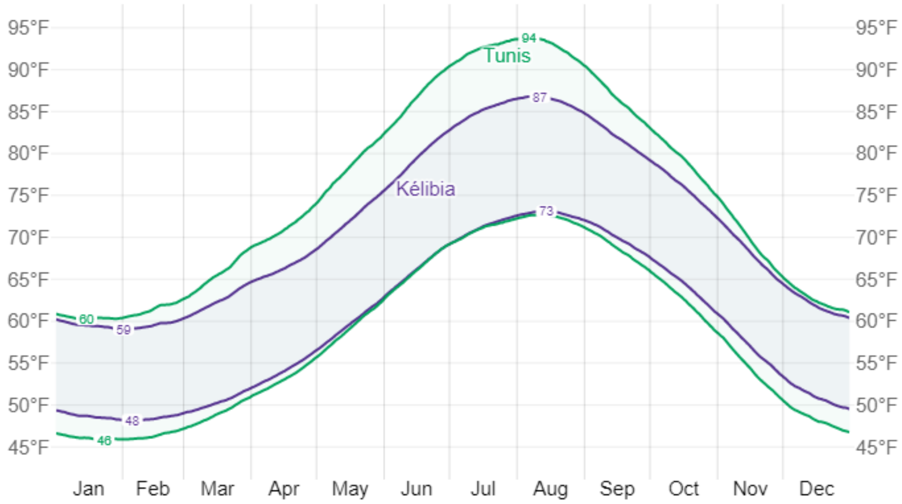

Figure 2.13: Comparison average temperatures - Tunis & Kélibia – [15]

Even the precipitation patterns differ between the two areas, with more abundant rainfalls in Tunis between March and August, and the opposite between September and December.

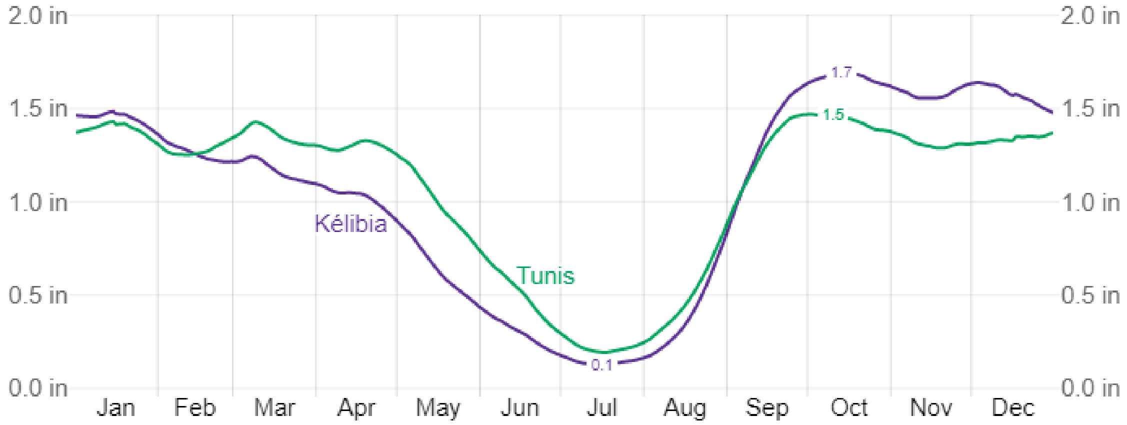

Figure 2.14: Comparison average monthly rainfall - Tunis & Kélibia – [15]

On the other hand, the average wind speed remains consistently higher in Kélibia, with a maximum discrepancy of 3.5 mph in December and a minimum of 0.7 mph in July.

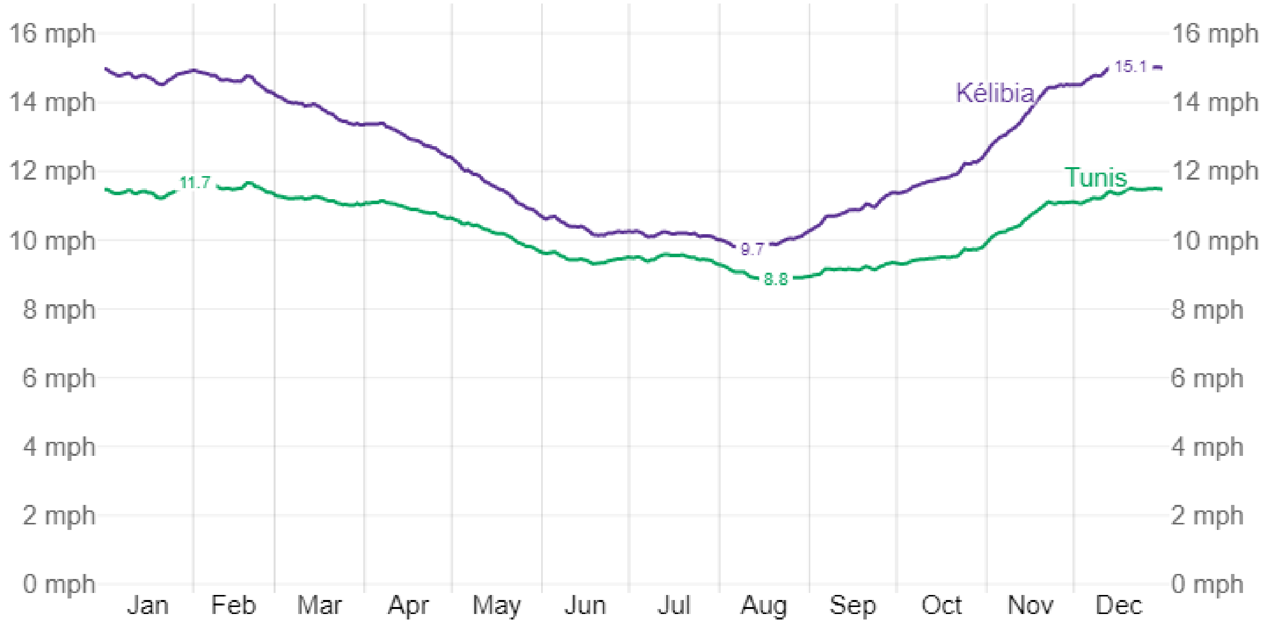

Figure 2.15: Comparison average wind speed - Tunis & Kélibia – [15]

To conclude, the current climate risks in Kélibia and Menzel Temime are droughts and wind speed, while in Tunis are heat waves and floods.

2.5 Climate projections

The project will become operative around 2030 and it will have a lifespan of about 40 years, until 2070. Since there is no data available for that exact timeframe, the following chapter will describe the projected climate of the periods 2040-2059 and 2060-2079 for the two areas of interest; it should be noted that the projections will present both the SSP2 – 4.5 and SSP5-8.5 scenarios. Specific hazards caused by climate change such as floods and wildfires are extremely difficult to predict, therefore the projections are only available for the next ten years.
In the next decade, the area of Menzel Temime and Kélibia will face medium risks (more than 20%) of water scarcity and heat waves, while Kélibia will also have medium risks of coastal flood [16, 17].

Likewise, the region of Sidi Hassine in Tunis (close to Mornaguia) will also be at medium risk of water scarcity and heatwaves, moreover, it will have a high risk (more than 50%) of wildfires [18].
With the SSP2-4.5 scenario for the 2040-2059 period, the Nabeul region (located in the Cap Bon peninsula) will have an increase of mean temperatures of 1.03°C in the coldest month (January) and of 1.26°C in the warmest (August); while between 2060-2079, the temperatures will be 1.52°C higher in January and 2.75°C warmer in August. By 2070, the average temperatures will be 20.92°C, against the average 19.13°C of 2013 [19].
On the other hand, the SSP5-8.5 scenario presents a more extreme situation, with an increase of 1,38°C in January and of 2,76°C in July for the 2040-2059 period, and of +2,35°C (January) and +4,59°C (August) for 2060-2079. By 2070, the average temperature for this scenario will be 22,1°C [19].

Table 2.2 Mean temperature increase for the Nabeul region [19]

NABEUL					
PERIOD	**SCENARIO**	**MEAN TEMPERATURE INCREASE (deg. C)**			
		DJF	**MAM**	**JJA**	**SON**
2040-2059	SSP2 -4.5	+1,23°	+1,35°	+3°	+1,58°
	SSP5 - 8.5	+1,57°	+1,81°	+2,7°	+2,08°
2060-2079	SSP2 -4.5	+1,69°	+1,76°	+2,72°	+2,2°
	SSP5 - 8.5	+2,46°C	+2,87°	+4,38°	+3,31°

According to the SSP2-4.5 scenario, the Tunis area follows similar trends, with a 1.01°C increase in the coldest month and a 2.11°C rise in August during 2040-2059. Again, on the same path of Nabeul, the increase will become +1.52°C in January and +2.76°C in August between 2060-2079. The temperatures will thus be warmer in this location, as the projected mean for 2070 is 20,88°C [19].

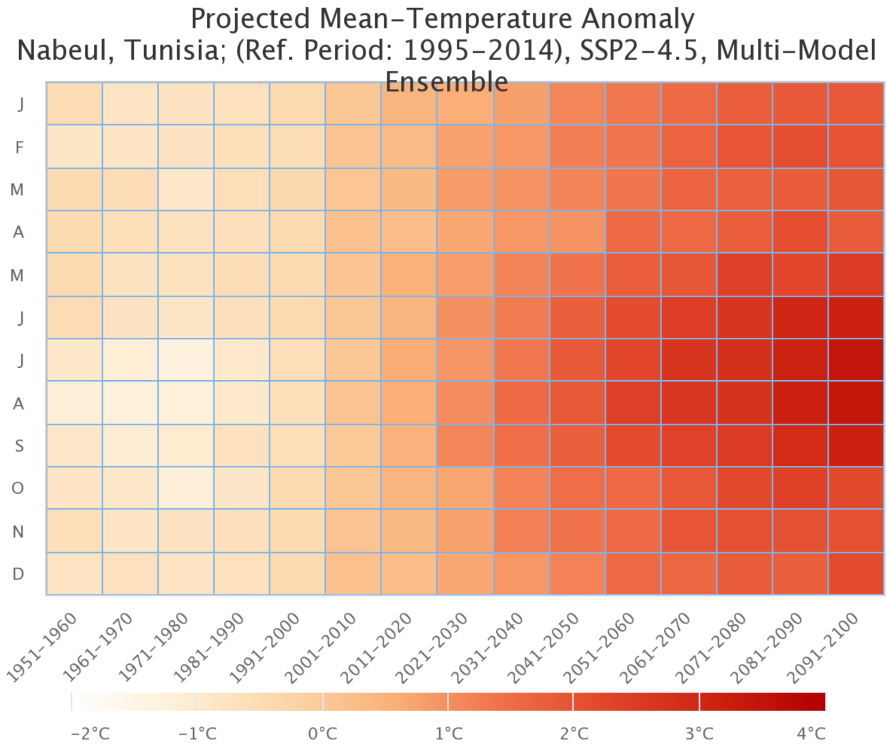

Figure 2.16: Projected Mean - Temperature Anomaly Nabeul. Reference Period: 1995-2014, SSP2-4.5 - [19]
The SSP5-8.5 scenario foresees a 1,38°C increase for the coldest month of 2040-2059 (January), and a 2,79°C rise for the warmest (July). In 2060-2079, the temperature growth will be respectively of +2,36° in January and +4,65°C in August. In 2070, the projected mean temperature will be 22,07°C.

Table 2.3: Mean temperature increase for Tunis area

TUNIS					
PERIOD	**SCENARIO**	**MEAN TEMPERATURE INCREASE (deg. C)**			
		DJF	**MAM**	**JJA**	**SON**
2040-2059	SSP2 -4.5	+1,22°	+1,37°	+2,01°	+1,59°
	SSP5 - 8.5	+1,57°	+1,84°	+2,7°	+2,09°
2060-2079	SSP2 -4.5	+1,69°	+1,77°	+2,73°	+2,21°
	SSP5 - 8.5	+2,47°	+2,91°	+4,42°	+3,34°

According to the SSP2-4.5 scenario, between 2040 and 2059, the Nabeul region will have a maximum of 22,55 days with a temperature above 35°C, against the current maximum of 13,84 [19]. Within 2060-2079, the number of days will increase to a maximum of 25,08 [19]. With the SSP5-8.5 scenario instead, the maximum number of hot days during 2040-2059 is 24,4, which will increase to 28,4 between 2060-2079 [19].
While in Tunis there is currently a maximum average of 15,1 days exceeding 35°C, for the SSP2-4.5 scenario, the maximum average will be of 23,9 days in August in the first time slot, and of 26,3 days in the second [19]. The SSP5-8.5 scenario shows instead an average maximum of 25,5 days above 35°C between 2040-2059, and of 28,9 between 2060 and 2079 [19].
Therefore, both the regions will experience a great increase in the number of days with a temperature higher than 35°C. The Tunis area, characterized also at the present time by a warmer climate, will endure more hot days than Nabeul for the entire project lifecycle.

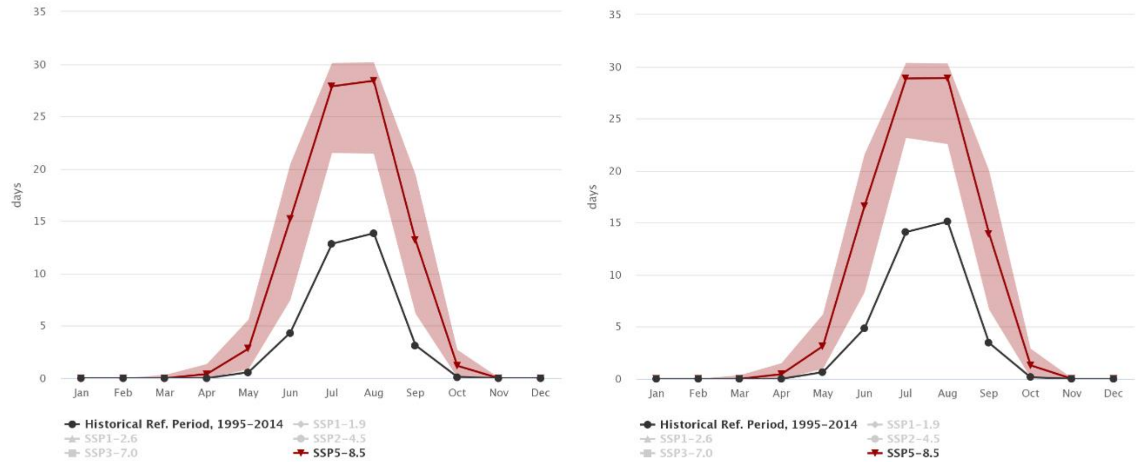

Figure 2.17: Projected Climatology of Days with Heat Index >35 for 2060-2079, SSP5-8.5, Nabeul (on the left) and Tunis (on the right) – [19]

Furthermore, in the next decades Nabeul will experience more consecutive dry days. The SSP2-4.5 scenario shows the greatest discrepancies from the historical maximum averages occurring in April, with +3,02 days for the 2040 – 2059 period and +2.65 days between 2060 and 2079 [19]. The SSP5-8.5 scenario again indicates April as the month becoming increasingly drier, with a discrepancy of +3,13 days from the historical mean in the first period, and of +4,34 days in the second [19].

Table 2.4: Consecutive dry days increase for the Nabeul region [19]

NABEUL					
PERIOD	SCENARIO	CONSECUTIVE DRY DAYS INCREASE (Max number)			
		DJF	MAM	JJA	SON
2040-2059	SSP2 -4.5	+1,75	+1,74	+0,48	+0,96
	SSP5 - 8.5	+1,57	+2,42	+0,22	+1,1
2060-2079	SSP2 -4.5	+1,21	+1,93	+0,78	+0,88
	SSP5 - 8.5	+1,79	+3,76	+0,91	+1,98

Likewise, Tunis will experience the highest number of consecutive dry days in April for both periods of reference. The difference will be of +3.2 days for 2040-2059 and of +2.7 for 2060-2079 (SSP2-4.5) [19]. The SSP5-8.5 on the other hand, forecasts the drier months to be March and April equally (+3,2 days) between 2040-2059, and only April (+4,45 days) between 2060-2079. Overall, the SSP2-4.5 scenario indicates a slight decrease in the number of consecutive dry days in 2060-2079 compared to the previous decade; this slope doesn't occur with the SSP 5-8.5 scenario. within the project's lifecycle, the two areas will have more dry days between 2051 and 2060.

Table 2.5: Consecutive dry day increase for the Tunis area [19]

TUNIS					
PERIOD	SCENARIO	CONSECUTIVE DRY DAYS INCREASE (Max number)			
		DJF	MAM	JJA	SON
2040-2059	SSP2 -4.5	+1,81	+1,8	+0,46	+0,71
	SSP5 - 8.5	+1,56	+2,48	+0,2	+1,08
2060-2079	SSP2 -4.5	+1,21	+1,93	+0,75	+0,95
	SSP5 - 8.5	+1,8	+3,78	+0,9	+1,98

In conclusion, it is possible to confirm that the main climate risks for both areas will be temperature increases, heatwaves, and droughts. Moreover, while it is not possible to predict with certainty which the risks will be for other climate hazards, it may be necessary to consider the possibility of wildfires occurring in the Mornaguia area, and of coastal floods happening in Mlaâbi [15, 16, 17] as previously indicated.

