New **E**nabling **V**isions and Tools for **E**nd-use**R**s and stakeholders thanks to a common **MO**deling app**R**oach towards a Climat**E** neutral and resilient society

D6.1 Report on NEVERMORE case studies characterization

August 2023

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056858.

Executive summary

This document presents the work carried out for the case study characterization including the main results obtained at case study level. NEVERMORE aims to develop integrated models and tools for simulating and assessing the impacts and risks of climate change, to make mitigation and adaptation policies more effective.

The development of this deliverable has involved collaborative work between case study leaders, supporters and technical partners to carry out the most detailed analysis of the sectors, climate, policies and drivers that can play a relevant role in the evaluation of the effects of climate change in each case study in order to define feasible adaptation and mitigation pathways.

The document begins with the methodological approach necessary to carry out both the analysis of the geographical landscape and the climate conditions, including the analysis of the vulnerable sectors, the current and future climate, the definition of the baseline in adaptation and mitigation and the analysis of the legal framework that directly affects the identification and selection of policies to be implemented in each evaluated area. In addition, the methodology developed for the identification of the most relevant drivers at case study level is presented through the development of a PESTLE analysis following different steps and consultations with stakeholders.

After presenting the methodology, the document continues with the analysis and results for each case study covering the main points presented in the *Approach* section which were explained above. All the chapter that cover the case studies, follow the same structure to improve the understanding of the document and the comparison between case studies. Each case study section concludes with a summary of the main results and conclusions extracted from the characterization including the identification of drivers with the local stakeholders.

Although it is a very extensive document due to the fact that a very detailed evaluation of the five case studies that make up the local framework and scope of the NEVERMORE project is presented. The results obtained are the initial stage to continue working on the activities of the WP6 in order to be able to complete the risk and vulnerability analysis in each case study cases. This will help to provide solutions and tools so that the case studies can work on the development of plans and strategies that help them to improve the adaptation and mitigation of the effects of climate change.

In the legal framework, it must be considered that all the case studies have a deep legal framework that establishes the starting point for defining and guiding the strategy that helps to define the priority lines in climate adaptation and mitigation. This analysis of the legal and policy framework, which has been carried out jointly with WP5 activities, has been included as an *Annex* to this document to help in the understanding of the regulatory framework as a starting point of adaptation and mitigation in each case study.

The document ends with a series of conclusions and recommendations to continue working with the case studies and the following activities of the project, being able to offer solutions and tools adapted to the real needs and that really help in decision-making in climate adaptation and mitigation.

6. Case Study 4 – Mediterranean region (Murcia region) characterisation

The Region of Murcia is an autonomous community of Spain located in the southeast of the Iberian Peninsula, on the coast of the Mediterranean Sea (Figure 128). With an extension of 11,313 km², it is the ninth largest region in Spain by area, representing the 2.9% of the total area of Spain. Considering the hydrology, the region of Murcia extends mostly in the Segura hydrographic basin with small areas located in other hydrographic basins.

The total population of the Region is 1,531,878 inhabitants in 2022 according to the data provided by the National Institute of Statistics of Spain (INE). Slightly less than a third of its population lives in the capital of the region. With a population density of 135 inhabitants per km^2, that is much higher than the mean population density of Spain. The Region is divided in 45 municipalities, being it total GDP of 32,205 million € in 2021 and the GDP per capita of 21,236 € in the same reference year. This GDP per capita is significantly lower than the national average. The region of Murcia is the third largest exporter of fresh fruits and vegetables in Spain, with more than 2.5 million of tons in total values with a monetary value higher than 2,564 million euros (reference data, 2019). In this sense the agricultural sector is a benchmark at regional level. Currently, its direct activity represents 24.3% of the total GDP of Murcia and indirectly affects approximately the 50% of the GDP. These values must be highlighted, considering that the region suffers important problems due to the lack of water and the associated water stress.

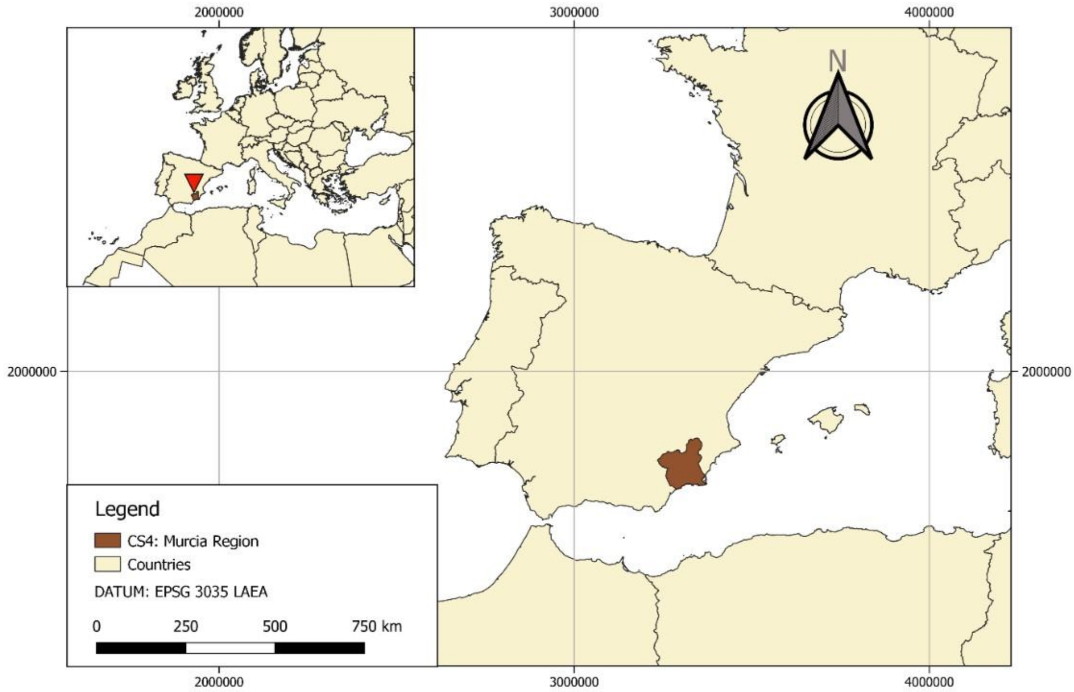

Figure 128. Location of CS4, Murcia Region.

The climate is defined as semi-arid subtropical Mediterranean. Among its characteristics, the thermal amplitude between seasons stands out, presenting hot summers and mild winters and the climatic differences between the coast and the interior areas, with temperatures that oscillate according to location altitude. In the Region of Murcia, rainfall is scarce and irregular (varies from 400 mm to 200 mm between areas) and it is concentrated in autumn and spring, appearing in torrential forms, leading to floods and torrential events.

6.1. Analysis of geographical landscape and historical climate conditions

This section includes an analysis of the historical and future climate in the Region of Murcia and also the main sectors that will be affected by forecast changes in the climate due to the increase of emissions and the associated effects in social, economic and environmental systems.

6.1.1. Climate analysis and characterisation of vulnerable sectors

In this initial section, two relevant objectives are covered: (i) an assessment of the main climate data (temperature, precipitation and wind) in the historical and future period (from 2023 to 2100) under two different climate scenarios for the region of Murcia and (ii) identification and description of the main assets per vulnerable sector that will be affected by future changes in the climate.

6.1.1.1. Climate and weather analysis

Climate analysis is based on the Essential Climate Variable (ECVs). More in detail, the following variables are evaluated: maximum annual daily cumulated precipitation, mean annual daily cumulated precipitation, mean annual daily maximum temperature, mean annual daily minimum temperature, mean annual daily mean temperature and mean annual daily mean surface wind speed.

○ Temperature

If we analyse the obtained results of climate models in the future for temperature, we identified that the mean annual daily temperature in the Region of Murcia (15.47ºC in the historical period) will increase according to the two considered climate scenarios. It is expected that the mean annual daily temperature increases more than 4.9ºC in the most unfavorable scenario (SSP585) in the long term. In this sense, the temperature will increase more than 20ºC by 2100. Considering the minimum and maximum mean annual daily temperature, the same pattern is expected facing a warmer climate with very high temperature in extremes. Table 36 presents the temperature results in the Region of Murcia for two different scenarios (SSP245 and SSP585) and the comparison with the mean values in the historical.

Table 36. Mean, Maximum and Minimum temperature and related anomalies comparing with the historical. Lighter red colour implies smaller changes while dark red implies higher changes.

Scenario and period		Mean temperature	Mean maximum temperature	Mean minimum temperature
Historical scenario		15.47	19.85	11.46
SSP245 scenario	2023-2039	16.67	21.19	12.68
	2040-2069	17.40	22.04	13.36
	2070-2100	18.20	22.98	14.18
SSP585 scenario	2023-2039	16.77	21.30	12.69
	2040-2069	18.03	22.68	13.94
	2070-2100	20.40	25.34	16.31
Anomaly SSP245 scenario	2023-2039	1.20 ↑	1.33 ↑	1.22 ↑
	2040-2069	1.93 ↑	2.19 ↑	1.90 ↑
	2070-2100	2.73 ↑	3.12 ↑	2.71 ↑
Anomaly	2023-2039	1.31 ↑	1.44 ↑	1.23 ↑

SSP585 scenario	2040-2069	2.56	2.82	2.48
	2070-2100	4.94	5.49	4.85

Figure 129 presents the results of the evolution of mean annual daily temperature along the period 2015-2100 using downscaled data from eight different climate models for the SSP245 climate scenario. The average value for the eight models under SSP245 is presented in Figure 130 where the confidence interval is represented by the maximum and minimum value of the set of models in each simulation year. The same representation for the temperature variation under SSP585 climate scenario is included in Figure 131 and Figure 132 respectively. Results show a high heterogeneity between model results and scenario with a growing trend along the evaluated period in both scenarios, being higher the temperature increase in the most extreme scenario (SSP585).

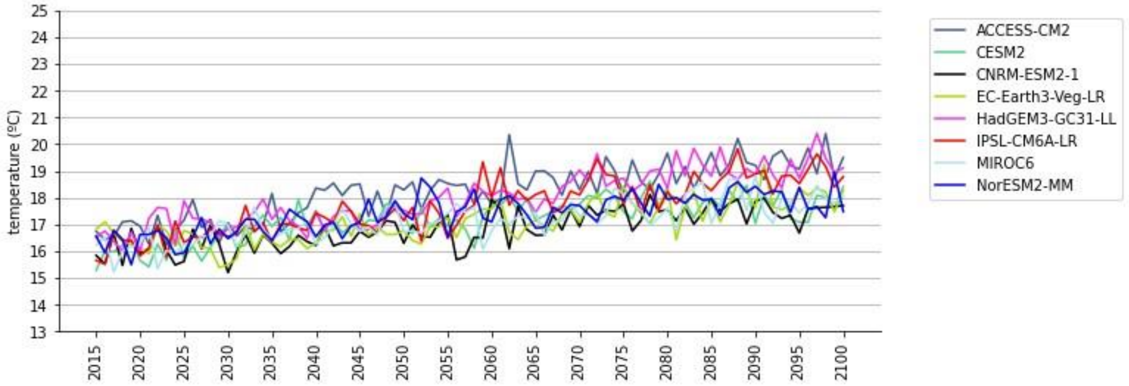

Figure 129. Mean annual daily temperature in the SSP245 scenario (2015-2100) for eight models in the region of Murcia obtained by statistical downscaling procedure.