3. SICILY

3.1 Sources

This chapter uses information, data and graphs or figures from the following sources:

[20] Climate change in Italy (2020). (link).
[21] Climate Projections – Precipitation (Sicily). Retrieved on July 22, 2022, from (link).
[22] Climate Projections – Mean Temperature (Sicily). Retrieved on July 21, 2022, from (link).
[23] Climate Projections - Observed Average Annual Precipitation of Sicily. Retrieved on July 23, 2022, from (link).
[24] Climate Projections - Observed Average Annual Mean Temperature of Sicily. Retrieved on July 23, 2022, from (link).
[25] Climatic Regions in Italy (G.M.P.E.). Retrieved on July 20, 2022, from (link).
[26] "Climate Atlas of Italy". Network of the Air Force Meteorological Service. Archived from the original on 14 November 2012. Retrieved on July 22, 2022, from (link).
[27] Think Hazard Trapani, Sicily. Retrieved on July 20, 2022, from (link).
[28] Climate Projections – Maximum temperature (Sicily). Retrieved on July 23, 2022, from (link).
[29] Climate Projections – Consecutive dry days (Sicily). Retrieved on July 23, 2022, from (link).
[30] Climate Projections – Max number of consecutive days with index > 35°C (Sicily). Retrieved on July 22, 2022, from (link).

3.2 Introduction

Italy, whose territory largely coincides with the homonymous geographical region, is located in Southern Europe and it is also considered a part of western Europe, between latitudes 35° and 47° N, and longitudes 6° and 19° E.

To the north, Italy borders France, Switzerland, Austria, and Slovenia and is roughly delimited by the Alpine watershed, enclosing the Po Valley and the Venetian Plain.

To the south, it consists of the entirety of the Italian Peninsula and the two Mediterranean islands of Sicily and Sardinia (the two biggest islands of the Mediterranean), in addition to many smaller islands.

The climate of Italy is influenced by the large body of water of the Mediterranean Sea that surrounds the peninsula. This sea constitutes a reservoir of heat and humidity for the country, and, within the southern temperate zone, it defines a Mediterranean climate that presents local differences due to the geomorphology of the territory. In fact, the Mediterranean Sea has a mitigating effect on the local climate, especially when the atmospheric pressure is high [20].

Conditions on the coast are different from those in the interior, particularly during winter months when the higher altitudes tend to be cold, wet, and often snowy. The coastal regions have mild winters and hot and generally dry summers; lowland valleys are hot in summer.

Figure 3.1: Climatic regions in Italy [6]

3.3 Sicily, climate and climate risk

The Italian conversion station will be positioned in Marina di Selinunte, located in the province of Trapani. Since there is no data available for that specific site, this section will describe the climate and climate risks of Sicily.

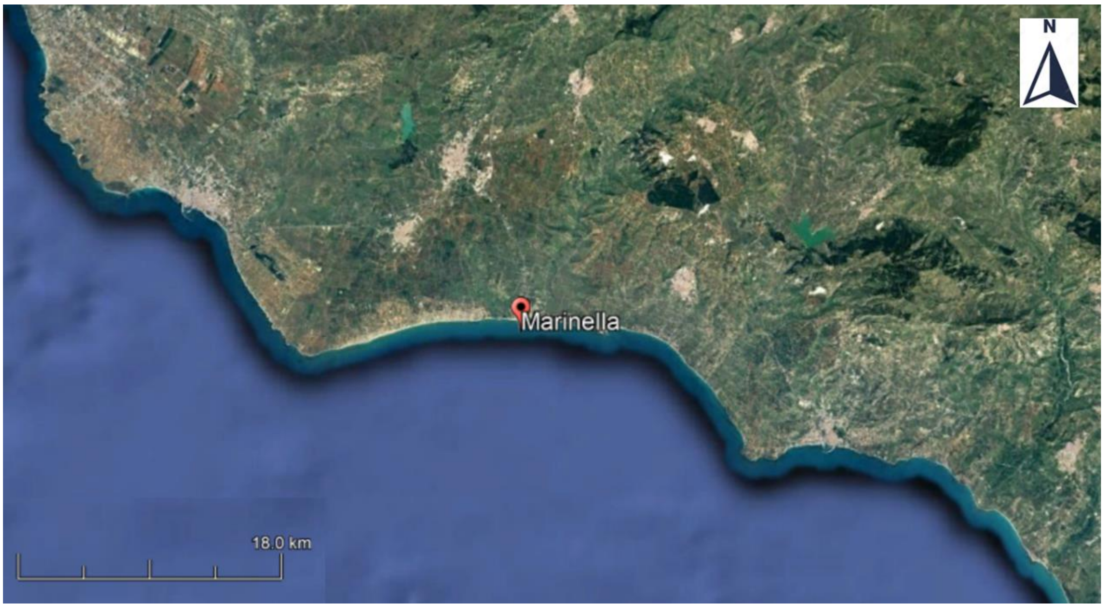

Figure 3.2: Project area – Google Earth

Sicily is in the central Mediterranean Sea, in the South of the Italian Peninsula in continental Europe, from which it is separated by the narrow Strait of Messina. Sicily has a typical Mediterranean climate with mild and wet winters and hot, dry summers and highly variable intermediate seasons. On the coasts, especially in the South-West, the climate is affected by the African anticyclone, which causes summertime to be extremely warm. The following analysis is based on the climate data of the last thirty years. Sicily has maximum temperatures that fluctuate between 12.5 °C in winter and 29.7 °C in summer (Figure 3.3). As for the minimum temperatures, they are usually between 6.22 °C in winter and 21.4 °C in summer (Figure 3.4). Data show that precipitations are concentrated in the cold months (from October to February), with minimum values in June and July, accounting respectively for 9 and 7 mm (Figure 3.5).

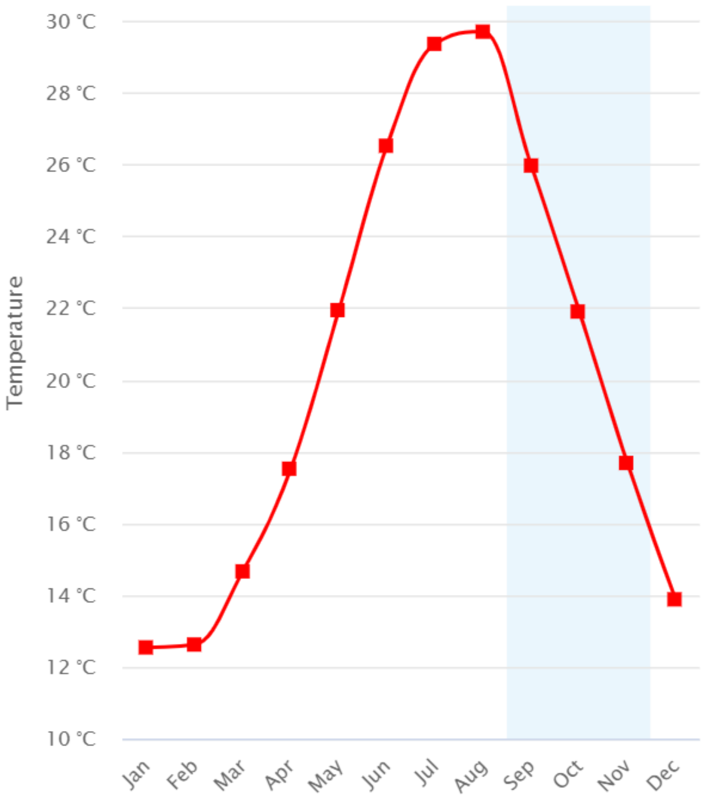

Figure 3.3: Monthly Climatology of & Max Temperature 1991-2020 Sicily, Italy [9]

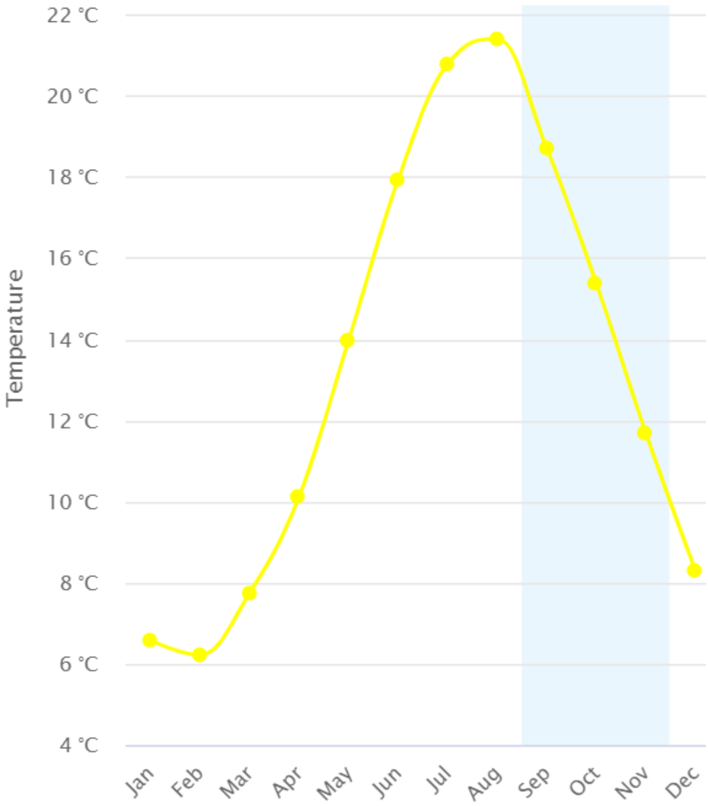

Figure 3.4: Monthly Climatology of & Min Temperature 1991-2020 Sicily, Italy. [9]

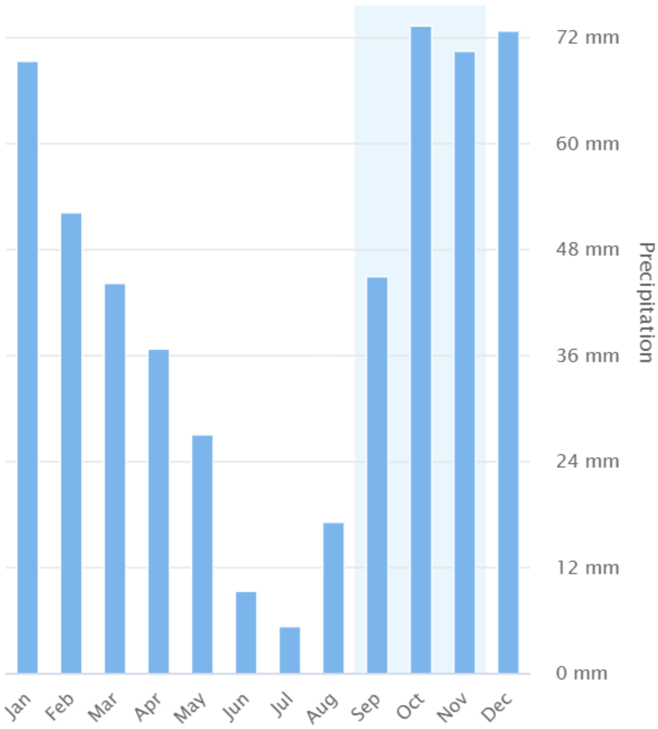

Figure 3.5: Monthly Climatology of & Precipitation 1991-2020 Sicily, Italy. [9]

Table 3.1: Amount of precipitation each month for the project area [9]

Months	January	February	March	April	May	June	July	August	September	October	November	December
Precipitation (mm)	69	54	47	39	24	9	7	13	36	78	69	76

In Sicily, temperatures have been steadily increasing since the early 1970s, when the average temperature was of 15.6°C against the 17.4°C of 2021. The discrepancy of +1.8°C in only 50 years shows that the local climate is warming quickly.

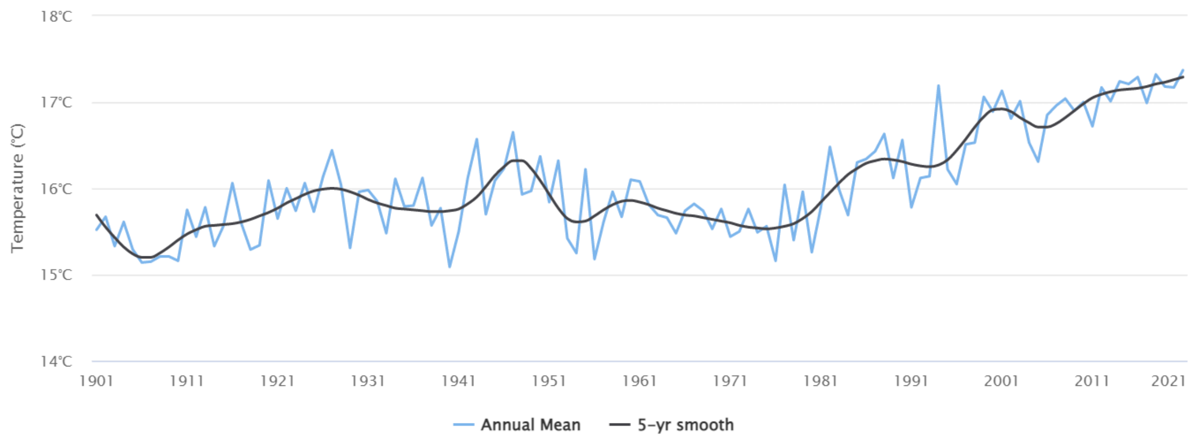

Figure 3.6: Observed Average Annual Mean Temperature of Sicily, Italy for 1901-2021. [3]

Looking at historical precipitation data, it is possible to observe variable trends with recurring increasing and decreasing cycles. Between 1960 and 1990, the average values present a slight increase from the ones of previous decade, with a peak of 580mm per year in the 1970s. On the other hand, the 21st century saw a slight rise in the average precipitations during the increasing period, followed by a great decrease in the 2010s. Indeed, 2021 was the beginning of the new increasing cycle and had an average of 481 mm, a good 101mm less than in the 1970s.

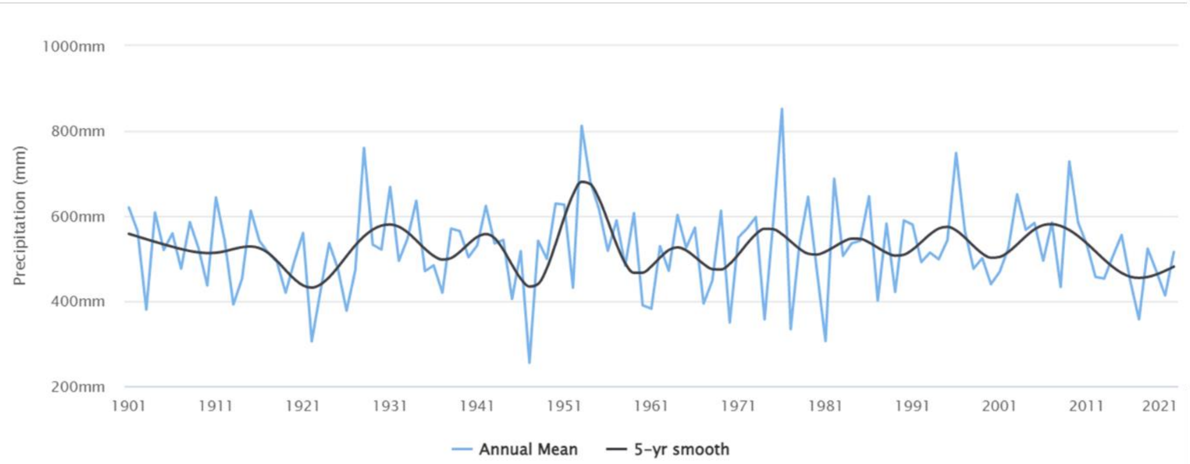

Figure 3.7: Observed Average Annual Precipitation of Sicily, Italy for 1901-2021. [4]

3.4 Climate projections

Based on the projections for the next 10 years made by Think Hazard, in the project area, river flood hazard is classified as very low based on modeled flood information currently available to this tool. This means that there is a chance of less than 1% that potentially damaging and life-threatening river floods occur in the coming 10 years.
Urban flood hazard is classified as very low based on modeled flood information currently available to this tool. This means that there is a chance of less than 1% that potentially damaging and life-threatening river floods occur in the coming 10 years.
Coastal flood hazard is classified as high according to the information that is currently available. This means that potentially damaging waves are expected to flood the coast at least once in the next 10 years.
Water scarcity is classified as medium according to the information that is currently available to this tool. This means that there is up to 20% chance droughts will occur in the coming 10 years
Extreme heat hazard is classified as medium based on modeled heat information currently available to this tool. This means that there is more than a 25% chance that at least one period of prolonged exposure to extreme heat, resulting in heat stress, will occur in the next five years.
The wildfire hazard is classified as high according to the information that is currently available to this tool. This means that there is greater than a 50% chance of encountering weather that could support a significant wildfire that is likely to result in both life and property loss in any given year.

Table 3.2: Overview of the main hazard levels for each variable. [8]

Variable	Hazard level
River flood	Very low
Urban flood	Very low
Coastal flood	High
Water scarcity	Medium
Extreme heat	Medium
Wildfire	High

The following projections will be based on climate data available on the Climate Change Portal, where it is possible to analyze how climate change will impact the Sicilian climate in the long term. According to the SSP5-8.5 scenario, between 2060 and 2080 the local temperatures will increase of about 2.1°C from the baseline (1995-2010), and during 2081-2100 the increase will be of about 4.73°C (Figure 3.8).
On the other hand, the intermediate scenario SSP2 – 4.5 shows milder increases: only 1.5°C for 2041-2060 and 2°C for 2081-2100 (Figure 3.9).

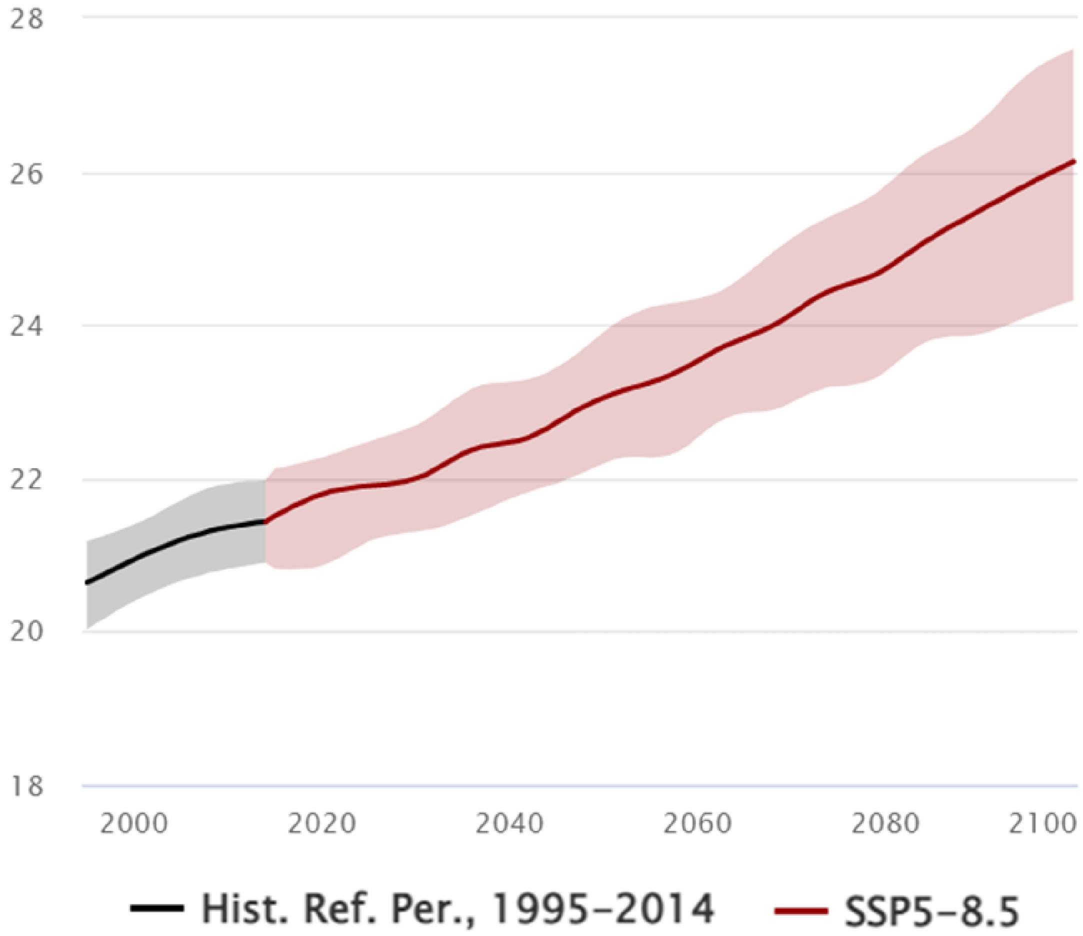

Figure 3.8: Maximum temperature in Sicily, 2000-2100, SSP5-8.5. [9]

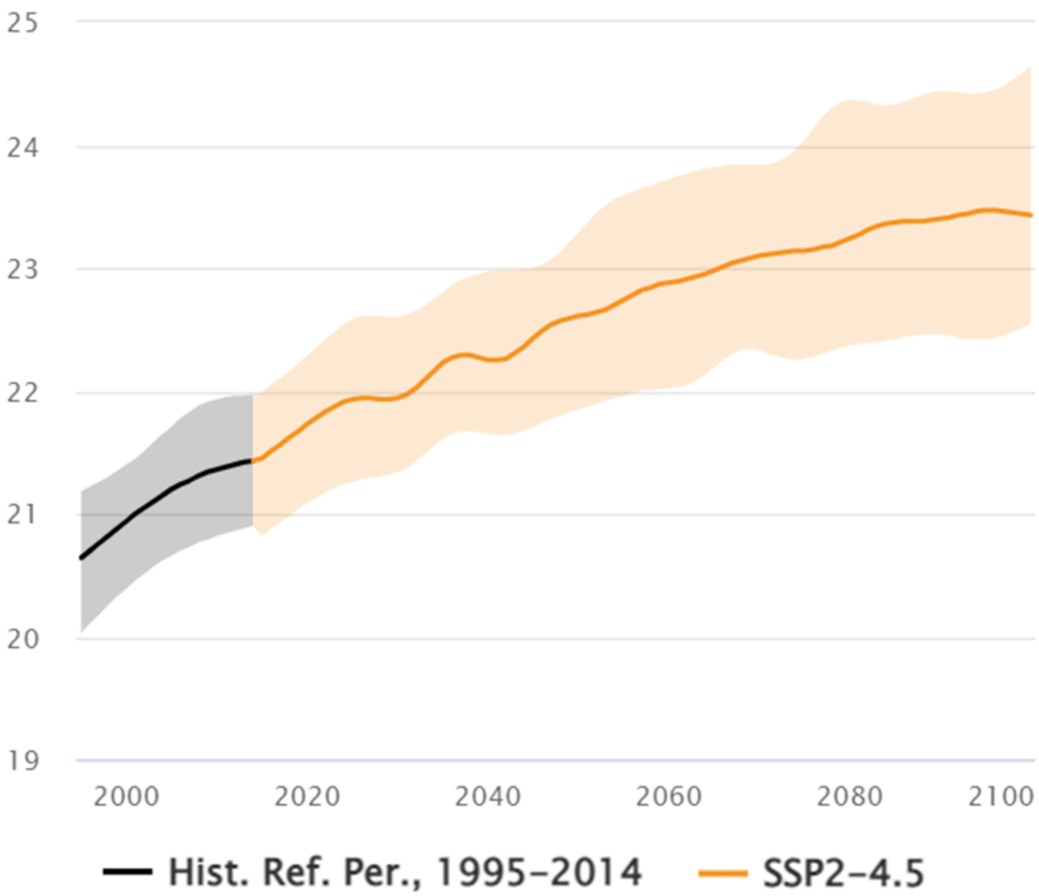

Figure 3.9: Maximum temperature in Sicily, 2000-2100, SSP2-4.5. [9]

The projected consecutive dry days, calculated with the SSP5-8.5 scenario, show an increase of 12 days for the medium term (2041-2060) and of 33 days for the long term (2081-2100). If the intermediate scenario is considered, the increase from the current average of 74 consecutive dry days is of 8 days for the medium term, and 19 for the long term.

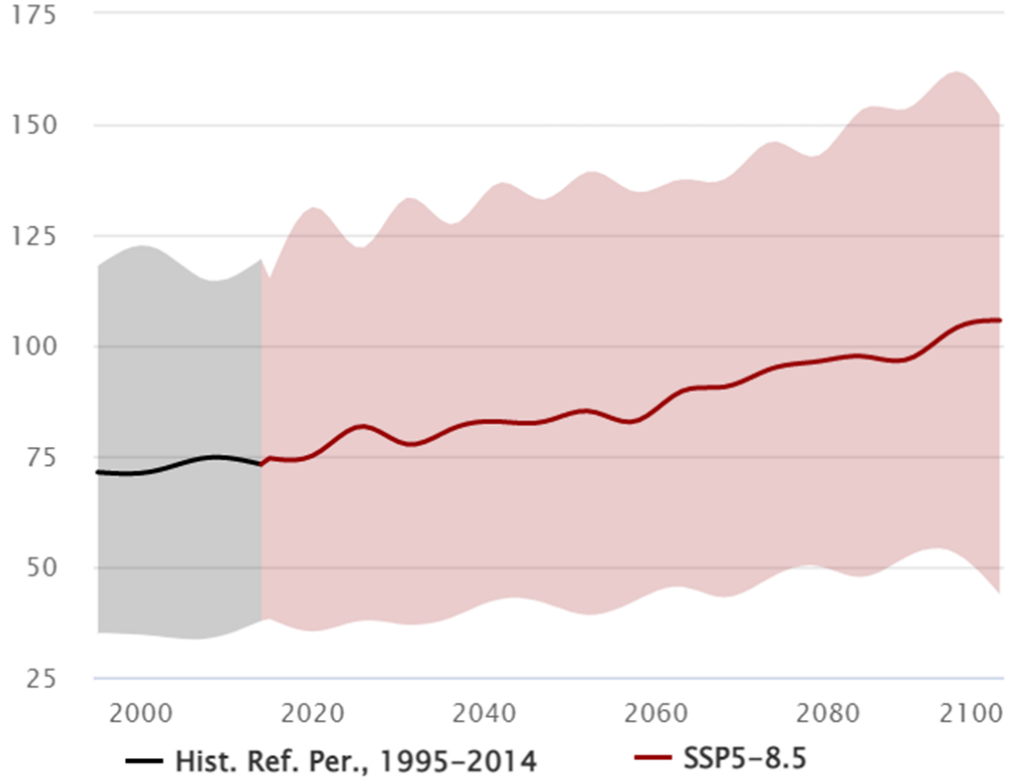

Figure 3.10: Consecutive dry days in Sicily, 2000-2100, SSP5-8.5. [10]

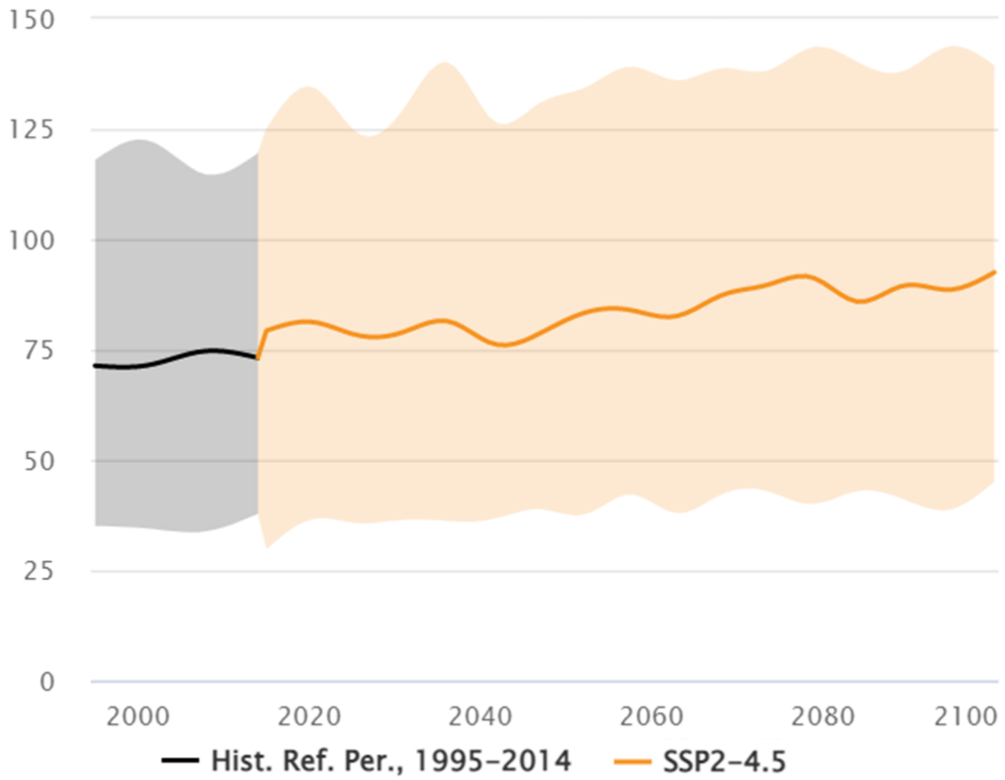

Figure 3.11: Consecutive dry days in Sicily, 2000-2100, SSP2-4.5. [10]

For the 2060-2079 period, the project area will have more days with a heat index greater than 35°C compared to the baseline (1995-2014). The difference will be of +9 days with the SSP2-4.5 scenario, and of +22 days with SSP5-8.5.
Between 2080 and 2100 the region will see a further growth in extremely warm days (over 35°C), both according to the SSP2-4.5 scenario (+19 days) and to the SSP5-8.5 one (+81 days).

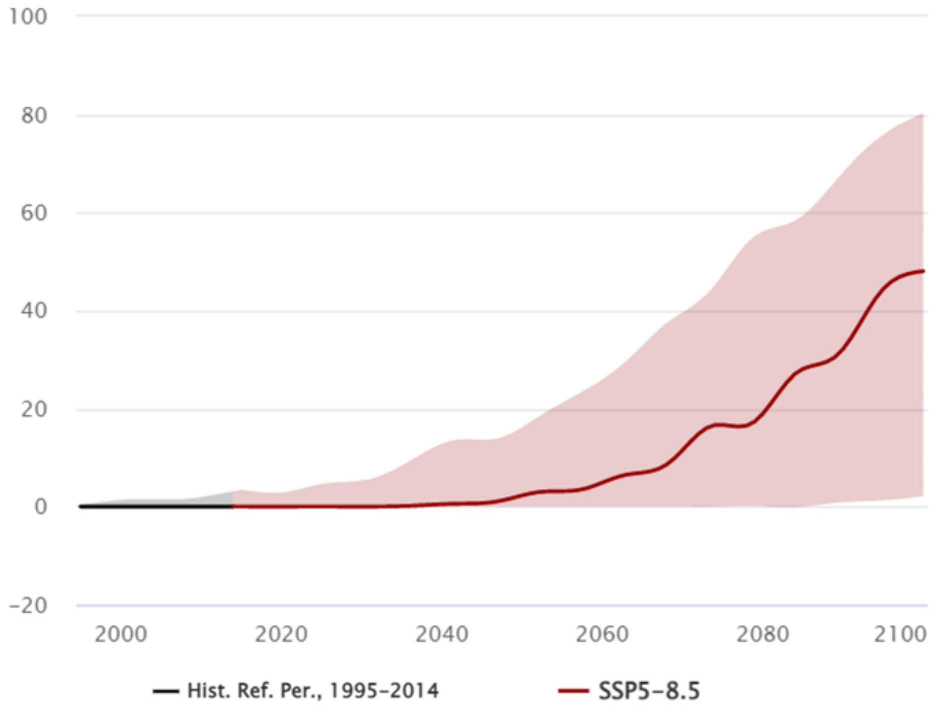

Figure 3.12: Projected days with index > 35°C Sicily, 2000-2100, SSP5-8.5. [11]

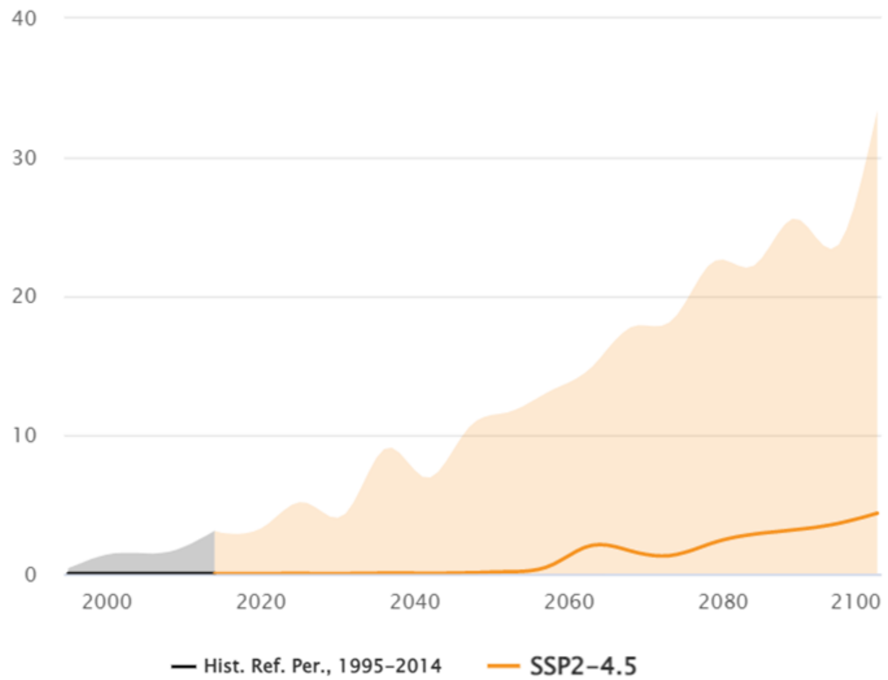

Figure 3.13: Projected days with index > 35°C Sicily, 2000-2100, SSP2-4.5. [11]

During the 21st century, Sicily will thus experience increases both of consecutive dry days (and so a decrease in precipitations) and of temperatures. These phenomena will probably, cause droughts and water scarcity, together with heat waves and wildfire hazards as previously mentioned.

4. MEDITERRANEAN SEA

4.1 Sources

This chapter uses information, data and graphs or figures from the following sources:

[31] IPCC WGI Interactive Atlas: Regional information (Advanced). Retrieved on July 21, 2022, from (link).

[32] IPCC WGII Sixth Assessment Report. Retrieved on July 21, 2022, from (Link).

4.2 Mediterranean Region climate change projections

Starting from the IPCC' projections of the Mediterranean Region's climate for the reference period 2040-2100 (SSP5-8.5 scenario), the days with maximum temperature above 35 °C will increase from the current average of 9.7 days (near term 2021-2040) to 17.4 days in the medium term (2041-2060) and to 40 days for the long term (2081-2100).

According to the intermediate scenario SSP2-4.5the days exceeding 35°C, will change from the current 8.7 days of average (near term 2021-2040) to 13.1 days (medium term 2041-2060) and to 19.8 days for the long term (2081-2100).