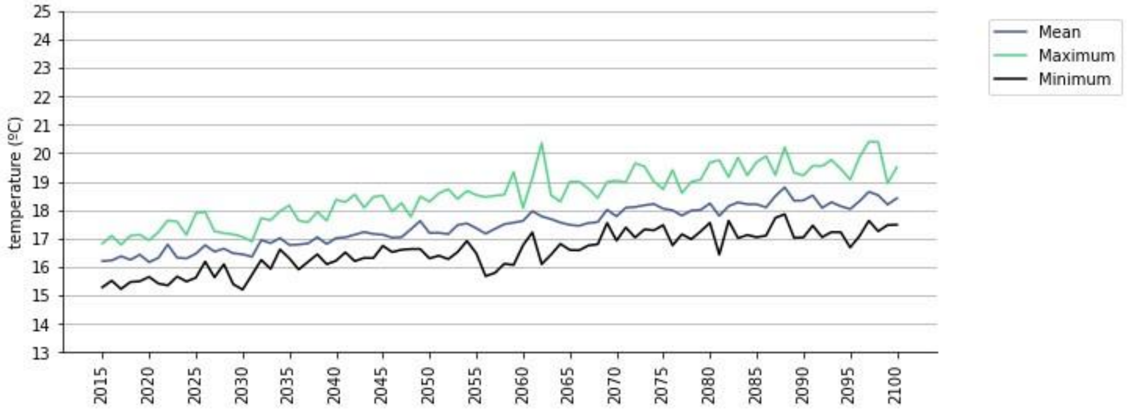

Figure 130. Ensemble mean annual daily temperate and range of variation (Maximum and Minimum) for a set of eight models in the SSP245 scenario (2015-2100) for the region of Murcia.

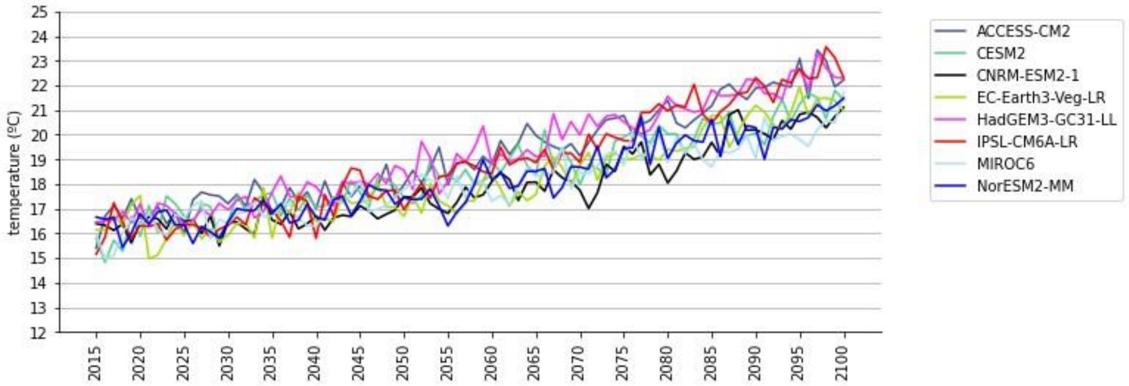

Figure 131. Mean annual daily temperature in the SSP585 scenario (2015-2100) for eight models in the region of Murcia obtained by statistical downscaling procedure.

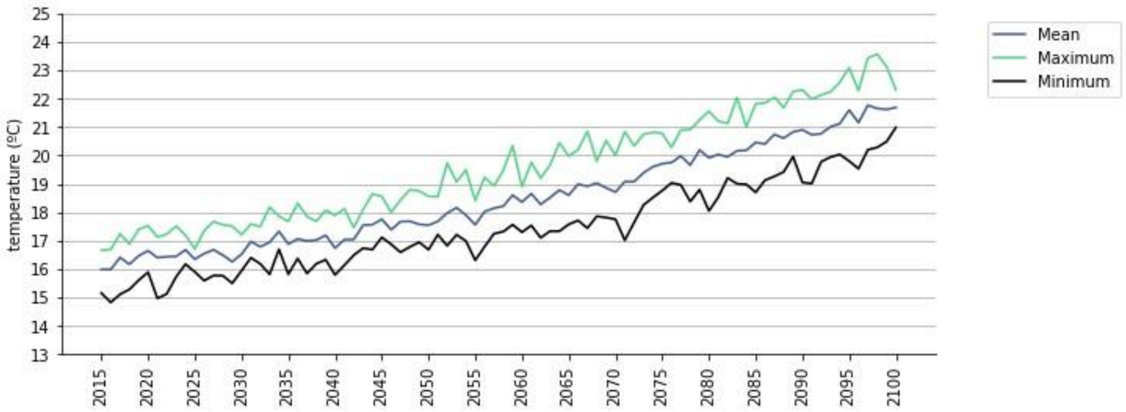

Figure 132. Ensemble mean daily annual temperate and range of variation (Maximum and Minimum) for a set of eight models in the SSP585 scenario (2015-2100) for the region of Murcia.

○ Precipitation

The evolution of precipitation in the future shows a slightly decreasing trend, which is completely contrary to that observed for temperatures, where a very pronounced increase is predicted. Considering its evolution throughout the time periods analyzed (Table 37), the decrease in precipitation will be more visible in the most unfavorable scenario (SSP585). The mean annual daily cumulated precipitation observed in the historical period is 1.06 mm/day, which is equivalent to an annual precipitation of 386.9 mm. The results of the models for the future, forecast a reduction in precipitation of up to 31.13% in the most unfavorable scenario. This decrease will mean ceasing to have an average of 120.45 mm of precipitation per year, which can cause a deficit of water resources at regional level in the long term. On the other hand, the maximum annual daily cumulated precipitation increases in all evaluated periods except in the long term in the most unfavorable scenario where there is more uncertainty. This puts us in front of a scenario of more torrential events in the region of Murcia.

Table 37. Mean and Maximum annual daily cumulated precipitation and related anomalies comparing with the historical. Lighter blue colour implies smaller changes while dark blue implies higher changes.

Scenario and period		Mean annual daily cumulated	Maximum annual daily cumulated
Historical scenario		1.06	35.91
SSP245 scenario	**2023-2039**	1.06	39.20
	2040-2069	0.96	36.92
	2070-2100	0.92	36.90
SSP585 scenario	**2023-2039**	1.02	36.70
	2040-2069	0.90	36.62
	2070-2100	0.73	34.23
Anomaly SSP245 scenario	**2023-2039**	0.00 ←	3.29 ↑
	2040-2069	-0.10 ↓	1.00 ↑
	2070-2100	-0.15 ↓	0.99 ↑
Anomaly SSP585 scenario	**2023-2039**	-0.04 ↓	0.79 ↑
	2040-2069	-0.16 ↓	0.71 ↑

	2070-2100	-0.33 ⬇	-1.68 ⬇

Figure 133 presents the results of the evolution of the mean annual daily cumulated precipitation along the period 2015-2100 using downscaled data from eight different climate models for the SSP245 climate scenario. The average value for the eight models under SSP245 is presented in Figure 134 where the confidence interval is represented by the maximum and minimum value of the set of models in each simulation year. The same representation for the mean annual daily cumulated precipitation variation under SSP585 climate scenario is included in Figure 135 and Figure 136 respectively. The results by model have great heterogeneity, which is very visible in the figures for comparing the results of the models, where no clear trend is observed by model evaluating the provided precipitation results.

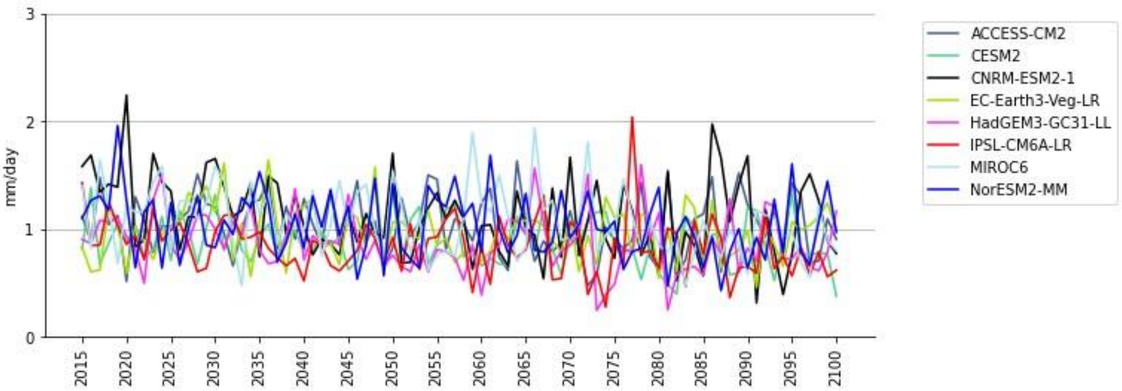

Figure 133. Mean annual daily cumulated precipitation in the SSP245 scenario (2015-2100) for eight models in the region of Murcia obtained by statistical downscaling procedure.

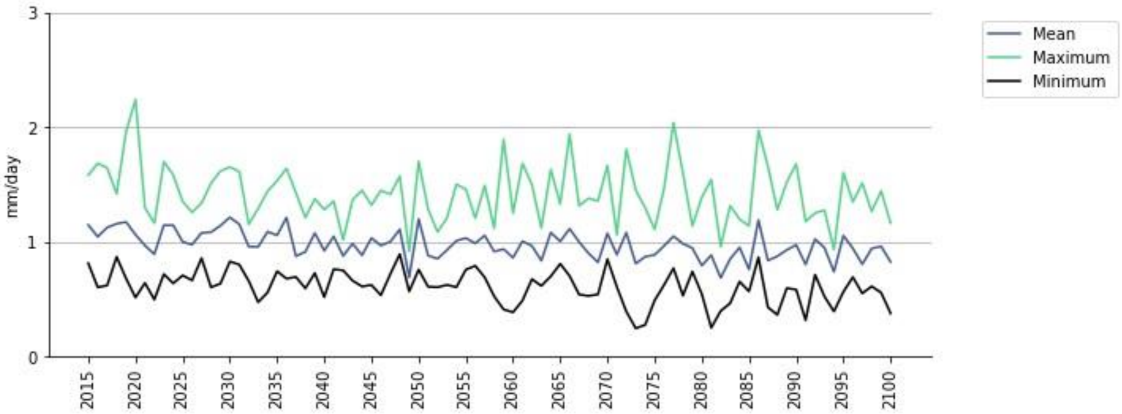

Figure 134. Ensemble mean annual daily cumulated precipitation and range of variation (Maximum and Minimum) for a set of eight models in the SSP245 scenario (2015-2100) for the region of Murcia.

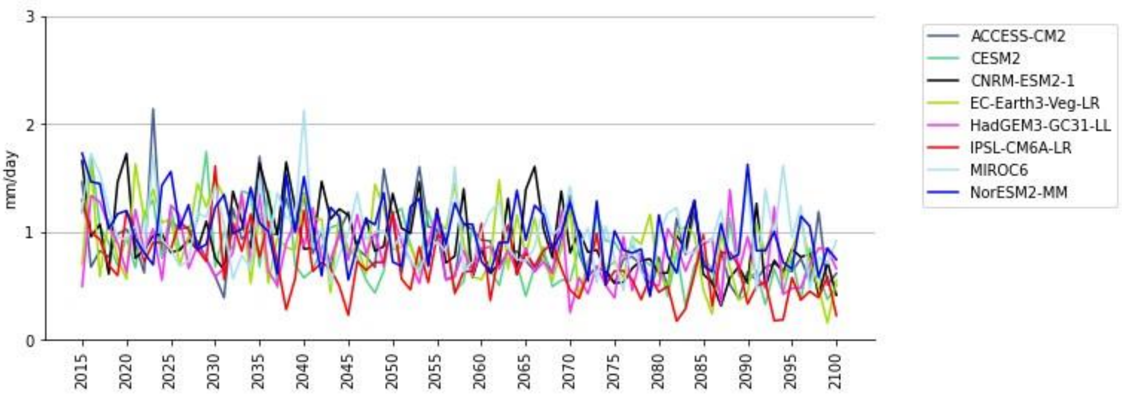

Figure 135. Mean annual daily cumulated precipitation in the SSP585 scenario (2015-2100) for eight models in the region of Murcia obtained by statistical downscaling procedure.

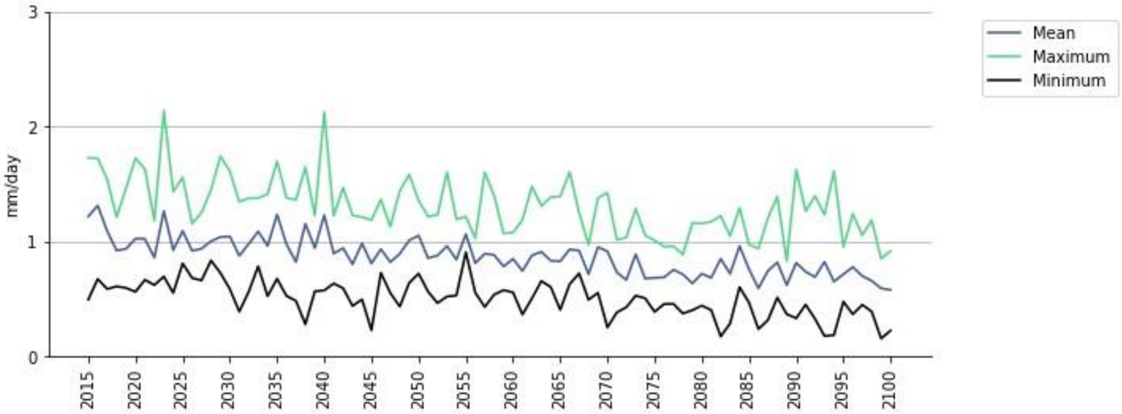

Figure 136. Ensemble mean annual daily cumulated precipitation and range of variation (Maximum and Minimum) for a set of eight models in the SSP585 scenario (2015-2100) for the region of Murcia.

○ Wind

Analyzing the results of the two selected climate scenarios for the future to investigate the evolution of the mean annual daily wind speed in the Region of Murcia, a trend is observed that projects a small decrease in the average wind speed if we compare it with respect to the average value of the historical scenario (Table 38). These changes in wind speed are conditioned by the increase in temperatures, together with the roughness and sealing of the land surface. However, and despite the forecast decrease, the average value will not fall below 3.2 m/s even in the most unfavorable scenario (SSP585).

Table 38. Mean annual daily surface wind speed and related anomalies comparing with the historical. Lighter grey colour implies smaller changes while dark grey implies higher changes.

Scenario and period		Mean annual daily surface wind speed
Historical scenario		3,40
SSP245 scenario	2023-2039	3,30
	2040-2069	3,29
	2070-2100	3,27
SSP585 scenario	2023-2039	3,33
	2040-2069	3,28
	2070-2100	3,23
Anomaly SSP245 scenario	2023-2039	-0,10 ⬇
	2040-2069	-0,10 ⬇
	2070-2100	-0,12 ⬇
Anomaly SSP585 scenario	2023-2039	-0,06 ⬇
	2040-2069	-0,12 ⬇
	2070-2100	-0,17 ⬇

Figure 137 presents the results of the evolution of the mean daily wind speed along the period 20152100 using downscaled data from six different climate models for the SSP245 climate scenario. The average value for the six models under SSP245 is presented in Figure 138 where the confidence interval is represented by the maximum and minimum value of the set of models in each simulation year. The same representation for the mean annual daily wind speed variation under SSP585 climate scenario is included in Figure 139 and Figure 140 respectively. It is observed in the figures that wind is more or less constant for both scenarios in the future evaluated period.

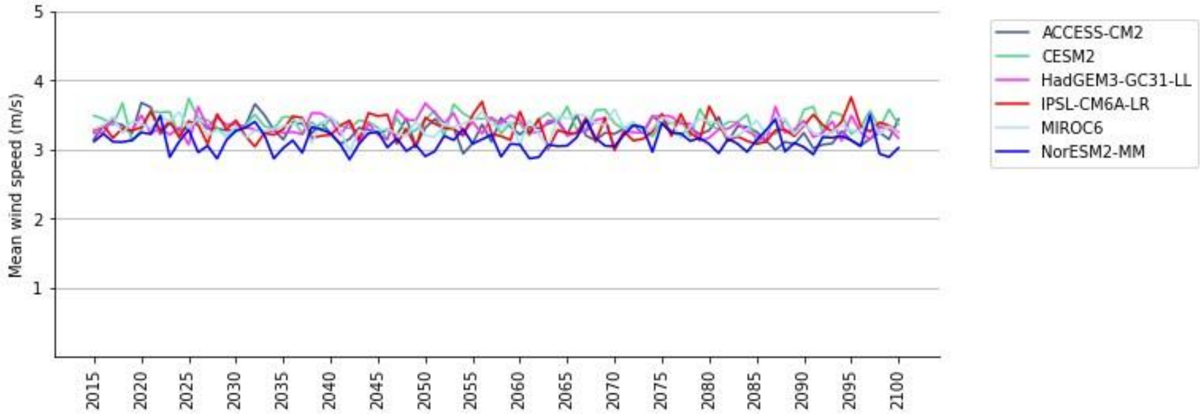

Figure 137. Mean annual daily wind speed in the SSP585 scenario (2015-2100) for six models in the region of Murcia obtained by statistical downscaling procedure.

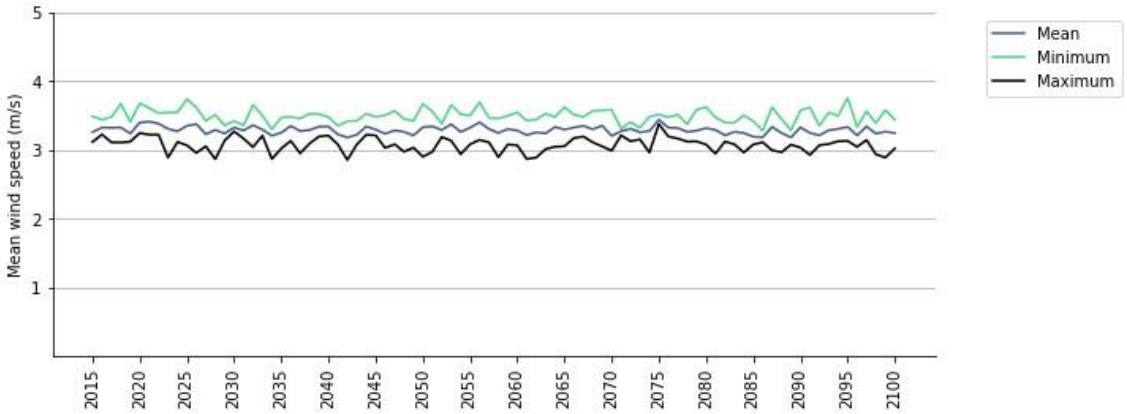

Figure 138. Ensemble mean annual daily wind speed and range of variation (Maximum and Minimum) for a set of six models in the SSP585 scenario (2015-2100) for the region of Murcia.

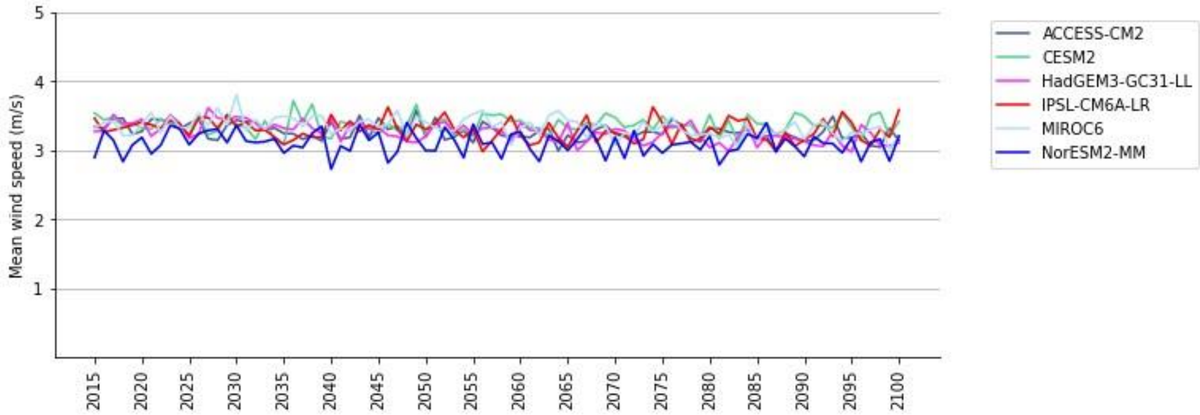

Figure 139. Mean annual daily wind speed in the SSP585 scenario (2015-2100) for six models in the region of Murcia obtained by statistical downscaling procedure.

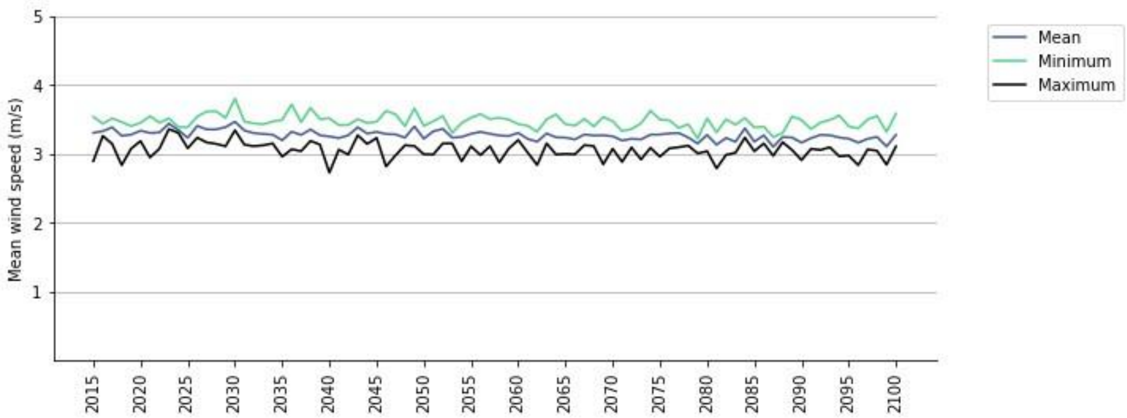

Figure 140. Ensemble mean annual daily wind speed and range of variation (Maximum and Minimum) for a set of six models in the SSP585 scenario (2015-2100) for the region of Murcia.