Table 4.1:Days with TX above 35 °C change days SSP5-8.5 (rel. to 1981-2010). [1]

Period	Scenario	Median (days)
Near Term (2021-2040)	SSP5-8.5	9.7
Medium Term (2041-2060)	SSP5-8.5	17.4
Long Term (2081-2100)	SSP5-8.5	40.0

Table 4.2:Days with TX above 35 °C change days SSP2-4.5 (rel. to 1981-2010). [1]

Period	Scenario	Median (days)
Near Term (2021-2040)	SSP2-4.5	8.7
Medium Term (2041-2060)	SSP2-4.5	13.1
Long Term (2081-2100)	SSP2-4.5	19.8

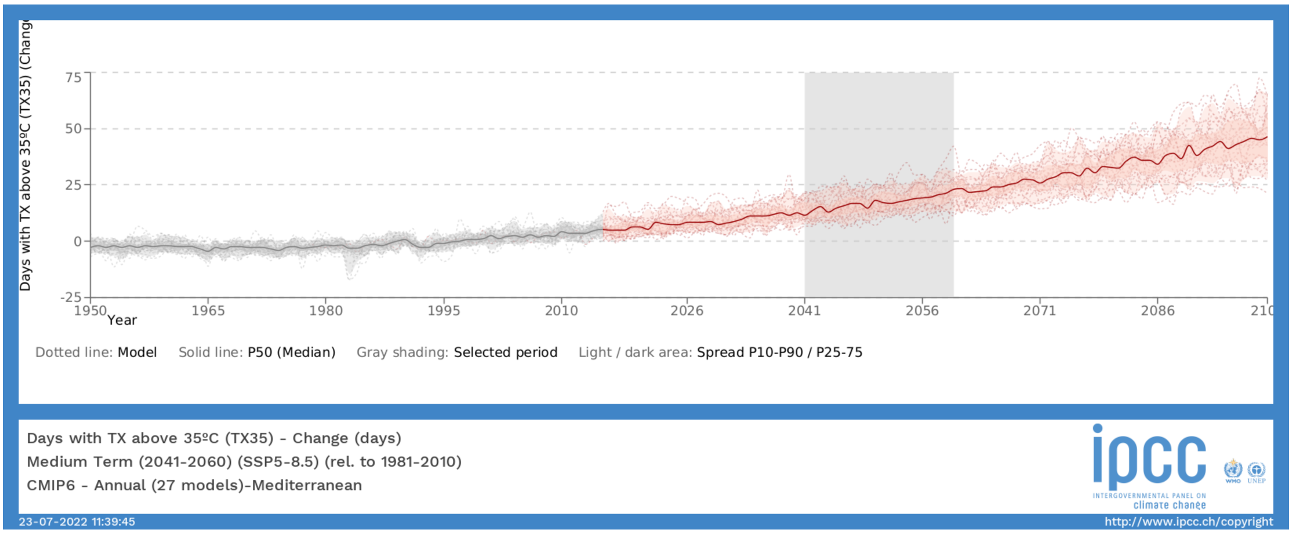

Figure 4.1: Days with TX above 35 °C change days SSP5-8.5 (rel. to 1981-2010). [1]

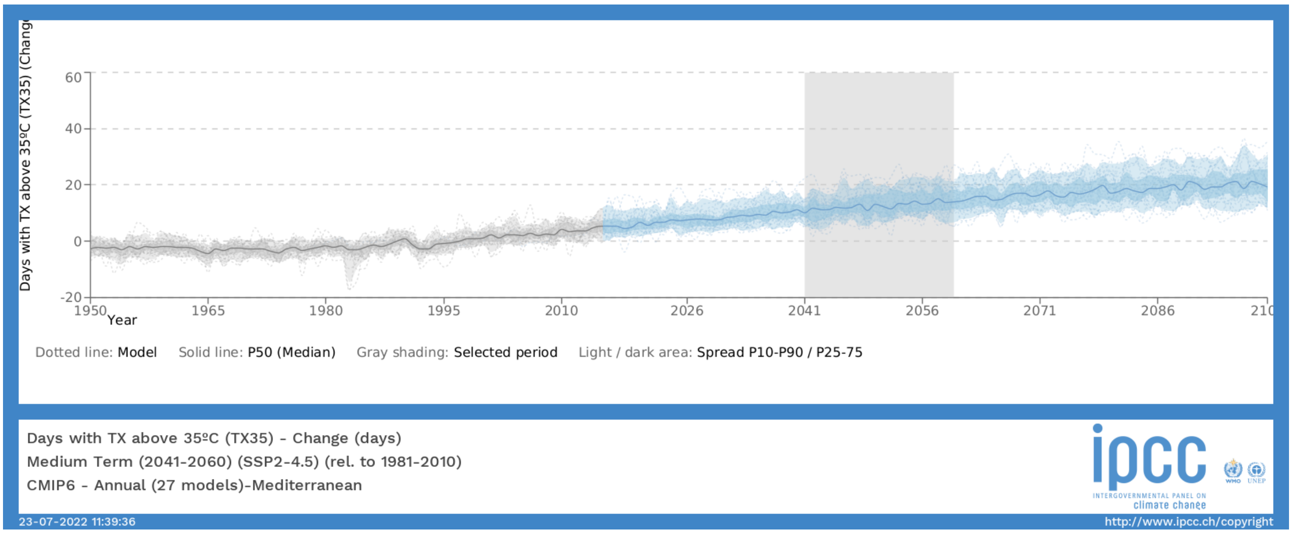

Figure 4.2: Days with TX above 35 °C change days SSP2-4.5 (rel. to 1981-2010). [1]

The consecutive dry days will also occur more frequently, passing from the current average of 4.6 days to 9.7 days in the medium term and to 20.8 days in the long term, if using the SSP5-8.5 scenario. While, when following the intermediate SSP2-4.5 scenario, the number of consecutive dry days will be 6.7 for the medium term and 10.3 for the long term.

Table 4.3:Consecutive dry days change days SSP5-8.5 (rel. to 1981-2010). [1]

Period	Scenario	Median (days)
Near Term (2021-2040)	SSP5-8.5	4.6
Medium Term (2041-2060)	SSP5-8.5	9.7
Long Term (2081-2100)	SSP5-8.5	20.8

Table 4.4:Consecutive dry days change days SSP2-4.5 (rel. to 1981-2010). [1]

Period	Scenario	Median (days)
Near Term (2021-2040)	SSP2-4.5	3.5
Medium Term (2041-2060)	SSP2-4.5	6.7
Long Term (2081-2100)	SSP2-4.5	10.3

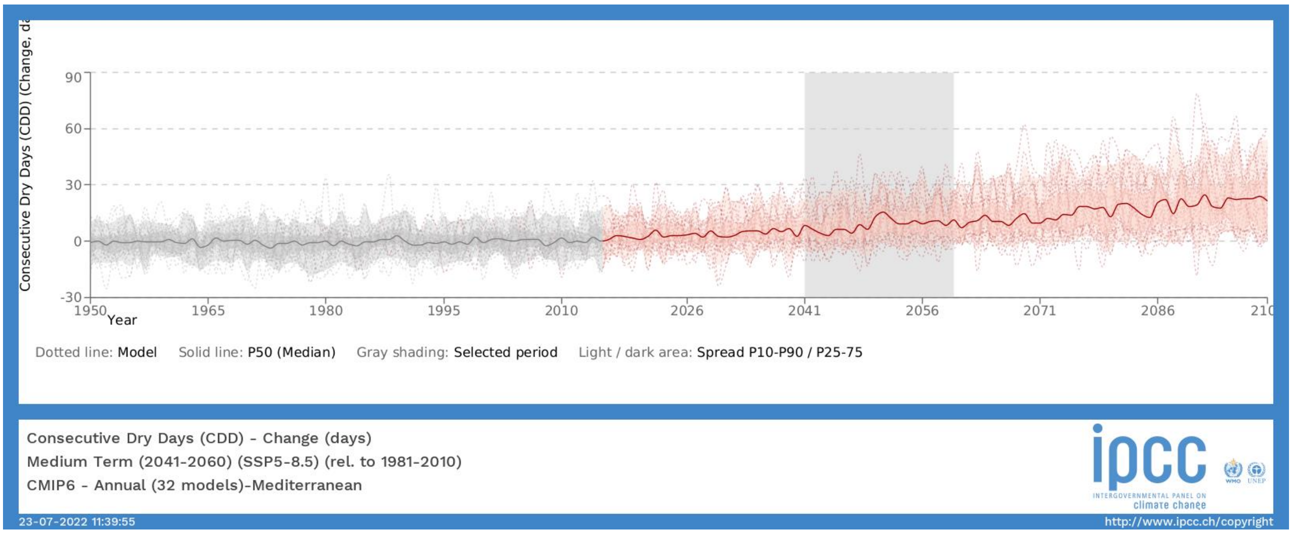

Figure 4.3: Consecutive dry days change days SSP5-8.5 (rel. to 1981-2010). [1]

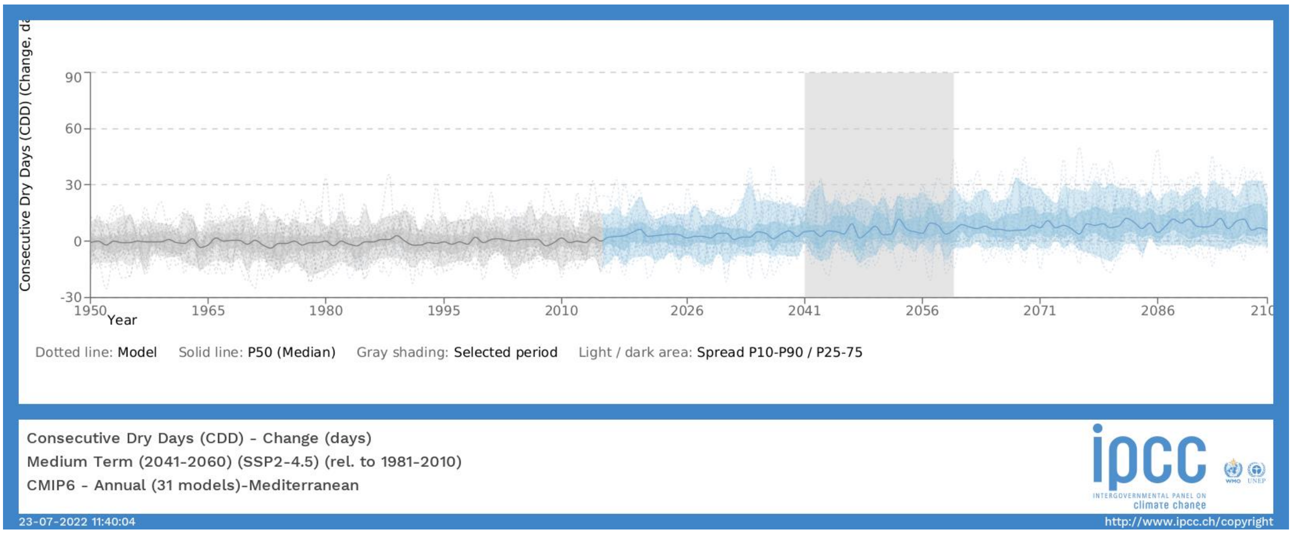

Figure 4.4: Consecutive dry days change days SSP2-4.5 (rel. to 1981-2010). [1]

For the sea level rise, the current 0.1 meters mean (near term 2021-2040) will grow to 0.3 meters (medium term 2041-2060) and 0.7 meters (long term 2081-2100), this according to scenario SSP5-8.5 by IPCC.

Based on scenario SSP5-4.5, the sea level will increase from the current 0.1 meters (near term 2021-2040) to 0.2 meters (medium term 2041-2060) or 0.5 meters (long term 2081-2100).

Table 4.5:Sea level rise change meters SSP5-8.5 (rel. to 1981-2010). [1]

Period	Scenario	Median (meters)
Near Term (2021-2040)	SSP5-8.5	0.1
Medium Term (2041-2060)	SSP5-8.5	0.3
Long Term (2081-2100)	SSP5-8.5	0.7

Table 4.6:Sea level rise change meters SSP2-4.5 (rel. to 1981-2010). [1]

Period	Scenario	Median (meters)
Near Term (2021-2040)	SSP2-4.5	0.1
Medium Term (2041-2060)	SSP2-4.5	0.2
Long Term (2081-2100)	SSP2-4.5	0.5

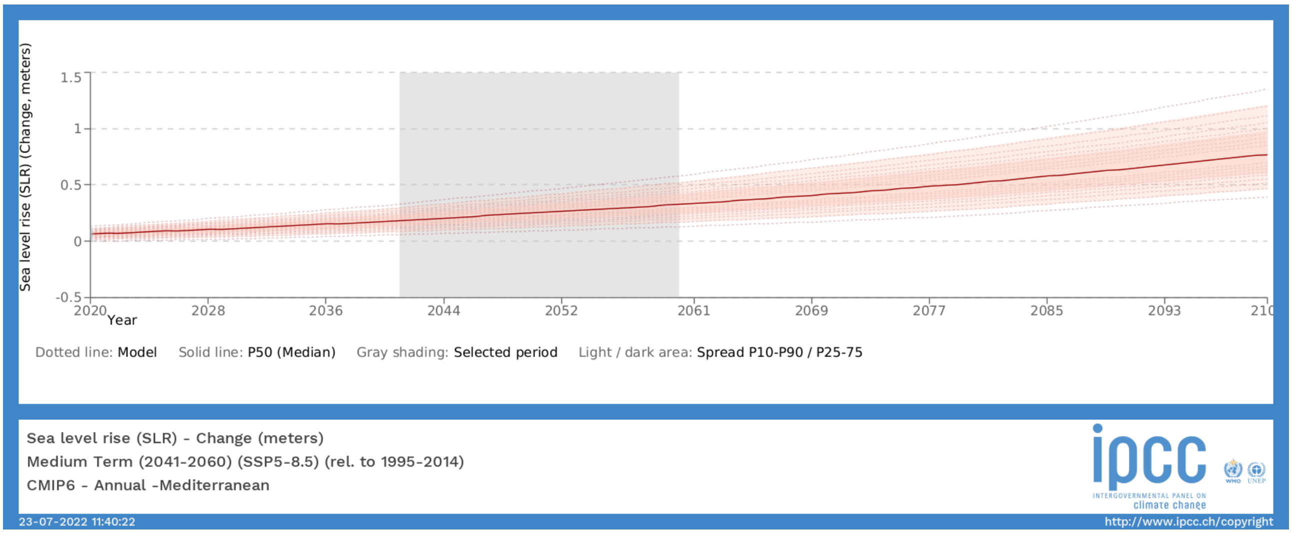

Figure 4.5: Sea level rise change meters SSP5-8.5 (rel. to 1981-2010). [1]

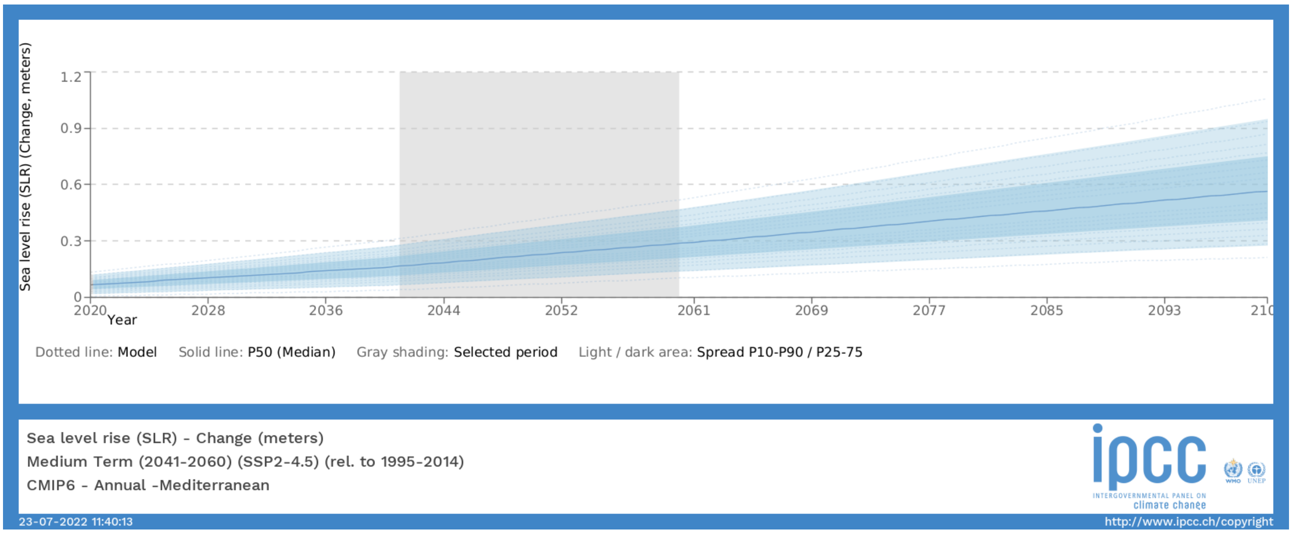

Figure 4.6: Sea level rise change meters SSP2-4.5 (rel. to 1981-2010). [1]

Using the intermediate scenario, for the reference period (2060-2070), the days with maximum temperature above 35 °C will be from 13 to 20, the consecutive dry days will be from 7 to 10, and the sea level rise will increase from 0.2 to 0.5 meters. The most important variable, according to degree of change, is the number of days with maximum temperature above 35 °C.

ANNEX

CLIMATE PROOFING ASSESSMENT

based on the European Commission's *Technical guidance on the climate-proofing of infrastructure in the period 2021-27 (2021/C 373/01)*

TUNISIA-ITALY POWER INTERCONNECTOR PROJECT

CONSOLIDATED CLIMATE SCREENING / PROOFING DOCUMENTATION

Draft for Consultations

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1. INTRODUCTION

1.1 SCOPE OF WORK

This document informs relevant authorities, investors, stakeholders and others on the climate-proofing process of the Elmed Interconnector Project, based on the European Commission's *"Technical guidance on the climate-proofing of infrastructure in the period 2021-27 (2021/C 373/01)".*

This document also aligns with the EU provisions that projects supported by EU funds and programs are subject to climate-proofing to qualify as compatible with the Union's commitment to the Paris agreement and the European Green Deal. Specifically, Projects of Common Interest (PCI) must undertake a climate proofing assessment to avail EU financial assistance via the Connecting Europe Facility (CEF) for Energy.