6.1.1.2. Vulnerable sectors: identification of exposure assets

As introduced in section 2.1.1.2, the key vulnerable NEVERMORE sectors for Murcia case study are agriculture, forest and fishing, and water and waste heritage for the high priority sectors, and with a second priority the sectors of industry and commerce and tourism, leisure and cultural heritage.

This was agreed with case study leaders in the first consultation (internal) as contrast exercise with the challenges and vulnerable sectors reported at proposal stage. The activity consisted on an online Jamboard in which the CS leaders identified their main challenges, to then relate them with the sectors and priorities for them (results can be seen in Figure 141).

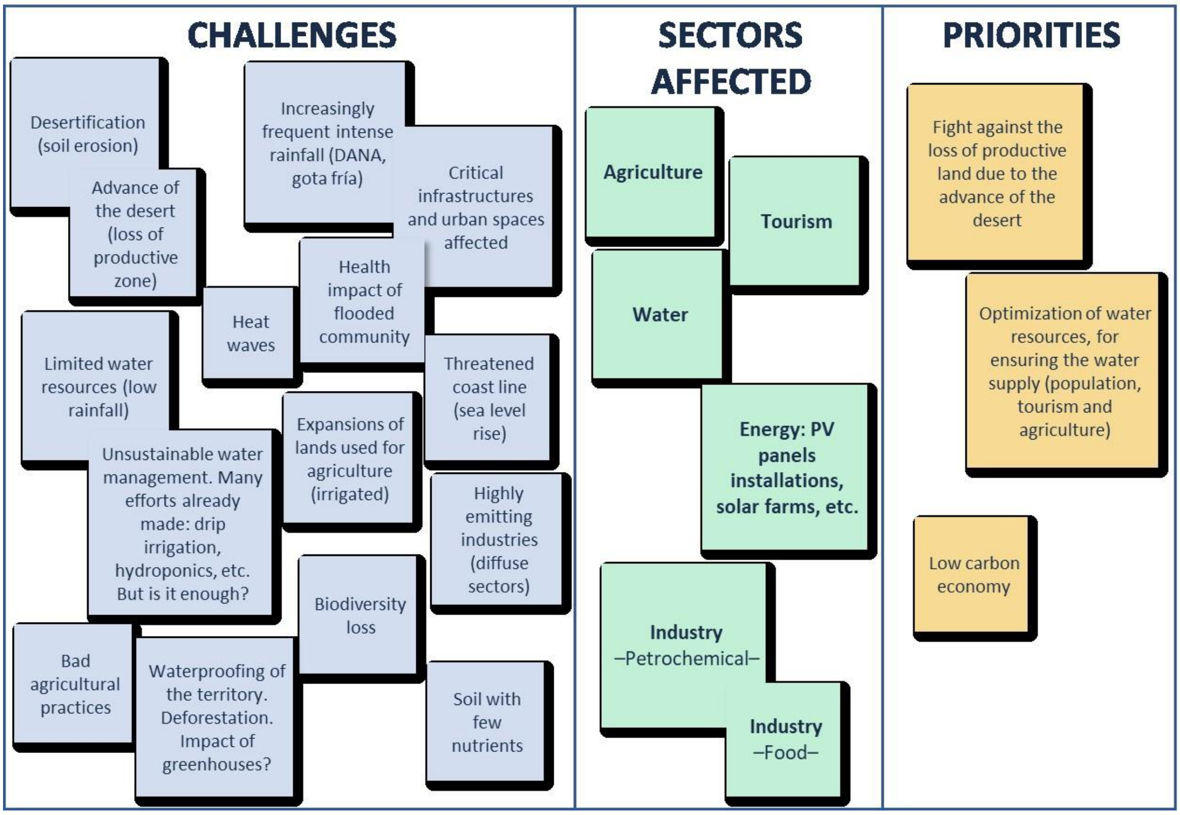

Figure 141. Results of the consultation with Murcia case study leaders on the CS challenges, related sectors affected and priorities

Then, the first consultation with the Local Council of Stakeholders was held, and a similar activity to confirm the selection and heard other voices on this was performed. During this activity (developed the 16th February 2023 in online format) the stakeholders overall recognized and agreed with the challenges previously identified.

○ Agriculture, forestry and fishing

The agriculture, forestry and fishing sector are very important in the Murcia economy being key to understand the social implications that climate change impacts could generate. In terms of surface or covered area in Murcia region, agriculture cover the 50% of the total area, followed by forestry, which reaches 45%, being the artificial part of anthropic activity concentrated in the remaining 5% of the total regional surface (Figure 142). This area distribution is very representative, since we are facing a region in which the primary sector plays a key role in the social and economic sector and also in the management of water resources that are quite limited.

Agriculture as primary sector in the region is quite important, considering their role in the regional economy, the effects of climate conditions and its location on the Mediterranean region under arid conditions with high influence of the Mediterranean Sea. These factors allow fishing and, above all, agriculture to acquire great development, and to stand out from other Spanish regions, due to the volume of production and the productivity of the crops. Murcia has 881,9 km^2 of crop area, being a third part of this area dedicated to agricultural production. The area over the last decade, both for the total and for the more general types of crops, were constant with small variation during the analysed timeline. It therefore implies an economic activity that manages the territory and of which it is necessary to know its different characteristics and the distribution of the different types of crop management (intensive or extensive agriculture, irrigated or rainfed, etc). Figure 143 presents the distribution between different crops types in the last years.

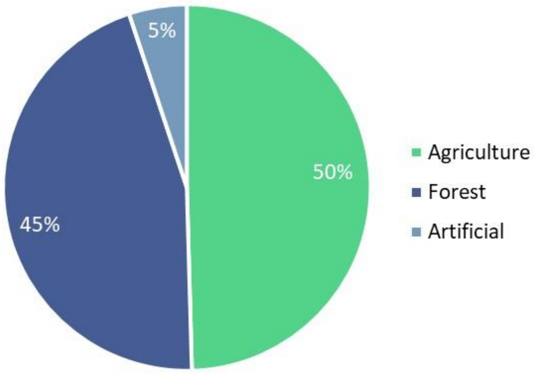

Figure 142. Percentage of area by use. Source: Own elaboration based on IFN4 data.

As it is presented in the Figure 143, the crop area was constant in the last 10 years, while there was an increase in crop production in the region (Figure 144). It is probably due to a more intensive crop management that generates a rotation in crop land use to take advantage of land constantly avoiding periods without management. This intensive management has generated an increase in greenhouse emissions. The evolution of the production of the two main crop types (annual and woody) is presented in Figure 144, covering the period 1975-2020.

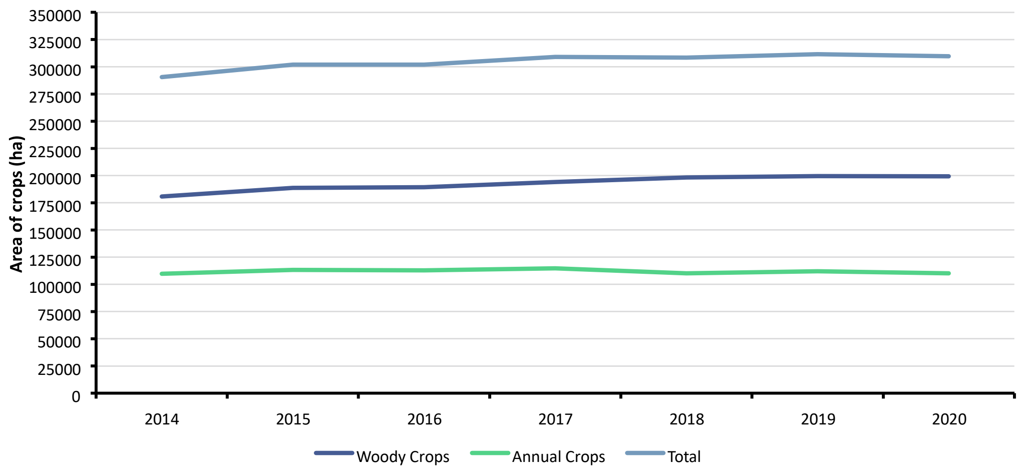

Figure 143. Evolution of the area of different crops. Source: Own elaboration based on INE data and data from the Autonomous Community of the Region of Murcia (CARM).

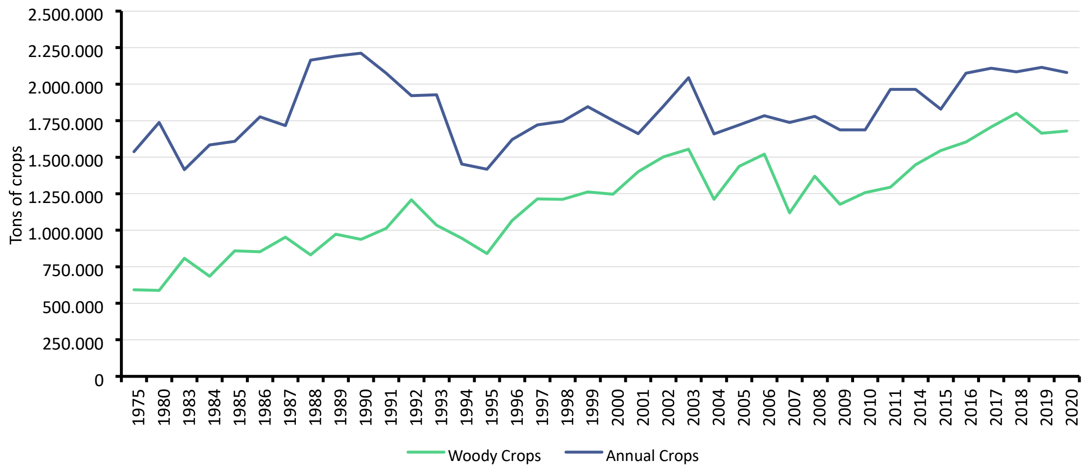

Figure 144. Evolution of the production of different crops. Source: Own elaboration based on INE and CARM data.

Since 1975, agricultural production has fluctuated considerably, although in general terms there has been a positive trend towards the increase of production due to technological improvements in this sector. Woody crops have increased their production more than three times in comparison with the initial tonnes of 1975. The changes in annual crops have been more drastic, and nevertheless, with respect to the general computation, they have undergone less growth in production. Initially, annual crops were three times more productive than the woody ones, nowadays that difference has been reduce. The Region of Murcia has ideal climate conditions for fruit and vegetable production, through improved productivity associated with greater water and energy efficiency. Therefore, the variety of horticultural crops as well as their productivity could be considered high. Figure 145 presents the distribution between different woody crop types in the last 40 years.

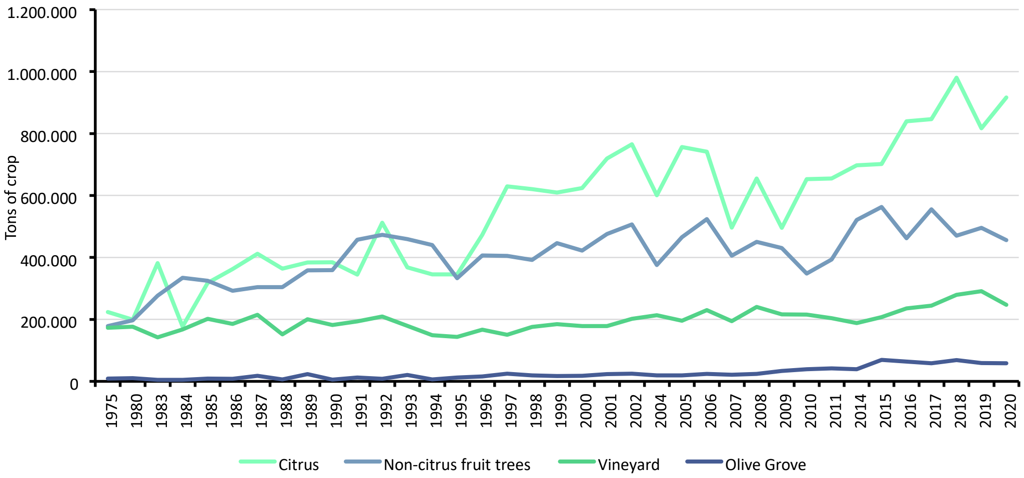

Figure 145. Evolution of the production of different woody crops. Source: Own elaboration based on INE and CARM data.

All woody crops have suffered an increase in their productivity since the 80s, although in different proportions. Fruit is the most widely grown crop and the one that has seen the greatest increase in this region, given its climate and topographical characteristics, which allow it to grow almost all year round. Citrus fruits are the ones with highest production, having quadrupled and almost quintupled their production volume since 1980. Also, it is necessary to reflect the development of two of the woody crops that are more relevant in Mediterranean, the olive tree and the vineyard, which despite the quality of the products derived from them, their production has not undergone major changes. In terms of quality, the region has four Protected Designations of Origin (DOP), one for pears and three associated with wines. Figure 146 presents the distribution between different annual crop types in the last 40 years.

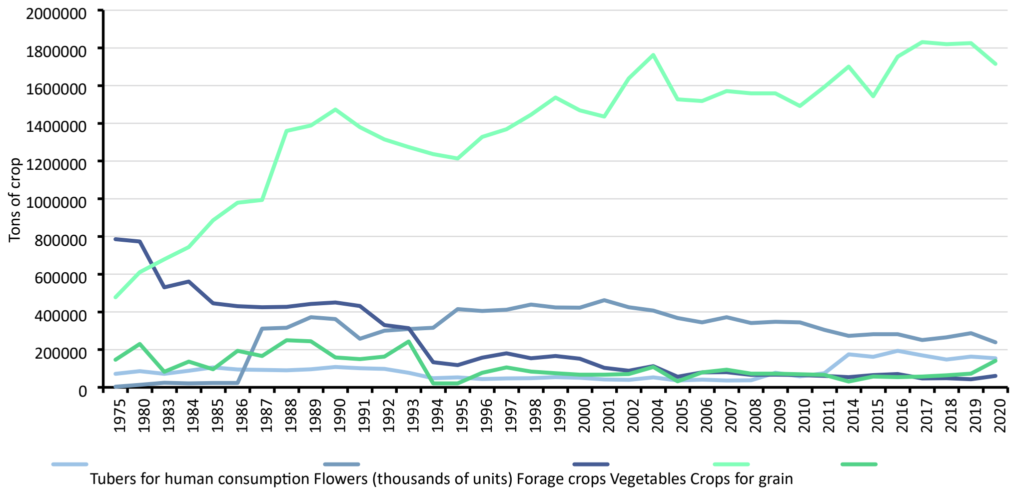

Figure 146. Evolution of the production of different arable crops. Source: Own elaboration based on INE and CARM data.

The annual or herbaceous crops recorded a greater increase in productivity in the region, compared to woody crops. This change is associated with historical events that took place in Spain. There was a big change in the cultivation pattern of herbaceous crops after 1975 and the Spain's entry into the European Union (EU) in 1986. From that decade onwards, Spanish products started to become more competitive and productive, as well as an increase in exports to EU and non-EU countries. The cultivation of forage and grain crops fell to a minimum in contrast to the exponential growth of flower and vegetable crops at the end of the 80s of the 20th century. Vegetables are the most produced crop type in this region, reaching more than 1.8 million tonnes in recent years. In addition, wheat together with the other grain cereals has seen its harvests almost disappear from being the most produced crop in the region at the end of the 20th century. It is also necessary to highlight the drop-in production of all crops during the periods of economic crisis (1994-1995 and 2008-2014) with significant decreases. Figure 147, presents the evolution of the two main crop types and the total in the period between 2014-2020.

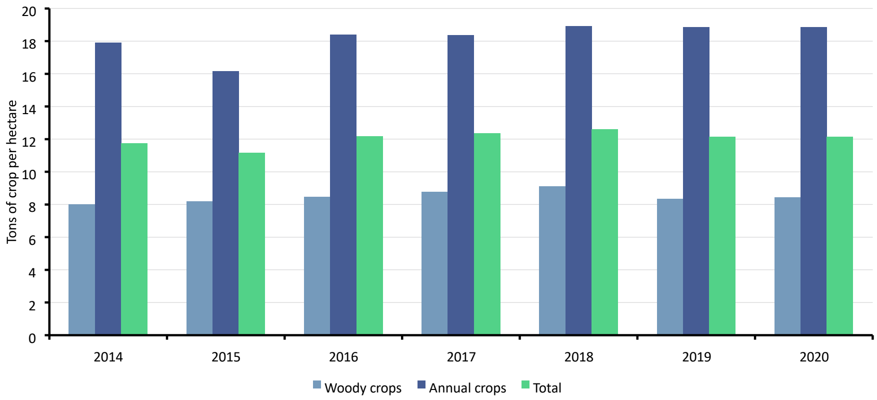

Figure 147. Evolution of the productivity of different crops and total. Source: Own elaboration based on INE and CARM data.

As a result of the average between the different types of crops, the total average productivity for the region is lower than the productivity of annual crops. This is due to the existence of more surface devoted to woody crops with lower production than annuals, which need more space (three times more than herbaceous crops) and results in a low productivity for this type of crop and as consequence, lower overall productivity. In this way, the lower productivity of woody crops in comparison with herbaceous crops in the region is clear.

It is also necessary to evaluate the impact of agriculture and more in general, the impact of all the primary sector in the employment. In this sense, the population employed in the primary sector in Murcia region, at least since 2008 (including agriculture and livestock), represents the 10-15% of the total number of people employed in the whole region. Despite being one of the least representative sectors, it is important to assess its economic impact, considering the subsectors that comprise it, as well as the area required and its productivity, particularly in the case of agriculture. Between the beginning of 2008 and the end of 2014, the average number of people employed in the primary sector increased from 8% to 14%, almost double the share of 2008, starting in the first quarter of 2015. Since 2018, employment is decreasing, reaching 2009 levels, where primary sector employment was around 10%. This employment percentage is presented in Figure 148, covering the period between 2008 and 2022.

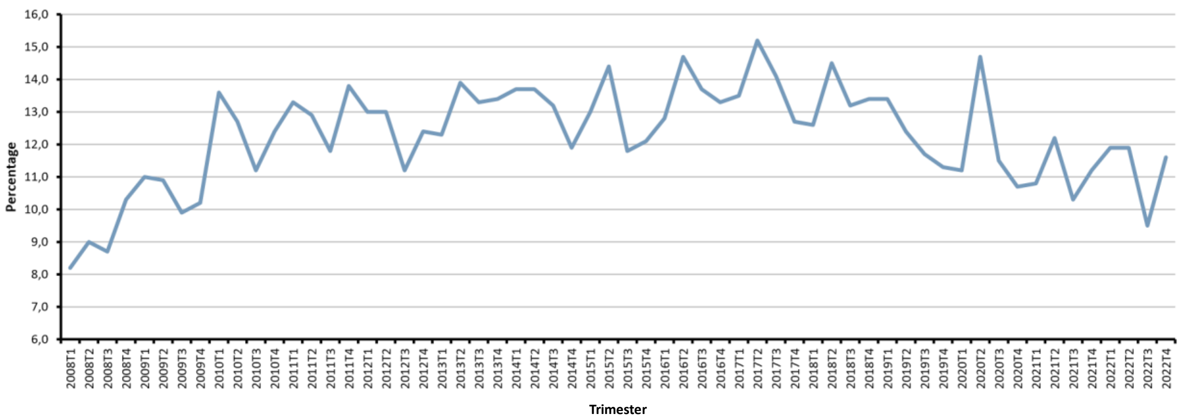

Figure 148. Evolution of the percentage of total employment in the agriculture and livestock sector. Source: Own elaboration based on INE data.

The evolution of livestock sector in the region, is presented in Figure 149. It should be noted that it has not suffered great variations, despite this, it is considered that all types of cattle have a grooving trend or remain stable. Pig farming is the most representative of the region, and since 1997 the number of pigs has exceeded one and a half million, sometimes reaching two million. Sheep are the most stable in terms of the number of heads, being slightly more than 500,000 since 1997. Goats are the most dynamic and have undergone the most drastic variations in population size. Finally, the bovine is the least representative, but the one that has grown proportionally more in the last 20 years, almost doubling its size (from about 50,000 head to almost 100,000 head).

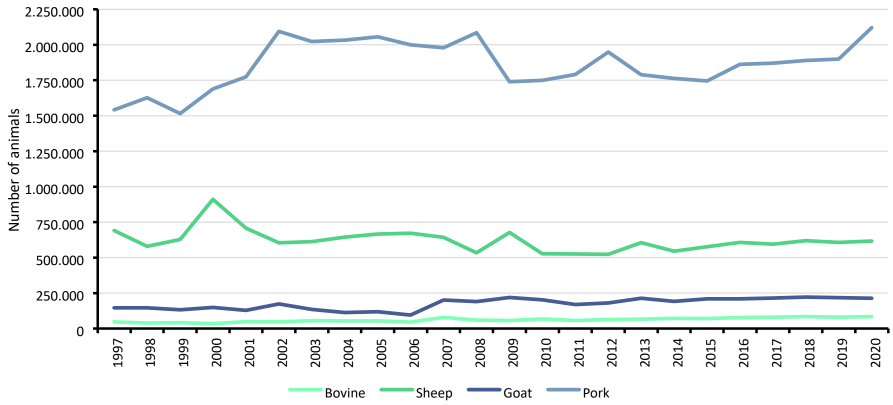

Figure 149. Evolution of the livestock cattle. Source: Own elaboration based on CARM data

In terms of fisheries (Figure 150), there is a large difference in volume and price between the different types of capture fisheries. The volume and market for aquaculture is higher than for sea fishing. Sea fishing is more constant in terms of the quantity of fish in weight extracted, and although there has been some change, the market value has not fluctuated. Between 2016 and 2019 aquaculture represented a stable relationship between the volume of fish and its cost and/or profit, however, after the COVID-19 pandemic, between 2020 and 2021, the price of fish from this type of fishing has increased in value with respect to the relationship that already existed.