The main objective of the study is the identification, classification and management of the project's climate-related physical risks, namely those related to climate mitigation (i.e., the amount of greenhouse gas emissions arising from the project and how the Elmed project can contribute to the overall targets for GHG reduction), as well as to climate change vulnerability (i.e. main climate change hazards and the nature and extent to which climate change and its impacts may harm the project).

Quantifying and monetizing greenhouse gas emissions remain the basis for the climate-mitigation analysis. The document includes the climate neutrality screening process and detailed Cost-Based Analysis (CBA) inclusive of the project's GHG emission assessment, monetization of the shadow cost of carbon, and the verification of the project's compatibility to credible GHG emission reduction pathways.
The Climate Risk and Vulnerability Assessment (CRVA) remains the basis for identifying, appraising and implementing climate change adaptation measures.

The essential contents of the climate-proofing report are also the pursuit of the following specific objectives:

- Foster project preparedness to integrate commensurate adaptation measures throughout the Elmed project development cycle, coordinated explicitly with the EIA process.
- Support investment decisions under European and other potential institutional and private budgets, providing science-based climate information on the project.

1.2 THE TUNISIA–ITALY INTERCONNECTION "ELMED PROJECT"

The **Elmed Power Interconnector Project** (hereafter "the Project" or "Elmed Interconnector") is a 200 km, 600 MW interconnection between Tunisia and Italy (Sicily) to be realized through an HVDC submarine cable.

Once built, the Project will determine significant benefits for the electricity systems of both countries and, overall, for the European and North African energy systems. The Project aims to improve the security of supply while increasing Renewable Energy Sources (RES) penetration both in EU and Nord Africa thus contributing to the achievement of the EU and global climate objectives.

1.3 PROJECT JUSTIFICATION

1.3.1 Project Foundation

The Italian Transmission System Operator (TSO), **TERNA** (Rete Elettrica Nazionale S.p.a) and the Tunisian energy utility **STEG** (Société Tunisienne de l'Eléctricité et du Gaz), started cooperating for the development of a project connecting the Italian and Tunisian electrical networks at the end of 2000s.

In 2007, the Governments of Italy and Tunisia signed a Joint Declaration instructing TERNA and STEG to develop the project to interconnect the electrical systems of the two countries. To reach this purpose, STEG and TERNA (Project Sponsors) established the company **ELMED Etudes Sarl** (a 50:50 joint venture) to carry out the necessary studies and activities preceding the construction of the infrastructure.

Since then, significant work was undertaken by Elmed Etudes during the Pre-Feasibility phase of the project to refine the approach to the interconnector and prepare its implementation. This phase identified the connection through a High Voltage Direct Current (HVDC) - 600 MW marine cable as the preferred project technological solution. Optimal site locations for building two conversion stations were identified near Partanna (Sicily – Italy) and Mlaâbi (Menzel Temime area in the Cap Bon peninsula – Tunisia), along with the AC cable routing from the converter stations to the respective countries' grid nodes. Currently, under a Technical Assistance (TA) grant agreement signed by the Government of Tunisia with the World Bank, the project is preparing the studies establishing the technical, environmental, social, and financial feasibility, including the Climate Proofing assessment – *this document.*

Given its strategic importance for the Italian and EU energy supply and sustainability goals of the two countries and the creation of a Euro-Mediterranean electricity network, the project was included in the TYNDP (Ten Year Network Development Plan) of the European Network of Transmission System Operators (ENTSO-E) and the Ten-Year Mediterranean Network Development Plan (TYMNDP) of the Mediterranean Association of Transmission System Operators (MED-TSO).
Further, having demonstrated positive effects in the mid and long-term scenarios[1] for Italy, Tunisia and other EU member states, the Project was included in the PCI list (Project of Common Interest), to benefit from accelerated planning and permit granting. By its inclusion in TYNDP and, subsequently, in the PCI[2] lists, the Project will be candidate for the Connecting Europe Facility (CEF) funding programme.

The Elmed interconnector is also included in the Italian National Energy and Climate Plan (PNIEC), the Republic of Tunisia's Development Plan 2016-2020 and "*Vision Stratégique du Secteur de l'Energie 2050*". The project is also endorsed by the Governments of Malta, France, Germany and Algeria.

In April 2019, the Italian Ministry of Economic Development (MISE) and the Tunisian Ministry of Industry signed an intergovernmental agreement to support the project's development, which entered into force on January 25, 2022.

[1] *Cfr.* (ENTSO-E, TYNDP 2020 Projects Sheets_29: Italy-Tunisa s.d.), and (World Bank 2018)
[2] Being part of the TYNDP is a requirement for transmission projects to be eligible for the PCI status.Inclusion in PCI list is an eligibility condition to avail EU financial assistance via the Connecting Europe Facility (CEF) for Energy.

1.3.2 Project Objectives and Benefits

Project objectives and benefits are seen in this document from the viewpoint of climate targets and sustainability. In this sense, the Elmed project contributes to the core objectives laid down in the TEN-E regulation for PCI eligibility. In addition, the project aligns with the European Green Deal key policy areas and new EU Taxonomy, and with the EU's New Strategy for Africa. Other specific drivers include **quality and security of supply, market integration and competition**, and related **socio-economic benefits** for the two interconnected countries.

The implementation of the Elmed Interconnector presents several direct and indirect benefits for climate-related targets and sustainability:

- **Energy efficiency:** the Elmed HVDC interconnection allows electricity to be transmitted across large distances and between countries with minimal technical line losses, cutting down on energy waste and copper use. Increased efficiency of HVDC reduces losses from 5 - 10% in an AC transmission system to around 2 - 3% for the same application in HVDC. At the same time, it also improves the performance and efficiency of the connected AC networks.
- **Emissions reductions:** as a result of the cross-border interconnection and more efficient transmission, power can be distributed among the interconnected areas (EU-Nord Africa), with a significant reduction of the electricity that needs to be generated to satisfy electrical demands. This entails generating less carbon emissions (higher RES production and share) and operating at lower emission levels than expected to prevail or materialize under "without-project" conditions, contributing to global emission reduction targets.
- **RES Integration:** T&D systems interconnecting electricity markets are increasingly seen as an enabler for renewable energy and climate neutrality objectives, and as such, a mean to help achieve the dedicated goal of sustainable energy. The Elmed project contributes to scaling up, diversifying and helping the deployment of RES between the two countries and overall in the Mediterranean region. The HVDC Elmed Interconnector also reduces overgeneration and the need for frequency regulation that comes with a high penetration of renewable electricity sources. Further, the Elmed project may allow more exchanges of green energy from an area where an excess of renewable generation is available to areas where only a small fraction of RES is generating energy. This contributes to avoiding the need to curtail renewable sources that cannot be used locally and increases the total amount of RES generation capacity that can be integrated into the electrical systems (EU-North Africa).
- **Climate targets:** the Elmed project has gained increasing support from the Italian and Tunisian Governments, EU and other international organizations, also considering the benefits it can offer to climate mitigation efforts. IPPC's climate projections underscore the importance for mitigation efforts to be mainly centered on the energy sector through a substantial increase of RES generation to reach national and global climate targets in the energy sector, with possible spillovers in other industry segments.
- **Socio-economic benefits:** the project may reduce socio-economic gaps in Europe and North Africa. Potential social and economic outcomes of the Elmed project include (i) employment and income-generating opportunities; (ii) enhanced government capacity to provide reliable and competitive energy services; (iii) productivity gains in both public and private sector, associated with cost reductions and reliability/security of supply for buyers and consumers, improving "Social Economic Welfare" (SEW).

Finally, the project could also encourage the role of Sicily as a European energy hub in the Mediterranean basin. Sicily, a lagging European region with low economic growth, could be favorably affected by the RES transition to overcome economic constraints. Economic progress of a similar scale can also sustain Tunisia's political progress.

1.4 PROJECT IMPLEMENTATION

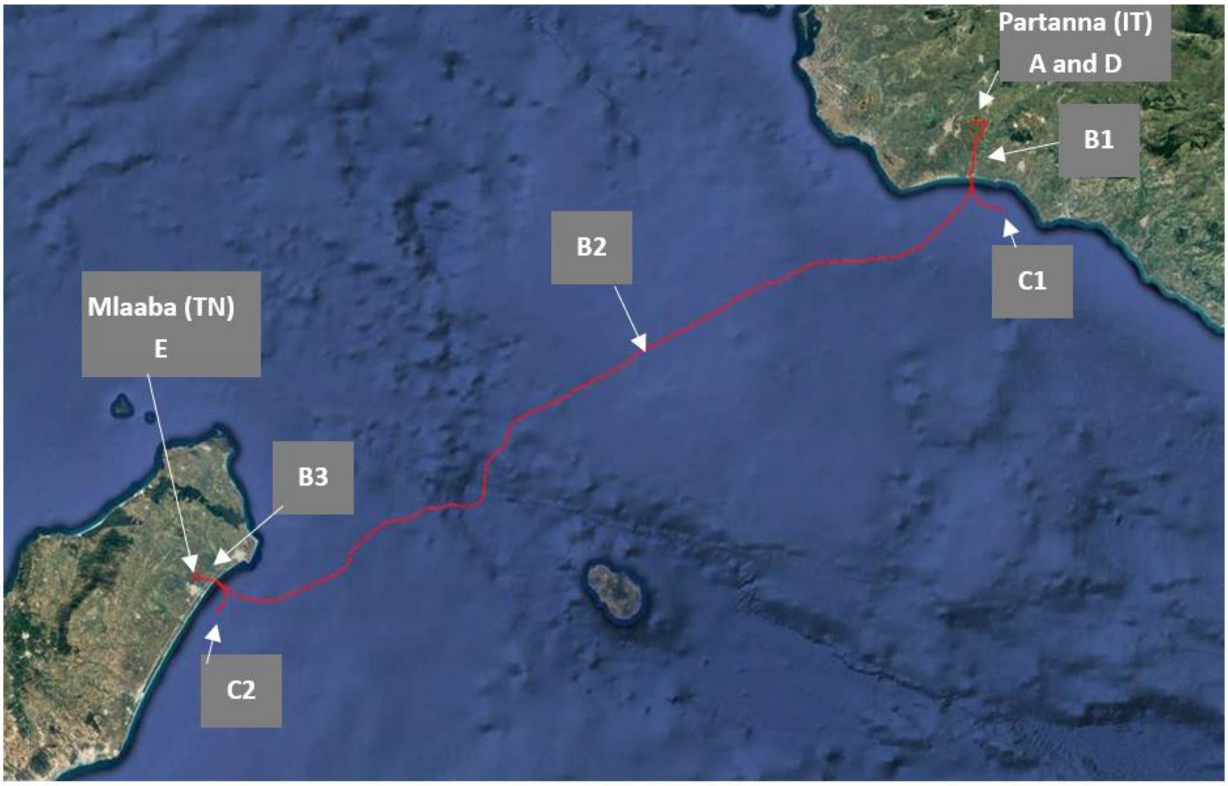
1.4.1 Project Components

The Elmed Interconnector project will link the European and North Africa energy markets with a direct current interconnection between the electricity grids of Tunisia and Italy. The interconnection will ensure an operating voltage of ± 500 kV and a Net Transfer Capacity (NTC) of 600 MW.

The infrastructure components consist of a 200 km long subsea HVDC cable connecting the Italian and Tunisian coasts, and short stretches of underground transmission line (HVDC cables) between shore landfall points and converter stations (10 km underground cable in Tunisia and 16 km in Italy). In addition, the project entails constructing two Alternating/Direct Current (AC/DC) converter stations: one in Mlaâbi municipality, in the Cap Bon area of Tunisia, and the other in Partanna municipality in Sicily, Italy.

At the Italian side, the new AC/DC converter station will be connected through a 2 km underground cable (HVAC 220 kV) to Partanna HV Substation. The Tunisian side infrastructure components require a new DC/AC converter station in Mlaâbi. Associated works include facilities required during construction (work sites, crossings, construction sites, access roads).

Figure 1: Overview of the Project



More specifically, the ELMED Interconnector will be composed of the following installations:

Table 1: Summary of project components

MARINE COMPONENTS	
Marine HVDC cable	HVDC cable between the two landing points in Tunisia and Italy (200 km) (**Work B2**);
Marine electrode cables	n.2 electrode cables between each landing point and one electrode to be located at the seaside (**Work C1 and C2**).
ITALIAN SIDE	
Converter substation	AC/DC converter station near the HV substation in Partanna; (**Work A**)
Land routing section	DC underground cable between the landfall point and the converter station (16 km) (**Work B1**), and Ac cables between the AC/DC converter station and HV substation in Partanna (2 km) (**Work D**);
Landfall	Transition point from DC marine cables to DC terrestrial cables in Marinella di Selinunte
TUNISIAN SIDE	
Converter substation	DC/AC converter station in Mlaâbi municipality of Menzel Temime, Nabeul Tunisia (**Work E**)
Land routing section	DC underground cable between the landfall point and the Mlaâbi converter station (6 km) (**Work E**);
Landfall	Transition point between DC marine cables and terrestrial cables in Kelibia

The project is currently in permitting phase through Phase 2 of World Bank's technical assistance to the Republic of Tunisia to prepare technical feasibility studies, which will help define a bankable structure that may enable private sector participation in financing. Commissioning is expected in 2028 for the HVDC interconnection between Italy and Tunisia. The Elmed interconnector and the converter stations will be designed for a technical lifetime of 40 years.

1.4.2 Financial Information

The Elmed interconnector has an updated estimated CAPEX (2022) of about 850 MEUR and OPEX of 3 MEUR for the HVDC Interconnector. This estimate includes the cost of the undersea and underground HVDC transmission cable and converter stations, laying of both DC cables, protection of the DC undersea cable, and engineering, supply, and installation of necessary accessories.

Financial analyses performed by project promoters have demonstrated a need for investment subsidies from institutional financial entities (e.g. CEF program, World bank funds etc.).

Regarding the ownership structure of the future ELMED interconnector, the inter-governates agreement between Italy and Tunisia signed in 2019, TERNA and STEG will implement the project. The ownership and governance arrangements on the commercial, regulatory, and financial structure of the Project will be regulated under a dedicated cooperation agreement.

2. DEFINITION AND SCOPE OF THE CLIMATE PROOFING PROCESS

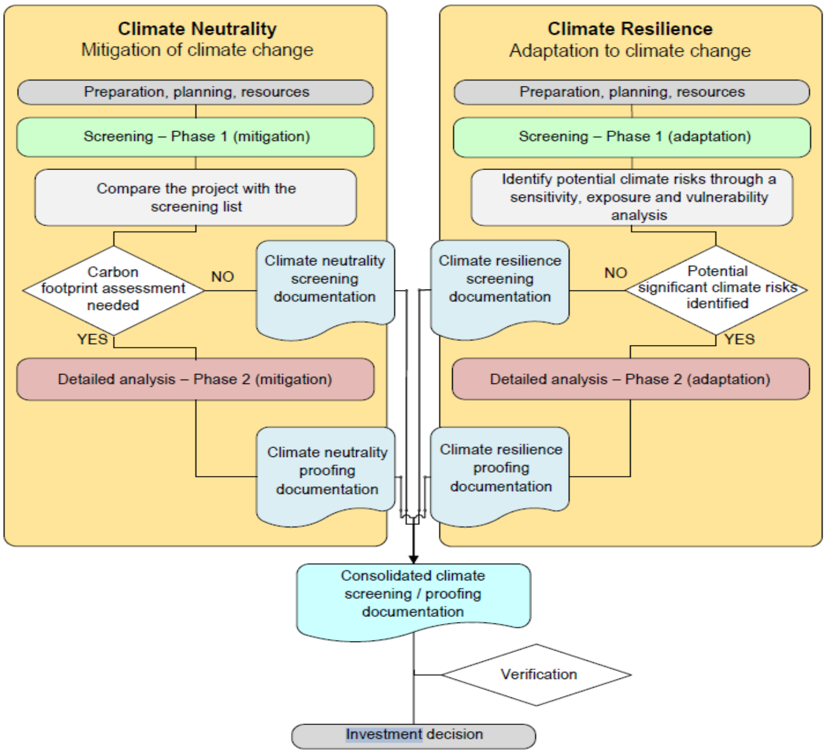
Climate proofing is a systematic process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects. It enables European institutional and private investors to make informed decisions on projects that qualify as compatible or contribute to the EU's broader sustainability commitments of the Paris agreement. It may also be a useful reference for public authorities, implementing partners, stakeholders and other interlocutors of the project.

As an essential component of an investment decision, the Climate Proofing documentation provides potential investors with consolidated and credibly documentation to ensure that financing and investment operations do not contradict or impair climate objectives and that the infrastructure is resilient to climate change hazards.

The process comprises two pillars (Mitigation and Adaptation) and two phases (screening and detailed analysis). The detailed analysis is subject to the outcome of the screening phase.

The approach presented in this documentation largely mirrors the methodology described in detail by the EU Commission technical guidance on the climate-proofing of infrastructure in 2021-2027 ('*Guidance on the climate-proofing of infrastructure in the period 2021-2027*'). As a result, it draws on internationally recognized methodologies for assessing and mitigating GHG emissions and for the Climate Risk and Vulnerability Assessment (CRVA). A reference and further reading section lists the various sources of information referred to throughout the document and is provided as Appendix A.

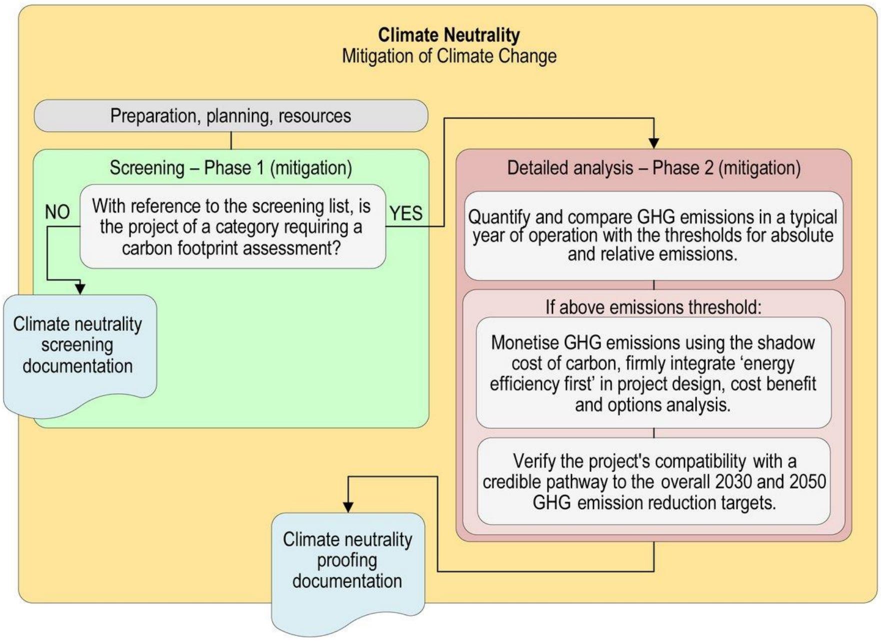
Figure 2: Climate screening/proofing process



3. CLIMATE NEUTRALITY (MITIGATION OF CLIMATE CHANGE)

For climate change mitigation, the primary reference for assessing GHG emissions is the EIB's Carbon Footprint Methodology (European Investment Bank, 2022), as recommended in the 'Guidance on the climate-proofing of infrastructure in the period 2021- 2027' (EC 2021[2]).

Figure 3: Climate proofing – Mitigation Phase



3.1 Methodology and Limitations

The climate neutrality assessment is based on the outcome of the Screening (Phase-1 mitigation) that determines whether the Detailed Analysis (Phase-2 mitigation) should be carried out. As further elaborated in Section 3.2, the screening phase reveals that a Phase-2 may not be necessary for the Elmed project. However, this report presents a Detailed Mitigation Analysis based on the project's CBA, undertaken in compliance with the ENTSO-E methodologies approved by the EU Commission.

Specific methodological considerations drive the decision to present a detailed mitigation analysis:

(i) Extend all possible information to stakeholders and potential investors so that any opinion concerning the project's climate mitigation inputs may build on science-based, reliable and up-to-date information.

(ii) Underline the strategic importance of the ENTSO-E CBA for the project, as the reference methodology and regulatory framework for the climate assessment of TYNDP transmission projects across Europe, and for PCIs and CEF Energy funding requirements[3].

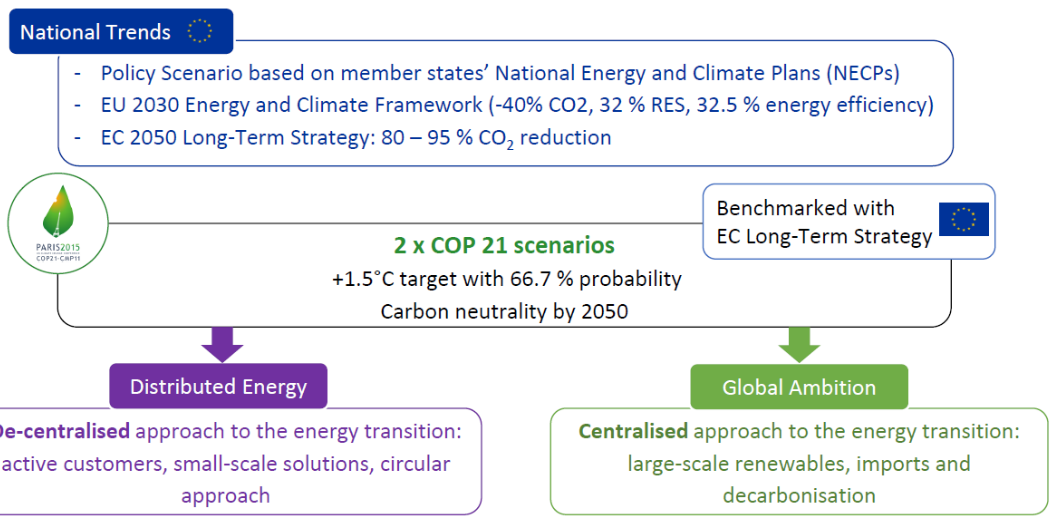
(iii) Integrate the results of the carbon footprint analysis in the Elmed project development cycle, so that it can be used as a tool to select and promote options low-carbon choices as well as the energy efficiency first principle.

[3]The ENTSO-E CBA is in compliance with TEN-E Regulation (EU) No 347/2013 (EU 2013), and specifically *Chapter IV: Regulatory treatment – Rules and guidance for the Cost-Benefit Analysis (CBA), Cross-Border Cost Allocation (CBCA) and incentives for PCIs*

The methodology and indicators elaborated for the mitigation detailed analysis are summarized in Table 3 to provide a complete overview of the CBA's methodological approach and limits. The figures provided for each indicator refer to the cost (gain) of the overall Elmed project infrastructure, namely the carbon footprint effects expressed as the sum of delta (**Δ)** on Italian and Tunisian side respective infrastructure components, quantified for a typical year of operation. In addition, to verify that the project qualifies as compatible with climate pathways aligned with the relevant national, EU Green Deal and global COP21 targets, the climate neutrality benefits delivered by the Elmed project are assessed under the following climate scenarios:

1) **"National Trends"** designed to reflect the most recent National Energy and Climate Plans (NECP), submitted to the EC in line with the requirement to meet current European 2025 and 2030 energy strategy targets. National Trends aims to reflect the commitments of each Member State to meet the targets set by the EU in terms of efficiency and GHG emissions reduction for the energy sector. At the country level, National Trends is aligned with the NECPs of the respective Member States, which translate the European targets to country-specific objectives for 2025 and 2030.
2) **"Distributed Energy"** and "**Global Ambition"**, also referred to as "COP21 Scenarios", are two scenarios in line with the COP21 targets to reduce EU-28 emissions to net zero by 2050. These scenarios are also meant to assess sensible pathways to reach the target set by the Paris Agreement for the COP21: 1.5°C or at least below 2°C by 2100.

Figure 4: National Trends and COP21 Climate Scenario of the ENTSO-E CBA



3) The Elmed project assessment also includes a '**Current Trends'** scenario, a future where the energy transition is slower than planned. Requested to ENTSO-E by the Agency for the Cooperation of Energy Regulators (ACER), the Current Trends scenario considers a future with low economic growth, which leads to restrictions in meeting the EU climate targets. A complete description of the climate scenarios is provided in the TYNDP 2020 Scenario Report (ENTSO-E 2020[3]).

Finally, the outcome of the project's mitigation analysis is summarized in the project's climate neutrality statement in Section 3.4.

3.2 Screening – Phase 1

Electricity transmission lines are included in the screening list of project categories that generally require a carbon footprint assessment. However, the EIB carbon footprint methodology stipulates that the investments in electricity T&D networks must be divided into three categories, as each category is characterized by its objectives and contribution to GHG emissions[4].

Based on the main project drivers of RES integration, Efficiency and Market Integration, and Quality and Security of Supply (*cfr.* Section 1.3.2), and since not primarily intended to increase the supply (volume) of electricity through the network, the Elmed investment should fall under Category I.

As such, per the EIB's carbon footprint methodology, **the Elmed Project investment should have little or no impact on GHG emissions**. Their effects are excluded from the carbon foot printing calculation to quantify GHG emissions. Consequently, <u>the Elmed project does not need to undertake a detailed mitigation analysis.</u>

The mitigation screening result for the Elmed project also builds on the EU Taxonomy Regulation, and specifically on the conclusions of the final report on sustainable economic activities drawn by the Technical Expert Group on Sustainable Finance (TEG) (EC 2020[4]), and EU Regulation No. 2021/2139 establishing the technical screening criteria under which an economic activity qualifies as contributing substantially to climate change mitigation (EC 2021[1]):

- Support the integration of renewable energy into the power grid
- Support the transition from carbon-intensive energy supply, via electrification and the parallel development of low carbon power generation capacity
- Support of grid management technology used for integrating low carbon emission generation and demand-side energy savings
- Decreases direct emissions from transmission and distribution (T&D) infrastructure

The performance metrics and thresholds in these criteria are science-based and developed on the basis of a robust methodology and an inclusive process (*cfr.* JRC, 2021*).* TEG designated the Transmission and Distribution of the Electricity sector as one of the key economic activities that will substantially contribute to climate change mitigation in alignment with EU-Paris benchmarks. The T&D of the Electricity sector (NACE sector D.35.12[5]) is considered per definition as significantly contributing to climate change mitigation objectives because of its emissions profile while considering the need for electrification to achieve the climate objectives (EC 2020[2]). Of note, the sector was designated as a substantial contributor based on the sector activities' performances on Mitigation (intended as activities with a net positive contribution – net negative emissions) and as "enabling" activities, meaning that they directly enable other sectors to make a substantial contribution to reducing emissions (EC 2020[4]), (JRC 2021). <u>Hence, based on the technical screening criteria of the Taxonomy, a carbon footprint assessment is not necessary for investments in electricity T&D networks.</u>

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[4] Annex 2: Network Investments – Gas and Electricity (European Investment Bank, 2022)

[5] The T&D of Electricity Sectors description under the EU Taxonomy includes the following infrastructures and therefore all the project infrastructure components within the Elmed project boundary:

(i) Construction and operation of transmission Systems that transport the electricity on the extra high-voltage and high-voltage interconnected System.

(ii) Construction and operation of distribution Systems that transport electricity on high-voltage, medium-voltage and low-voltage distribution Systems.

(iii) Construction and operation of interconnections that transport electricity between separate Systems.

Further, regarding climate scenarios, the Interconnected European System projects under TEN-E regulation (such as the Elmed Project) meet the technical screening criteria for activities that can set sectors on a path consistent with full decarbonization by 2050. Therefore, they are derogated from carrying out the quantitative mitigation assessment (or "detailed analysis" under the EC's Technical Guidance) (EC 2020[3], pp. 238-239). This derogation will be subject to regular review of the above criteria, or if major policy changes negatively affect the EU's commitments to decarbonization.

3.3 Detailed Analysis – Phase 2

Based on the outcome of the screening phase, the Detailed Mitigation Analysis - Phase 2 may be excluded from the Climate-Proofing process of the Elmed investment. The project is considered to have little or no impact on GHG emissions and qualifies to contribute substantially to climate change mitigation and decarbonization pathways.

Still, as described in 3.1, this report presents the outcome of the project's CBA executed by ENTSO-E, in compliance with the EC's technical guidance (EC 2021[2]) and TEN-E Regulation (EU 2013). As already mentioned, the ENTSO-E based his assessment to the reference CBA methodology approved by the EU Commission for the climate assessment of the PCI projects and CEF Energy funding requirements.

The detailed analysis for the Elmed project is presented in table format (Table 2), followed by a methodological aide on indicators and supplementary information (Table 3).

Table 2: Table of Results- Italy & Tunisia net indicators – ELMED Project Detailed Analysis (Mitigation)

	Indicators				Scenarios				
Category	**Shortcut**	**Full name**	**Indicator**	**Unit (weighted average)**	**2025 National Trends**	**2030 National Trends**	**2030 Global Ambition**	**2030 Distributed Energy**	**2030 Current Trends**
B1. Socio Economic Welfare	**ΔSEW**	Annual Socio-Economic Welfare (SEW) increase (excluding Energy Not Served cost)	B1	M€ / year	**32**	**82**	**58**	**59**	**28**
	ΔSEW_CO2	Annual Socio-Economic Welfare variation resulting from CO2 emissions	B1_CO2	M€ / year	**5**	**6**	**19**	**3**	**5**
	ΔSEW_RES	Annual Socio-Economic Welfare increase resulting from RES integration	B1_RES	M€ / year	**1**	**4**	**12**	**21**	**0**
B2. CO2 variation	**ΔCO2_market**	**Annual CO2 variation from market simulation**	**B2a**	**ktonnes / year**	**-190**	**-226**	**-370**	**-83**	**-199**
	ΔCO2_market_monetised	Annual Societal gain variation resulting from CO2 variation from market simulation	B2a_€ at 100 €/ton CO2 price	M€ / year	**15**	**16**	**6**	**17**	**15**
B3. RES integration	**ΔRES**	Annual avoided curtailment (RES integration)	B3	GWh / year	**14**	**89**	**268**	**387**	**3**
B4. Non-CO2 emissions	**ΔNOx**	Nitrogen oxides	B4a	kg / year	**-218**	**-573**	-	-	-
	ΔNH3	Ammonia	B4b	kg / year	**-31**	**-115**	-	-	-
	ΔSO2	Sulphur dioxide	B4c	kg / year	**13**	**-291**	-	-	-
	ΔPM5	Particulate matter 5	B4d	kg / year	**-21**	**-18**	-	-	-
	ΔPM10	Particulate matter 10	B4e	kg / year	**-19**	**-57**	-	-	-
	ΔNMVOC	Non-methane volatile organic compounds	B4f	kg / year	**-12**	**-36**	-	-	-
B5. Grid losses	**Δlosses**	Variation of network losses	B5	GWh / year	**162**	**64**	-	-	-
	Δlosses_monetized	Variation of network losses monetized	B5_€	M€ / year	**8**	**2**	-	-	-

Table 3: Methodology of CBA Indicators - Mitigation detailed analysis

Category	*How to read the results*	*Indicators*	*Additional details on the methodology*
B1. Socio Economic Welfare	**B1 – Increase in socio-economic welfare** • A positive number means an increase in SEW • A negative result means a decrease in SEW	• **About B1 – SEW:** In power system analysis, SEW is the sum of the short-run economic surpluses of electricity consumers, producers, and transmission owners (congestion rent). Transmission networks have an effect on the sum and the distribution of these surpluses. Investment in transmission capacity generally increases the total sum of the individual surpluses by enabling a larger proportion of demand to be met by cheaper generation units that were not available before because of a transmission bottleneck. • **About SEW resulting from CO2 emissions reduction and RES integration:** The CO2 costs - ETS costs - used for the monetization of the CO2 emissions is fully internalized within the SEW. Because market simulations - for calculating the SEW - are using the same ETS costs, the monetized CO2 emissions are consistent with market simulations and can therefore correctly be displayed separately. However, for the separated expression of monetized RES integration (B1_RES), there is no correct methodology available, nor can it directly be "extracted" from market simulations. This is why ENTSO-E has assumed the monetized value of RES integration by the given method (described in detail within the TYNDP 2020 Implementation Guideline). Because this is just an assumption, the sum of monetized CO2 and monetized RES can exceed the SEW.	CBA Guideline 3.0 Section 6.4 CBA Implementation Guideline
B2. CO2 variation	**B2a Annual CO2 variation from market simulation (ktonnes / year)** • A positive value means the project causes an increase in CO2 emissions • A negative value means the project causes a decrease in CO2 emissions **B2a_€ Annual Societal cost variation: CO2 variation from market simulation monetized (M€ / year)**	• **About B2 – Variation in CO2 emissions** The European electricity system is a significant contributor to CO2 emissions. In this context, grid development can play a role in modifying the level of carbon emissions. In particular, new interconnector projects enable cheaper generators to replace more expensive plants with potentially higher CO2 emissions, leading to potentially lower CO2 emissions. This indicator gives the change in CO2 emission due to a new project or investment and in divided into two parts: the pure CO2 emission in tons and additionally the societal costs in €/year. The variations that are taken into account for this indicator are variations resulting	CBA Guideline 3.0 Section 6.5 CBA Implementation Guideline

	• A positive value means the variation in CO_2 emissions caused by the project translates in a monetized gain for society of X M euro/year • A negative value means the variation in CO_2 emissions caused by the project translates in a monetized cost for society of X M euro/year.	from the change of generation plan (B2a). Indicator B2a_€ considers a given ETS price and a societal cost of CO_2, which represents the effort that should be made in order to reach the European climate-neutral goal.	
B3. RES integration	**B3 Annual avoided curtailment (RES integration) (GWh / year)** • The project reduces curtailed electricity from RES by X GWh per year.	• **About B3 – RES integration:** B3 provides a stand-alone value for the additional RES available for the system as a result of the reinforcement project or investment. It measures the reduction of renewable generation curtailment in MWh (avoided spillage) and the additional amount of RES generation that is connected by the project. The integration of both existing and planned RES is facilitated by: • The connection of RES generation to the main power system; and • Increasing the capacity between one area with excess RES generation to other areas in order to facilitate an overall higher level of RES penetration.	CBA Guideline 3.0 Section 6.6 CBA Implementation Guideline
B4. Other GHG emissions (kg/year)	**B4 Other GHG emissions (kg/year)** • A positive value means the project increases emissions. • A negative value means the project reduces emissions.	• **About B4 – Non-direct GHG emissions** Other non-CO_2 emissions must be considered as they also have an impact on climate change so cannot be neglected. Pollution levels are increased via direct emissions, such as particulate matter and toxic elements, or via indirect methods that promote chemical reactions. This indicator gives the change in non-direct greenhouse emissions due to a new project or investment.	CBA Guideline 3.0 Section 6.7 CBA Implementation Guideline
B5. Impact on grid losses	**B5 Variation of network losses (GWh / year)** • A positive value means the project increases network losses by X GWh per year. • A negative value means the project decreases network losses by X GWh per year. **B5_€ Variation of network losses monetized (M€ / year)** • When the project increases losses, B5_€ expresses the cost that is borne by society to cover losses. When the project decreases losses, B5_€ expresses savings for society due to the avoided losses.	• **About B5 – Impact on grid losses** The energy efficiency benefit of a project is measured through the change of thermal losses in the grid. At constant power-flow levels, network development generally decreases losses, thus increasing energy efficiency. Specific projects may also lead to a better load-flow pattern when they decrease the distance between production and consumption. Increasing the voltage level and the use of more efficient conductors also reduce losses. However, transmission projects over long distances may increase losses. Although new interconnections generally decrease the electrical resistance of the grid and consequently the losses, the additional exchanges, resulting from the increase of the transfer capacities, and the change in generation size can lead to an increase.	CBA Guideline 3.0 Section 6.8 CBA Implementation Guideline

3.4 Climate Neutrality Statement

The Elmed Project is substantially contributing to reducing emissions to meet the EU’s climate and energy targets for 2030 and reach the objectives of the European Green Deal.