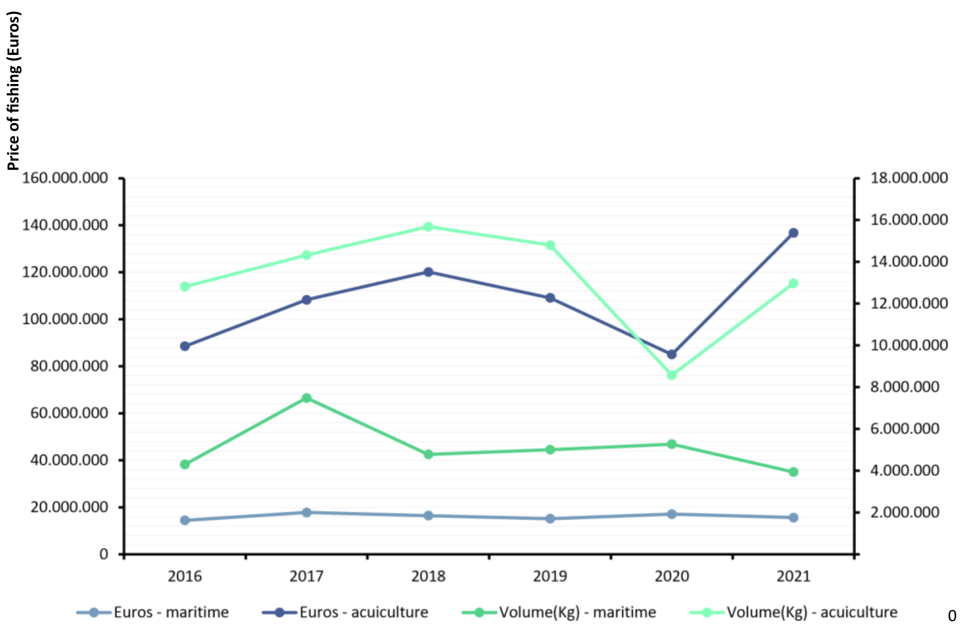

Figure 150. Evolution of the fishing volume and prices. Source: Own elaboration based on CARM data.

The size of the employed population in the fisheries sector is low, and has decreased slightly over the last 20 years (Figure 151). Despite of the changes and fluctuations in the sector, the number of employees in the fisheries sector is still above 500.

Figure 151. Evolution of the total fishing employment. Source: Own elaboration based on CARM data.

According to the 4th Forest National Inventory of Spain (IFN4, acronym in Spanish), 70% of the forest area in Murcia region corresponds to woodlands with less than 10% of the Forest Cover Fraction (FCC, acronym in Spanish), which includes scrubland, wetlands or scattered woodland. Around 27% of the forest area is covered by conifers, mainly *Pinus* and *Juniperus* species that are adapted to water scarcity and high evapotranspiration conditions. Mixed and broad-leaved forests are poorly represented in the region, since they barely correspond to 10,000 hectares each (around 1% of the region's area).

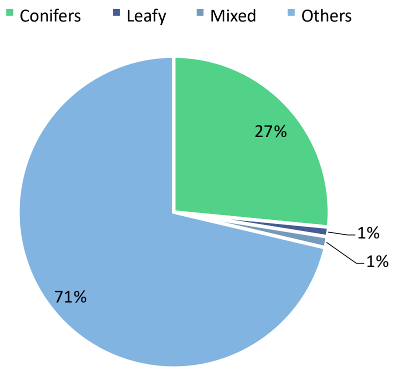

Figure 152. Percentage of area of different types of forest. Source: Own elaboration based on IFN4 data.

○ Water and waste

Water is a key resource in Murcia region, considering the region's arid climate conditions. The lack of water is due to the scarcity of rainfall, as well as the dependence for irrigation on the Tajo-Segura water transfer, in force since the 1980s, and the exploitation of water for the development of the primary sector. Water limitation mainly affects irrigated crops as well as the water access for domestic activities. In addition to the accessibility of water, the quality of the water to which one has access must be assessed. One of the most famous examples is that of the Mar Menor, the largest lagoon in Spain, associated with RAMSAR wetlands, protected natural spaces and areas of special importance for the Mediterranean, as well as other areas protected for their high ecological value, is also in a state of poor quality. This is due to the discharge of water contaminated by different substances associated with economic activities in the area, including fertilizers and pesticides from agriculture. Nowadays, available water comes almost equally from surface and subsurface water, which endangers the status of aquifers, given the volume of water used (Figure 153 and Figure 154). It is important to emphasise that when access to one type of water decreases, the access to the other increases as they counterbalance each other to maintain access to the same volume of water or at least to cover human and economic needs. However, since 2008 the volume of water available has decreased, being affected as consequence the development of economic activities that requires water and the household water consumption.

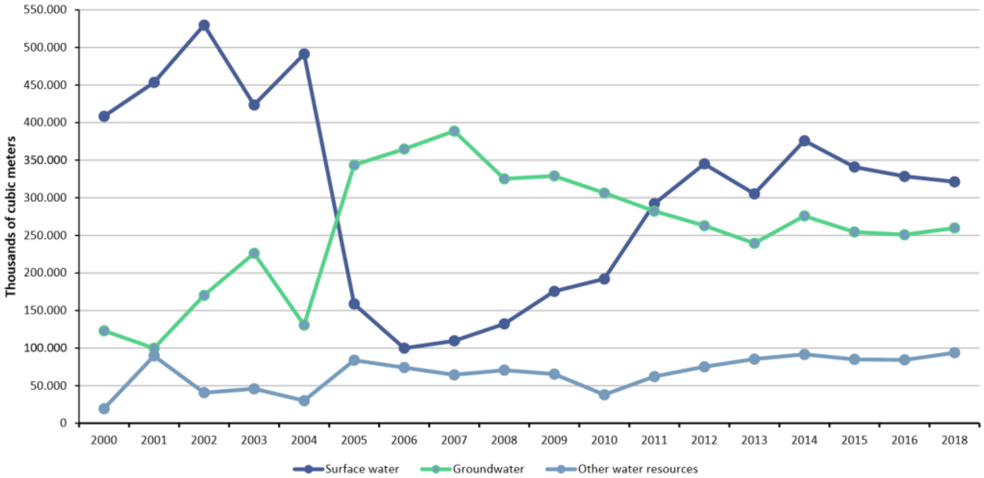

Figure 153. Volume of water available by origin. Source: Own elaboration based on INE data.

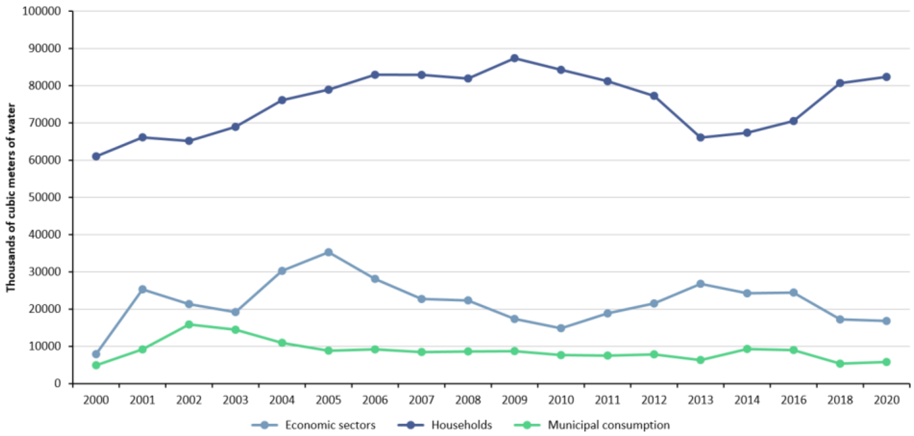

Figure 154. Volume of water by user. Source: Own elaboration based on INE data

It is important to highlight that the 80% of the water supplied is for households or domestic consumption, being the only use that maintains the volume of required water, covering the needs with available water that comes from aquifers. It also occurs during periods of water stress or worse weather conditions in which water availability is very reduced.

Related to water availability, water consumption, water stress and climate conditions, it is necessary to consider the price of water for supply, but also for consumption and treatment. The first two costs are more expensive in the region of Murcia than the Spanish average, as water for domestic consumption in Murcia costs a 25% more than the average, and the cost of supply in general in Murcia region is 50% more than the average. However, the cost of water treatment is similar between Murcia and the national average. In general terms, at national and regional level, the cost of access to water increased, being twice or three time higher in cost in the recent years, due to drought climate conditions related with climate change, the high use of surface and groundwater resources or the water pollution, conditions that are all affecting but not at the same rate.

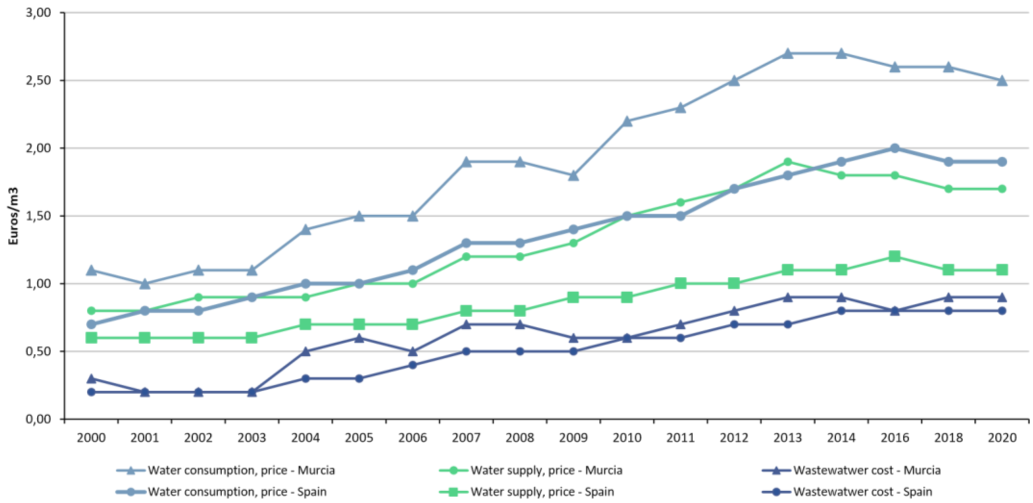

Figure 155. Cost of water by volume consumed, supplied and wastewater in Murcia and national average. Source: Own elaboration based on INE data

Due to the climate conditions, the population size and the trends of the Water Stress Index (WSI) (Figure 155), it is important to take care of the water resources and its quality, and make a good management of water by means of well-defined strategies including good practices to improve water security. The WSI shows the volume of water that is available per person over the course of a year, and the Table 39 shows the categories established for this WSI according to various authors (Damkjaer & Taylor, 2017).

Table 39. Categorisation of WSI.

Category	Contemporary WSI threshold (m^3 capita−1 year−1)
No stress	>1700
Water scarcity	1700 >1000
Water stress	1000-500
Absolute water stress	<500

Figure 156. Water Stress Index (m^3/capita^{-1}/year^{-1}) in Murcia and national average. Source: Own elaboration based on INE data

Murcia and the national average of the index follow a similar trend, although they changed positions after the period 2006-2009, where they had almost identical values. The WSI indicates that Spain is under absolute water stress, maintaining a stable trend around 400 $m^3capita^{-1}yr^{-1}$ since 2005. Murcia followed the same trend between 2005 and 2010, after which it increased to about $m^3capita^{-1}yr^{-1}$, which it has maintained until 2018, slightly improving its water situation. This causes water to have a heavier weight as a vulnerable sector in this region, and nationally.