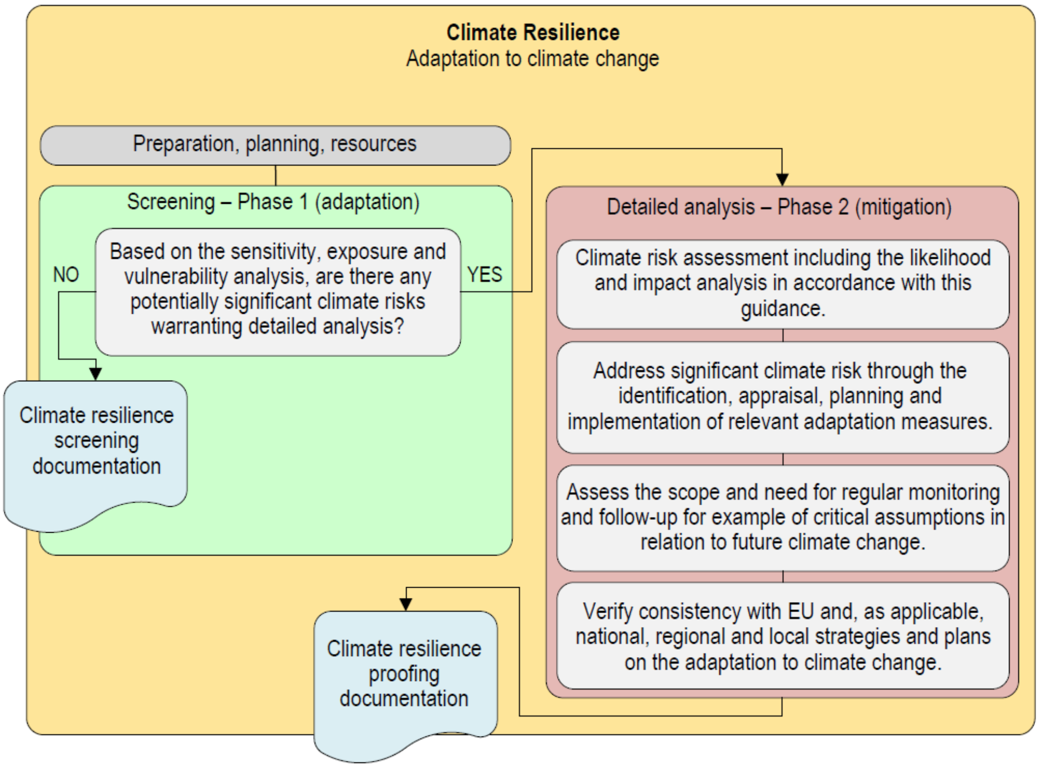
Whilst the Elmed project does not require a Climate Proofing Phase 2 - Detailed Mitigation Analysis, the carbon footprint assessment of the project and other climate-mitigation indicators elaborated from ENTSO-E cost-benefit analysis methodologies, following Regulation (EU) No 347/2013, show that <u>the project is expected to be operating at lower emission levels than would be expected to prevail or materialize under “without-project” project conditions, or to maintain the same level of output while reducing related GHG emissions.</u>

4. CLIMATE RESILIENCE (ADAPTATION TO CLIMATE CHANGE)

For adaptation, the climate-proofing documentation center around the Climate Vulnerability and Risk Assessment (CVRA) as the reference tool that helps identify the significant climate risks for the project. This approach is recommended in the 'Guidance on the climate-proofing of infrastructure in the period 2021- 2027' (EC 2021[2]) and aligns with the steps to be taken to mainstream climate resilience process throughout the project development cycle, as described in the "*Guidelines for Project Managers: Making vulnerable investments climate resilient* (EC 2012)".

Further, the climate resilience analysis for the Elmed project builds on the guidance provided by the EU Taxonomy Regulation, particularly on the technical screening criteria under which an activity qualifies as contributing substantially to climate change adaptation and the classification of climate hazards and typical sensitivities of Electricity T&D projects (EC 2021[1])(EC 2020[3]).

Figure 5: Climate proofing – Adaptation Phase



4.1 Approach and Methodology (Adaptation)

An integrated CVRA of the Project is undertaken to help manage the risks from climate variability and change and help mainstreaming climate resilience into Elmed's project lifecycle. The different assets and supporting infrastructure of the Elmed interconnector project may have different levels of vulnerability and adaptive capacity to climate change. Therefore, for this CVRA, the Climate Proofing - Adaptation Phase aims to identify the relevant climate variables and hazards for all the Elmed physical components identified in Section 1.4.1, at the planned locations in Italy and Tunisia.

The CVRA consists of two phases:

1) **Climate vulnerability assessment** (Screening – Phase 1 Adaptation): identify which physical climate risks may affect the performance of the project during its expected lifetime;
2) **Climate risk assessment** (Detailed Analysis – Phase 2 Adaptation): the risk assessment is undertaken if any of the project components are assessed to be at risk from one or more of the physical climate hazards screened in Phase 1, to evaluate the materiality of the risks (likelihood and magnitude).

This CVRA provides an initial screening (qualitative assessment) concerning the project's climate vulnerability and risks, informed by expert opinion and supporting literature and data.
The project is characterized by significant technical complexities. It may be subject to adjustments in the subsequent execution and construction phases, depending on updated technological solutions and solutions to be adopted by the suppliers.
During the engineering phase the suppliers will define the detailed technical characteristics for each equipment and system, according to the requirements set by ELMED.
In this phase, the CVRA will be consequently updated to provide a final vulnerability and risk screening, and necessary adaptation measures.,

This approach is in line with the EC technical guidance on climate-proofing, intended as a summarizing document proportionate to project complexity (EC 2012); (EC 2021[2]). Its primary purpose remains to demonstrate to stakeholders, investors and verifiers that climate resilience has been considered in the climate proofing documentation. In this sense, the CVRA aims to integrate the Elmed project development cycle without replacing or duplicating associated studies. The subsequent phases of the project will include a detailed analysis of hazards, climate trends and scenarios which may impact on the project, **and will incorporate appropriate climate resilience (adaptation) measures to manage risks to acceptable levels**.

4.2 Climate Vulnerability Assessment (Screening – Phase 1 Adaptation)

Analyzing the vulnerability of a project to climate change is the first step (screening phase) of the climate proofing adaptation assessment. The CVRA aims at identifying the physical climate risks that are material to the Elmed specific assets and components, and is broken down into three steps, comprising a sensitivity analysis (i.e., how sensitive the project's components are to climate hazards), an assessment of current and future exposure (i.e., the probability of these hazards materializing at the project locations), and then a combination of the two for the overall vulnerability assessment.

4.2.1 Sensitivity

The **sensitivity** analysis focuses on identifying the sensitivities of the physical components of the project to the climate variables and related hazards, as per EU Taxonomy classification (Table 4):

Table 4: Classification of climate-related hazards

	Temperature-related	Wind-related	Water-related	Solid mass-related
Chronic	Changing temperature (air, freshwater, marine water)	Changing wind patterns	Changing precipitation patterns and types (rain, hail, snow/ice)	Coastal erosion
	Heat stress		Precipitation or hydro-logical variability	Soil degradation
	Temperature variability		Ocean acidification	Soil erosion
	Permafrost thawing		Saline intrusion	Solifluction
			Sea level rise	
			Water stress	
Acute	Heat wave	Cyclone, hurricane, typhoon	Drought	Avalanche
	Cold wave/frost	Storm (including blizzards, dust and sandstorms)	Heavy precipitation (rain, hail, snow/ice)	Landslide
	Wildfire	Tornado	Flood (coastal, fluvial, pluvial, ground water)	Subsidence
			Glacial lake outburst	

Typical sensitivities are screened using a qualitative assessment (review of key literature, project documentation, and technical expert judgement) to identify potential climate resilience issues and the level of impact on the project's physical components, as summarized in Table 5:

Table 5: Key Climate Change Impacts on Elmed physical components[6]

Climate Variables	Physical Components	Key Impacts
Temperature related	• Transmission and distribution underground cables • OHL Overhead Line • Substations (infrastructure, switching gear, etc.) • Transformers	• Can reduce electricity carrying capacity of lines (decreased conductivity) • Can increase losses within substations and transformers. • Transformers derating
Wind-related	• Overhead lines • Towers (pylons) and poles	• Wind and storm damage (strong winds can damage T&D lines) • Increasing heat convection (positive impact - Up to 20% capacity increase for each m/s rise in wind speed
Water-related	• Transmission towers • T&D underground and marine cables • Substations (infrastructure, switching gear, etc.) • Transformers • Control/ICT System	• Heavy rains and flooding can undermine tower structures through erosion. • Drought can increase dust and lightning damage. • Potential for energy supply disruptions from sources that rely on hydropower • Flooding can damage underground cables and infrastructure in general (e.g. substations inundations), with equipment mounted at ground level in substations especially susceptible • Water-related extreme events can damage HVDC marine cables. • Acute climate events can damage control systems through loss of ICT service or reduced quality of service.
Solid-mass related	• Underground cables • Substations • Towers (pylons) and poles	• Soil movements can cause landslides, damaging T&D assets and components • For buried pipelines or other transmission infrastructure, making them harder to reach in case of repairs and increasing repair costs. • Toppled electricity poles

4.2.2 Exposure

Further, the level of **exposure** of the Elmed project physical elements is based on an analysis of current and projected climate scenarios and literature review of potential climate hazards in the Electricity T&D sector, taking into consideration associated uncertainty. For both the sensitivity and exposure analysis, the scoring system is summarized in a single table format and ranks the climate variables to which the Elmed project is most vulnerable to.

[6] Source: adapted from (ADB 2012).

Table 6: Key Climate Change Impacts on Elmed physical components[7]

VULNERABILITY ANALYSIS			SENSITIVITY		EXPOSURE	
Climate Variables	**Hazard Type (Chronic/Acute)**	**Hazard**	**Sensitivity Y/N**	**Sensitivity Level**	**Current Climate**	**Future Climate**
Temperature related	Chronic	Changing Temperature, Heat Stress and Temperature Variability	Y	**Low**	⇑	⇑
		Permafrost thawing	N			
	Acute	Heat Wave	Y	**Low**	⇑	⇑
		Cold Wave	Y	**Low**	⇑	⇑
		Wildfire	Y	**Low**	⇑	⇑
Wind-related	Chronic	Changing wind patterns	N			
	Acute	High wind speeds (Cyclone, hurricane, typhoon, tornadoes)	Y	**Medium**	=	=
		Storms (sand and dust)	Y	**Low**	=	=
Water-related	Chronic	Changing precipitation patterns and variability	N			
		Ocean acidification and saline intrusion	N			
		Sea level rise	Y	**Low**	=	⇑
		Water stress	N			
	Acute	Drought	N			
		Heavy precipitation (rain, hail, snow/ice)	Y	**Low**	=	=
		Flood (coastal, fluvial, pluvial, ground water)	Y	**Low**	=	=
		Glacial lake outburst	N			
Solid-mass related	Chronic	Coastal erosion	Y	**Medium**	=	=
		Soil degradation	N			
		Soil erosion	Y	**Medium**	=	=
		Solifluction	N			
	Acute	Avalanche	N			
		Landslide	Y	**Low**	=	=
		Subsidence	Y	**Low**	=	=

[7] Source: adapted from (ADB 2012).

Table 7: Sensitivity Assessment Legenda

Level of Sensitivity	Definition
HIGH SENSITIVITY	• Permanent or extensive damage requiring extensive repair
MEDIUM SENSITIVITY	• Widespread infrastructure damage and service disruption requiring moderate repairs • Partial damage to local infrastructure
LOW SENSITIVITY	• Localized infrastructure service disruption; no permanent damage • Some minor restoration work required
NOT SENSITIVE	• Screened-out due to project context and/or geography • No infrastructure service disruption or damage

Table 8: Exposure and Current/Future Climate Assessment Legenda

Ranking of Exposure
HIGH EXPOSURE
MODERATE EXPOSURE
LOW EXPOSURE

Current/Future Climate Exposure
⇑ **INCREASE**
⇓ **DECREASE**
= **MINIMAL CHANGE**

4.2.3 Vulnerability Ranking

Based on the outcome of the assessment determined by applying the Vulnerability Matrix (**Errore. L'origine riferimento non è stata trovata.**), significant climate hazards (High or Medium vulnerability rating, Table 11) are taken forward into the Climate risk assessment (Detailed Analysis – Phase 2 Adaptation), for further analysis.

Table 9: Climate Vulnerability Assessment Matrix

		EXPOSURE		
		HIGH	MEDIUM	LOW
SENSITIVITY	HIGH			
	MEDIUM			
	LOW			

Table 10: Vulnerability Ranking Legenda

Ranking of Vulnerability
HIGH VULNERABILITY
MEDIUM VULNERABILITY

LOW VULNERABILITY

Table 11: Climate Vulnerability Assessment Matrix – Hazards with High Vulnerability Ranking

Climate Variables	Hazard Type (Chronic/Acute)	Hazard	Sensitivity Y/N	Sensitivity Level	Current Climate	Future Climate
Temperature related	Chronic	Changing Temperature, Heat Stress and Temperature Variability	Y	**Low**	⇑	⇑
	Acute	Heat Wave	Y	**Low**	⇑	⇑

4.3 Climate Risk Assessment (Detailed Analysis – Phase 2 Adaptation)

Informed by the climate vulnerability assessment, High or Medium vulnerabilities (per Table 11) are subject to more detailed assessment. The risk assessment module provides a structured method of analyzing climate hazards and their impacts to provide information for decision-making for the identification, appraisal and planning of adaptation options. This process works through providing a general overview of the most significant climate hazards identified in the Vulnerability Assessment, and then determines the likelihoods and severities of the associated impacts assessing the significance of the risk to the success of the project.

However, compared to vulnerability analysis, the Climate Risk Assessment more readily facilitates identification of longer ‘cause-effect’ chains linking climate hazards to the performance of the project across several dimensions (technical, environmental, social and financial etc.) and allows for the interactions between factors to be considered. This is in line with a ‘systems thinking’ approach (EC 2012).

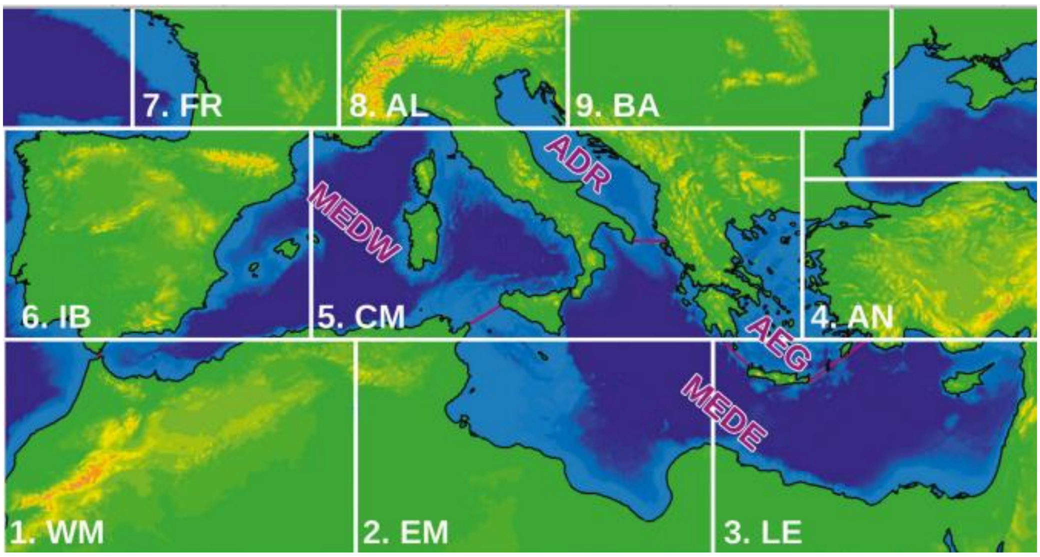
4.3.1 Significant Climate Risks to the Elmed Project

The most significant climate risks (Medium Vulnerability Ranking) that may affect the Project are related to Temperature Hazards, and namely:

1. **Temperature-Related: Medium Risk (Low Sensitivity/High Exposure):**
   - Changing Temperature
   - Heat Stress and Temp. Variability.
   - Heat Waves.

The ELMED investment is located in the Mediterranean Sea corresponding to the IPCC Mediterranean climate macro area. Based on IPCC categorization, it is possible to provide a general overview of how climate change impacts the project area, as it comprehends both the Italian and Tunisian sides of the project.

Figure 6: Mediterranean coastline, topography over land and bathymetry over the sea (MedECC 2020)

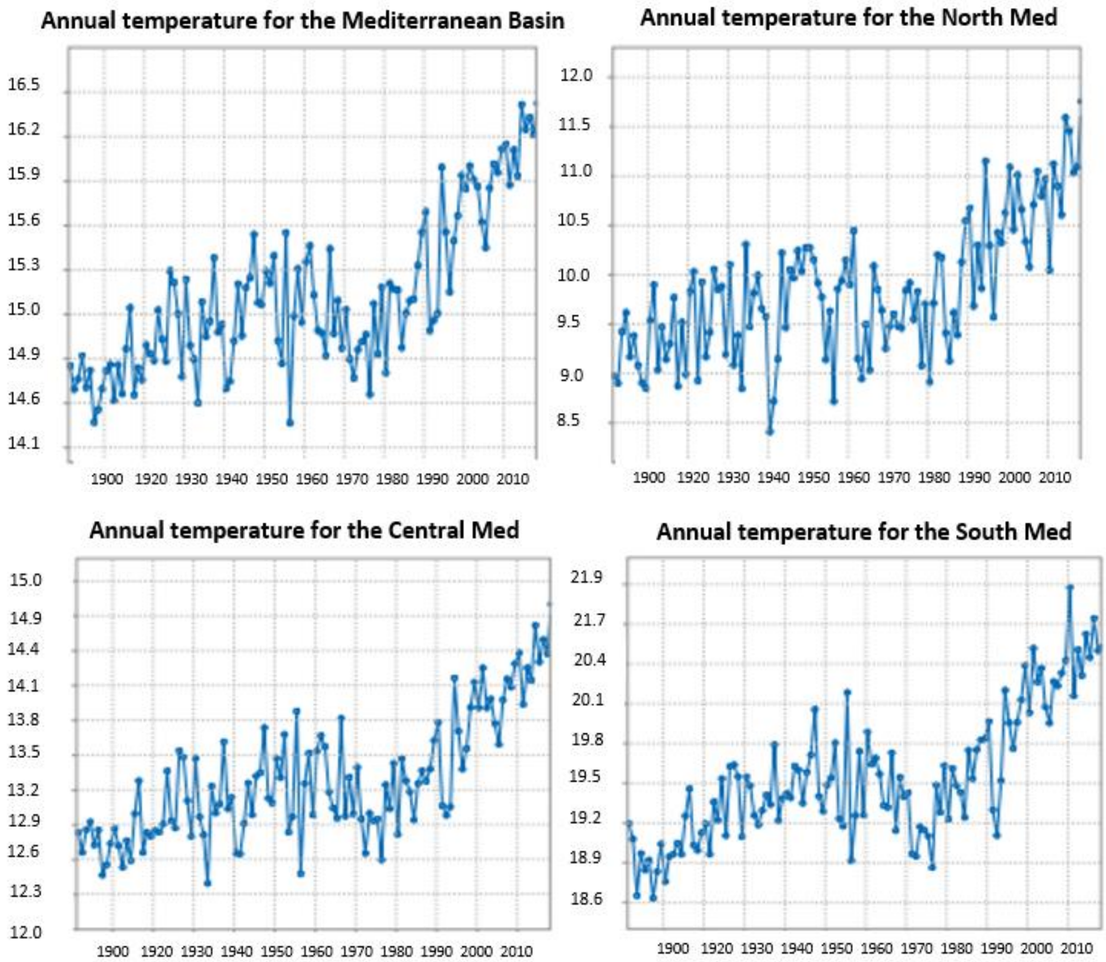


Air and sea temperature and their extremes (notably heat waves and temperature variability) are likely to continue to increase more than the global average in the Mediterranean area (high confidence). The projected annual mean warming on land at the end of the century is in the range from 0.9 to 5.6°C compared to the last two decades of the 20th century, depending on the emission scenario. Temperature extremes and heat waves have increased in intensity, number, and length during recent decades, particularly in summer, and are projected to continue increasing (high confidence) (CCP4, 2021).

The annual mean temperatures across the basin are currently 1.5°C higher than in the late 1800s [1], furthermore, the regional climate warming started during the 1980s and then accelerated at a higher pace than the global average [1]. While the climate warming process was found to be consistent over the Mediterranean, temperature trends varied depending on the region or country considered, on the season analyzed and on the type of data set investigated. A study considering data from different sources and reconstructions was able to recover temperature trends of the Mediterranean over the last 500 years and observed the recurrence of warming-cooling cycles (MedECC 2020). This data highlighted that the temperatures of the 20th century were only slightly warmer than those of previous warming periods. The last three decades were instead anomalous, presenting temperatures consistently warmer than the average, this thirty-years period was in fact the warmest of the last centuries (ibid). Indeed, it was possible to recognize clear trends of +0.1 to +0.5°C per decade since the 1980s (i*bid*).

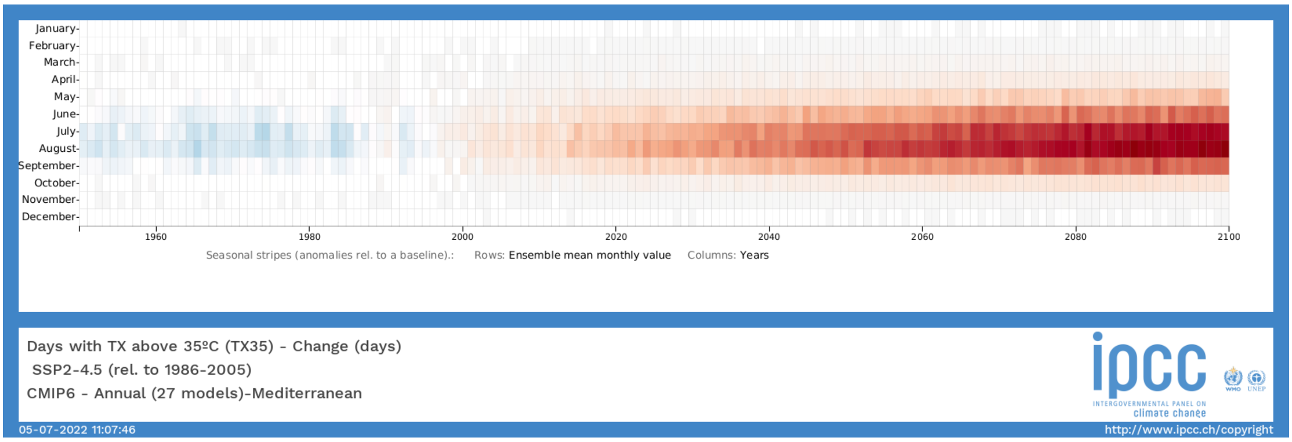
Specifically, the data regarding mean temperature shows an increase since 1990. The summer months are particularly affected by the increased temperatures. Further, the forecast of IPPC 6th Assessment Report (SSP 2 scenario) shows that the mean temperatures are constantly increasing: in august 2021 reached already 1.3°C above the baseline and they are expected to reach 3.9° C above the baseline in august 2100.

Figure 7: Mediterranean coastline, topography over land and bathymetry over the sea (MedECC 2020)



It is also possible to observe the aggravation of climate warming in the Mediterranean basin in the warmer hot and cold extremes, in the more frequent and intense heat waves, in the higher incidence of warm and tropical nights in many countries of the region and in the occurrence of severe climate events linked to extreme heat in the summer period. Figure 8 shows how the median number of days with temperature above 35ºC are expected to increase of 8.7 days in the Near-Term IPPC scenario (2021-2040) to 19.8 days in the Long-Term scenario (2081-2100) compared to the period 1986-2005 (number of days=0).

Figure 8: CMIP6 - Days with TX above 35ºC (TX35) Change days - Medium Term (2041-2060) SSP2-4.5 (rel. to 1986-2005) - Annual (27 models)-MED[8]



Period	Scenario	Median (days)	P25 | P75	P10 | P90	P5 | P95
Near Term (2021-2040)	SSP2-4.5	8.7	6.9 | 10.2	6.5 | 11.7	5.9 | 12.5
Medium Term (2041-2060)	SSP2-4.5	13.1	10.2 | 16.3	9.4 | 17.4	9.1 | 18.8
Long Term (2081-2100)	SSP2-4.5	19.8	15.7 | 22.9	15.1 | 26.1	13.3 | 26.6

Precipitation will likely decrease in most areas by 4% to 22%, depending on the emission scenario (medium confidence). Rainfall extremes will likely increase in the northern part of the Mediterranean region (high confidence) (CCP4, 2021).

4.3.2 Likelihood

The Likelihood part of the risk assessment looks at how likely the identified climate hazards are to occur within the Elmed project lifetime. Table 13 provides an illustrative overview of the likelihood analysis with the scale illustrated in Table 12. Building on IPCC climate scenarios and best available climate information, and qualitative expert judgement assessment, there is considerable certainty about the occurrence (Almost Certain probability) of the Temperature-Related identified risks in the project areas within the lifespan of the project.

Table 12: Scale for assessing the probability of a climate hazard

PROBABILITY/LIKELIHOOD SCALE OF CLIMATE HAZARDS				
1	**2**	**3**	**4**	**5**
Rare	**Unlikely**	**Moderate**	**Likely**	**Almost certain**
Highly unlikely to occur	Given current practices and procedures, this incident is unlikely to occur	Incident has occurred in a similar country / setting	Incident is likely to occur	Incident is very likely to occur, possibly several times
OR				

[8] *Ibid*

5% chance of occurring per year	20% chance of occurring per year	50% chance of occurring per year	80% chance of occurring per year	95% chance of occurring per year

Table 13: Probability of Significant Climate Hazards (Elmed project)

PROBABILITY/LIKELIHOOD OF SIGNIFICANT CLIMATE HAZARDS (ELMED PROJECT)						
Climate Variables	**Hazard**	**Rare**	**Unlikely**	**Moderate**	**Likely**	**Almost Certain**
Temperature related	Changing Temperature, Heat Stress and Temperature Variability					X

4.3.3 Impact/Magnitude

This part of the risk assessment looks at the potential consequences of the identified climate hazard materializing within the project area and lifecycle (referred as impact or magnitude). Risks are assessed on a scale of impact per hazard which follows recommended EC guidance (**Errore. L'autoriferimento non è valido per un segnalibro.**4). The impact relates to the project physical assets and operations, but also on other project important dimensions (health and safety, environmental impacts, social impacts, impact on accessibility for persons with disabilities, financial implications, and reputational risk). Tables 14-15 provides an overview of the impact analysis for the risk areas and the anticipated levels of consequences based on expert judgement and detailed project information. Based on the impact assessment, the identified Temperature related risks may have consequences ranked of **Major magnitude** to the Elmed project.

Table 14: Scale for assessing the magnitude of consequences of a climate hazard

MAGNITUDE OF CONSEQUENCE					
	1	**2**	**3**	**4**	**5**
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Asset damage / Engineering / Operational	Impact can be absorbed through normal activity	An adverse event which can be absorbed through business continuity actions	A serious event which requires additional emergency business continuity actions	A critical event which requires extraordinary / emergency business continuity actions	Disaster with potential to lead to shut down or collapse of the asset / network
Safety and Health	First Aid Case	Minor Injury, Medical Treatment Case with/or Restricted Work Case.	Serious injury or Lost Work Case	Major or Multiple Injuries, permanent injury or disability	Single or Multiple Fatalities
Environment	No impact on baseline environment. Localized to point source. No recovery required	Localized within site boundaries. Recovery measurable within 1 month of impact	Moderate harm with possible wider effect. Recovery in 1 year.	Significant harm with local effect. Recovery longer than 1 year. Failure to comply with env. regulations	Significant harm with widespread effect. Recovery longer than 1 year. Limited prospect of full recovery.

Social	No impact on society	Localized, temporary social impacts	Localized, long term social impacts	Failure to protect poor or vulnerable groups.National, long term social impacts.	Loss of social license to operate. Community protests.
Financial (for single extreme event or annual average impact)	Example indicators: x % IRR <2% Turnover	Example indicators: x % IRR 2 – 10% Turnover	Example indicators: x % IRR 10 – 25% Turnover	Example indicators: x % IRR 25 – 50% Turnover	Example indicators: x % IRR >50% Turnover
Reputation	Localized temporary impact on public opinion	Localized, short term impact on public opinion	Local, long-term impact on public opinion with adverse local media coverage	National, short-term impact on public opinion; negative national media coverage	National, long-term impact with potential to affect stability of Government

Table 15: Magnitude of consequence across various risk areas: Temperature-related risks

	TEMPERATURE RELATED RISK **Temperature Increase, Heat Waves, Temp. Variability**				
Impacts / ***Risk Area***	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Asset damage, engineering, operational					
Safety and health					
Environment, cultural heritage					
Social					
Financial					
Reputation					
Overall for the above-listed risk areas		**Minor**			

4.4 Climate Resilience Statement

The Elmed project has undertaken a comprehensive Climate Vulnerability and Risk Assessment (CVRA) as part of the climate-proofing documentation, to help manage the risks from climate variability and change and help mainstreaming climate resilience into Elmed's project lifecycle.

The CRVA clearly demonstrates to stakeholders, investors and verifiers that climate resilience has been considered in the project development cycle.

The outcome of the CVRA indicates that the climate resilience of the project is at Minor risk (overall risk assessment ranking: Minor) to Temperature related climate variables, based on the EU taxonomy classification, although Temperature increases (including heat waves and temperature variability) have an almost certain probability of occurring at the planned project locations in Italy and Tunisia, within the lifespan of the project.

The project's vulnerabilities and risks to the climate change effects outlined in the CVRA will form the basis to identify, appraise and planning climate eventually adaptation options.

The CVRA will be updated by including the identification and planning of necessary adaptation options towards the final engineering and execution phase of the project in accordance with the requirements indicated in the relevant IEC, ISO standards while always respecting EU regulations and Italian and Tunisian regulatory frameworks and laws.

APPENDIX A KEY REFERENCE DOCUMENTS

ADB. *Climate Risk and Adaptation in the Electric Power Sector.* 2012.

EC. *COMMISSION DELEGATED REGULATION (EU) 2021/2139 of the EU Parliament and of the Council establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change.* 2021[1].

—. *Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient.* 2012.

—. *Proposal for a Regulation of the European Parliament and of the Council on guidelines for trans-European energy infrastructure and repealing Regulation (EU) No 347/2013 (SWD(2020) 346 final).* 2020[2].

—. *REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL (Taxonomy).* 2020[1].

—. *Technical expert group on sustainable finance (TEG) - Taxonomy tools.* 2020[4].

EC. «Technical guidance on the climate proofing of infrastructure in the period 2021-2027.» 2021[2].

—. *TEG on Sustainable Finance. Taxonomy Report. Technical Annex - Updated methodology & Updated Technical Screening Criteria.* 2020[3].

EC, DG Energy. *Priorities of the CEF Energy Multi Annual Work programmed 2021 Call for proposals for Projects of Common Interest. CEF Energy Call Virtual Info Day, 14 September 2021.* 2021.

Elmed Etudes Sarl. «Feasibility Studies of the Tunisia-Italy Power Interconnection. Stakeholder Engagement Plan.» 2018.

ENTSO-E. «3rd ENTSO-E Guideline for Cost Benefit Analysis of Grid Development Projects.» 2020.

—. *TYNDP 2020 CBA Implementation Guidelines.* 2020[2].

—. «TYNDP 2020 Projects Sheets_29: Italy-Tunisa.» *TYNDP 2020 Projects Sheets.* s.d. https://tyndp2020-project-platform.azurewebsites.net/projectsheets/transmission/29 (consultato il giorno 6 1, 2022).

—. *TYNDP 2020 Scenario Report.* 2020[3].

EU. *REGULATION (EU) No 347/2013 on guidelines for trans-European energy infrastructure.* 2013.

European Investment Bank,. «Project Carbon Footprint Methodologies. Methodologies for the assessment of project greenhouse gas emissions and emission variations. Version 11.2.» 2022.

IPCC. *IPCC WGI Interactive Atlas: Regional information (Advanced), accessed on July 2022.* 2022.

Italiana, Gazzetta Ufficiale della Repubblica. «Accordo tra il Governo della Repubblica Italiana e il Governo della Repubblica Tunisina sullo sviluppo di una infrastruttura per la trasmissione elettrica finalizzata a massimizzare gli scambi di energia tra l'europa e il Nord Africa.» 2019.

JRC. «EU Joint Research Centre (JRC): Canfora, P., Dri, M., Polidori, O., Solzbacher, C. and Arranz Padilla, M., Substantial contribution to climate change mitigation – a framework to define technical screening criteria for the EU taxonomy.» 2021.

MED-TSO. «Detailed Project Description: 06_TNIT2 Tunisia - Italy. EC DGNEAR - GRANT CONTRACT: ENI/2018/397-494. "Med-TSO—Mediterranean Project II". Deliverable 2.1.2.» 2020.

—. *SURVEY ON THE SITUATION IN TERMS OF SOLUTIONS FOR GRID INTEGRATION AMONG THE MEDITERRANEAN AREA IN THE FRAMEWORK OF CLIMATE CHANGE AND ENERGY TRANSITION. EC DGNEAR - GRANT CONTRACT: ENI/2018/397-494. "Med-TSO—Mediterranean Project II". Deliverable 4.1.* 2020.

—. *THE MEDITERRANEAN MASTERPLAN 2020: REFERENCE ENERGY SCENARIOS AND PROJECTS ASSESSMENT. Project Sheet #4 – ITALY - TUNISIA.* 2018.

Ministero dello Sviluppo Economico (MISE). «Proposta di Piano Nazionale Integrato per l'Energia ed il Clima.» 2020.

World Bank. «PROJECT APPRAISAL DOCUMENT (Report No: PAD2551) ON PROPOSED GIF AND ESMAP GRANTS TO THE REPUBLIC OF TUNISIA FOR THE TUNISIA-ITALY POWER INTERCONNECTOR PROJECT.» 2018.