○ Industry and commerce

Industry and commerce are two of the main components of the economy of the Region of Murcia. Both, they play an important role in promoting economic growth, employment generation, innovation, and overall progress. The two sectors are interconnected, mutually reinforcing and facilitating economic activity, thus improving the standard of living of the population.

Commerce is associated with the export of agricultural products such as fruits and vegetables, as well as the income generated from tourism activities. However, climate change generates a significant challenge to the economic and commercial development of the Region, as changes in temperature and precipitation patterns are causing a shift in the growing seasons, leading the reduction in crop yields. In addition, changing water and thermal conditions are hampering the region's tourism industry, with changes in visitor destinations possibly driven by extreme temperatures or a scarcity of water resources.

The role of industry and commerce in the economic growth, employment generation, and innovation makes them significant contributors to the Gross Domestic Product (GDP) of the Region of Murcia as well as at country level. In this sense, the GDP represents the total value of all goods and services produced within that region or country during a given period. In general, a higher GDP indicates a more robust and healthy economy. Industry produces goods and services that are sold in the market, while commerce distributes, markets, and sells those goods and services. Together, these two sectors create jobs, generate income, and drive innovation, which in turn leads to economic growth that can be analysed thanks to the GDP growth. To evaluate the economic status, the GDP per capita of the region of Murcia has been calculated and compared with the national average of Spain (Figure 157), in order to have a comparison of the development and economic inequalities respect to the National level.

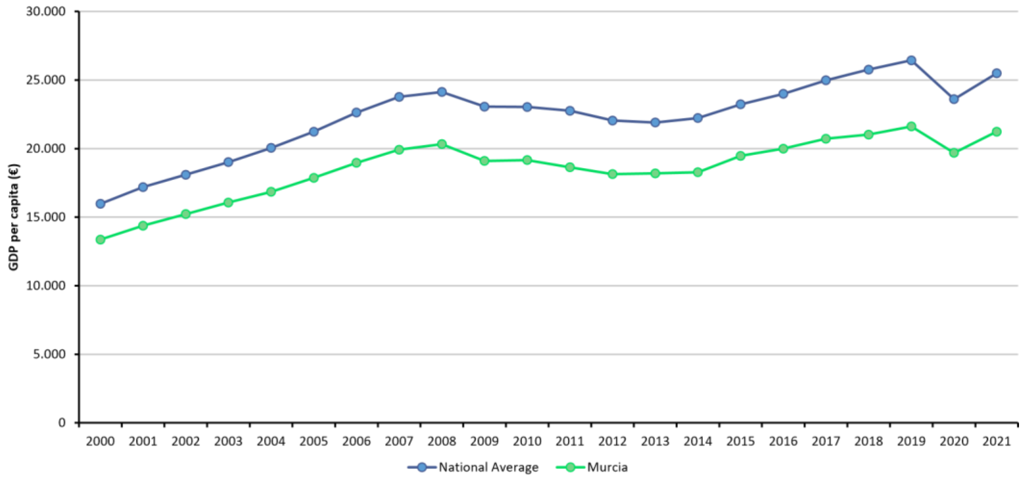

Figure 157. GDP per capita in Murcia and national average. Source: Own elaboration based on INE data.

Since 2000, the GDP per capita has increased, with a slight decline between 2008 and 2015, associated with the economic crisis, as well as in 2020 due to the effects of the COVID-19 pandemic. After these economic and health crises, the positive trend in GDP continues. The GDP in the Region of Murcia is between 15.5% and 18.5% lower than the National average of Spain. The increasing trend in the GDP, indicates an improvement of the economic conditions, which would allow a better development of the Region thanks to higher disposable income per capita.

The evaluation of the contribution of the industrial sector to the economy includes the Industrial Production Index (IPI) and the employment rates. The IPI is a metric used to measure changes in the output of industrial sectors over time and provides an indication of the sector's growth or reduction. Employment rates provide insight into the labour force participation of the industrial sector.

When analysing the IPI, it is essential to consider the seasonality of industrial development. Seasonality refers to the fluctuations in output that occurs during certain times of the year due to natural factors such as weather or holidays. In the case of the Region of Murcia, fluctuations and associated effects occurs during summer (July-August) and Christmas (December-January) holidays.

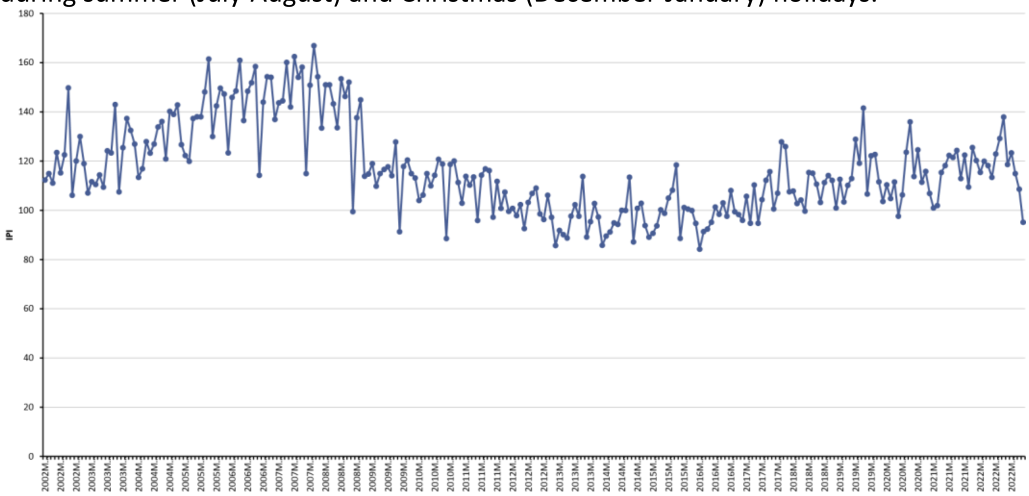

Figure 158. Industrial Production Index (IPI) in Murcia by trimester. Source: Own elaboration based on INE data.

The Industrial Production Index (IPI) (Figure 158) has been experiencing a negative trend since mid2008, which is a significant shift from the previous trend where it was increasing. This trend can be attributed to various factors such as the global financial crisis of 2008, which resulted in a decrease of the demand for goods and services, leading to a decline in industrial production. Between 2012 and 2016, the IPI reached its minimum value, with an annual average of 95-100. Despite the COVID-19 pandemic and the associated economic crisis, the IPI has shown signs of improvement, with a positive trend in industrial growth. This trend can be attributed to several factors, such as the implementation of economic measures by governments to boost the industrial production, increased demand for industrial goods and services due to changing consumer preferences, and the adoption of sustainable practices in the industrial sector.

As a result of these factors, the IPI has been increasing steadily and has reached levels last seen in 2002 by 2022. This positive trend indicates that the industrial sector is recovered from the effects of the economic crisis and is contributing to the overall economic growth of the Region. To ensures growth and sustainability in the industrial sector, it is essential to continue monitoring the IPI and associated industrial development in the next years.

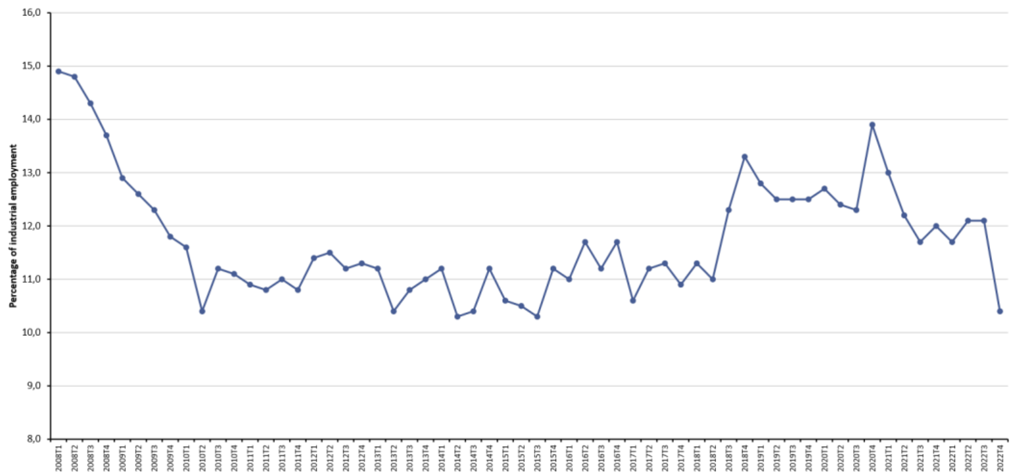

Figure 159. Percentage of industrial employment in Murcia by trimester. Source: Own elaboration based on INE data.

Following the onset of the economic crisis in 2007-2008, the employment rate in the industrial sector experienced a reduction of the 5%, and it remained between 10-12% until 2018. However, it began to show a growth trend from 2018, which was disrupted by the COVID-19 pandemic. The employment rate in the industrial sector has a high-degree of seasonality, with a recurring pattern of decline during the first quarter of each year. Between 2010 and 2017, the annual employment rate in the industrial sector was relatively stable, but between 2008-2010, it experienced a decline of 4%. It is also necessary to highlight that the employment rate in the industrial sector was recovered between 2018-2020, reaching pre-crisis levels in 2008. However, it experienced a decline again due to the COVID-19 pandemic, albeit to a lesser extent than during the previous economic crisis.

Industry and commerce are crucial components of the economy in the Region of Murcia. They have a close interlinkage, and together they promote economic growth, employment generation and innovation. However, the effects of climate change are a significant challenge to the Region affecting economic and commercial development, and also crop yields and tourism. However, the positive trends in GDP, IPI, and employment rates indicate the recover and good development of the industrial sector in the Region of Murcia. In this sense, continuous monitoring and sustainable practices are crucial for ensure a continuous growth and the economic sustainability of the Region.

○ Tourism, leisure and cultural heritage

Tourism is a key economic activity in the Mediterranean region, due to the great potential to attract visitors thanks to warm climate, the coast and the location. However, climate change and water scarcity are two issues that could significantly affect the tourism in this region. Temperature increase and sea level rise may affect the quality of beaches and reduce the availability of fresh water, which could limit the region resources to meet tourism demand. In addition, water scarcity may limit the availability of water and the region's ability to offer tourism services related with water.

It is important to point out that tourism development must be sustainable and responsible in order to minimise negative impacts on the environment and the local communities, especially in the context of climate change and water scarcity. Therefore, emphasis has been placed on the development of leisure and education initiatives to attract tourists interested in sustainable activities such as cultural, ecological or gastronomic tourism.

The tourism is classified into two categories according to the origin of tourists: domestic and international tourism. This differentiation generates variations in tourists' volumes, duration of stay, and expenditure patterns. Specifically, domestic tourism refers to travel and recreation undertaken by residents within their own country, while international tourism involves the movement of visitors across national borders for leisure or business purposes. These categories are distinguished based on factors such as the origin of tourists, travel behaviour, and economic impact on the destination. Considering the domestic tourism, the region has data on expenditures and duration of stays in both per capita and aggregate values. The evolution of overnight stays and total money spent by national tourism is presented in Figure 160.

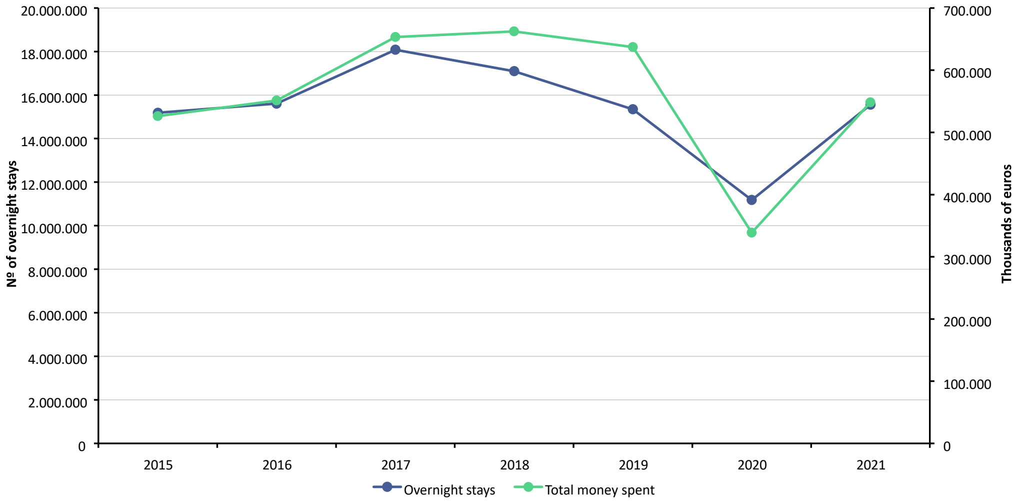

Figure 160. Evolution of the overnight stays and total money spent by national tourism in Murcia region. Source: Own elaboration based on INE or CARM data.

In the evaluated period (2015-2021), national tourists contributed over 15 million overnight stays in the Region of Murcia. However, due to the effects of COVID-19 pandemic, the number of stays was reduced by 3 million in 2020 due to mobility restrictions. In 2021, the expenditure levels have returned to pre-pandemic levels. Interesting is the effect between 2017 and 2019, where the tourists spent fewer nights in the region and the expenditure per day/night remained stable, indicating that tourists spent more money in tourism activities during this period. Figure 161 presents the number of days spent by tourist in the Regions and the average money spent per tourist.

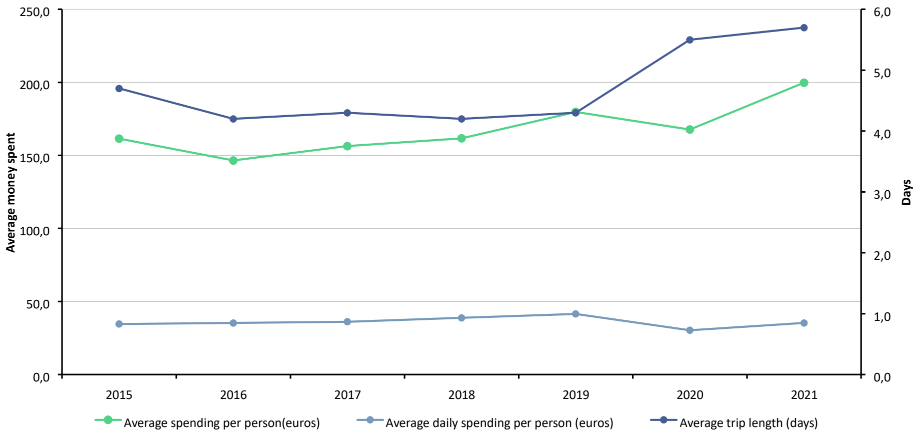

Figure 161. Evolution of the average trip length and money spent per person by national tourism. Source: Own elaboration based on INE or CARM data.

A deeper analysis of the data shows that the increase in average spending per person between 20152019 was due to an increase in the number of high-end tourists visiting the Region, who spent more on accommodation, dining and tourism activities. The COVID-19 pandemic caused a shift towards budget tourism as people sought more affordable options during 2020. However, in 2021, the highend tourism in the Region was recovered, leading an increase in average spending per person. This was accompanied by an increase in the number of days that tourists spent in the Region of Murcia, indicating that visitors were more willing to spend more time and money on their trips. In addition, the recovery of tourism in the Region has not only surpassed pre-pandemic values, but has also exceeded the National average in terms of number of visitors and expenditure. This suggests that the Region of Murcia is becoming an increasingly attractive tourist destination, and is likely to continue the growth in the coming years.

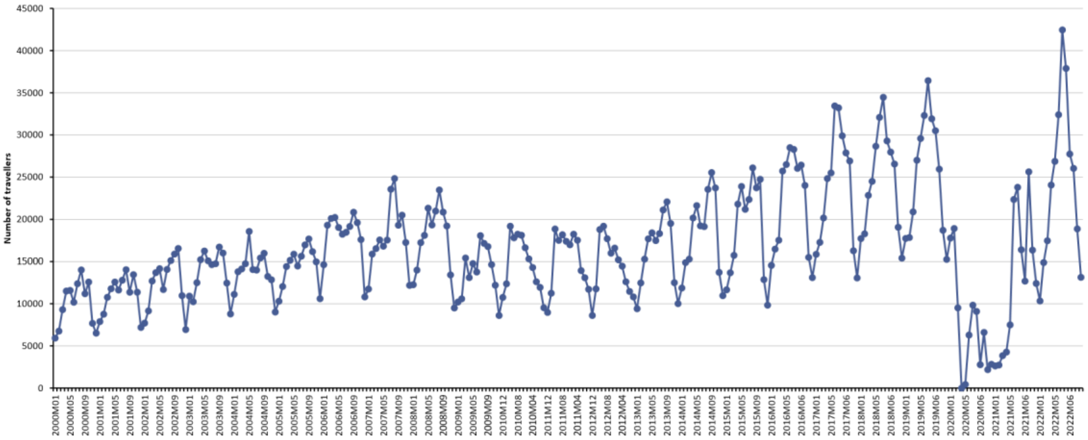

Figure 162. Evolution of total of international travellers. Source: Own elaboration based on INE or CARM data.

The Region of Murcia has seasonal pattern in its international tourism, with a concentration of tourist activity during the summer months when temperatures reach their peak values. This trend can be attributed to the warmest climate conditions in the Region, which make it an attractive destination for tourists seeking for warm weather and leisure activities.

Analysing the historical data from 2000 to 2008, it was found a positive overall trend in international tourism, marked by a consistent increase in the number of tourists throughout the year. The 20082012 period was significant challenges for the tourism in the Region of Murcia due to the global economic crisis. During this period, the number of international tourists visiting the Region experienced a decline. The economic downturn in the period, coupled with reduced disposable income and a general sense of uncertainty, resulted in a decrease in travel and tourism activity.

Nevertheless, the tourism sector in the Region of Murcia had a gradual recovery trajectory returning to pre-crisis levels of tourism in 2014, increasing its interest as tourism destination and multiplying by two the number of tourists from 2014 in 2019. However, the year 2020 presented an unprecedented setback for international tourism worldwide due to the outbreak of the COVID-19 pandemic. The travel restrictions, border closures, and health concerns led to a significant decline in international tourist arrivals in Murcia, as in the global trend. The Region faced an important decrease in visitor numbers, resulting in an impact on the local economy and tourism-dependent businesses.

Despite the adverse circumstances, there were signs of a slight recovery in international tourism towards the end of 2021. And from April 2022 onwards, the tourism in the Region witnessed a noteworthy resurgence, surpassing the previous trend and indicating a robust recovery. The rebound can be attributed to a combination of factors, including the management of the pandemic, effective marketing strategies, and the Region's inherent appeal as a tourist destination. The improvement in international tourism figures in the Region of Murcia from 2022 brought much-needed relief to the local economy, the labour market, and tourism-related businesses. The total spent by international tourism is presented in Figure 163.

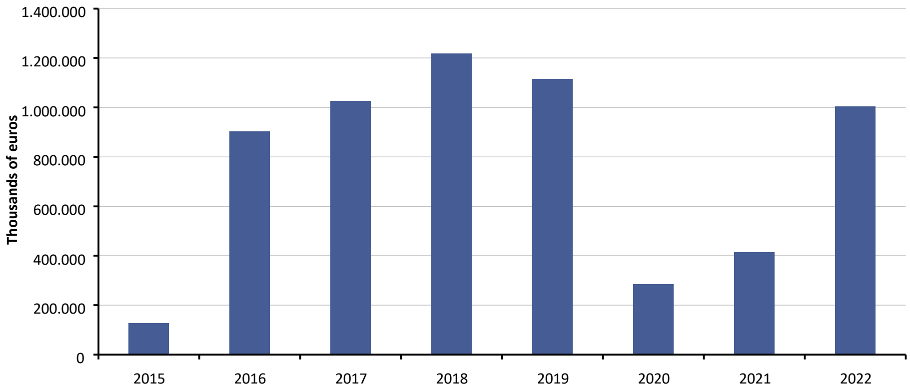

Figure 163. Evolution of the total money spent by international tourism. Source: Own elaboration based on INE or CARM data.

International tourist spending in the Region of Murcia typically reaches around one million euros and follows an upward trajectory affected by the COVID-19 pandemic. It caused a significant disruption to the tourism sector, leading to a decline in tourist spending during 2020 and 2021. This decline was over the 70%, reflecting the impact of the pandemic and the global measures implemented to control the effects. Travel restrictions, border closures, and quarantine requirements severely limited international travel and tourism activity. Nevertheless, signs of recovery emerged in 2021 as travel restrictions eased and vaccination campaigns gained momentum. This modest improvement indicated a gradual return of international tourists to the region and the resumption of economic activity in the tourism sector. As the year progressed, there was a noticeable rebound in tourist spending, contributing to the stabilization and recovery of the tourism economy. By 2022, tourist expenditures returned to pre-pandemic levels similar to 2017. The recovery can be attributed to factors such as the reduction of travel restrictions, increase of consumer confidence and the effective marketing campaigns that attracted international visitors back to Murcia.

As has been seen throughout the description of the sector, the values for tourism in the Region have recovered and returned to pre-pandemic levels. However, it must be considered that it is a seasonal sector that can be greatly affected by the impacts of climate change and its derivatives, mainly affecting the seasonality of tourism.

6.1.2. Climate change factors analysis: adaptation and mitigation baseline

This section presents a review of CO_2 emissions and the stock of carbon stored in the soil and vegetation in the Region of Murcia. The Region of Murcia has available information on CO_2 emissions for the period 2000-2020 following the categories defined by the National Greenhouse Gas Emissions Inventory Report (developed by the Spanish Ministry for Ecological Transition and Demographic Challenge), according to the guidelines set out in the IPCC established in the 2006 IPCC Guidelines (IPCC, 2006) (Table 40). In this sense, the evaluation of emissions has been carried out for each sector of activity in the Region considering. The level of emissions and removals in the Region plays an important role in defining a baseline of the current state and thus being able to propose strategies and solutions that allow the implementation of adaptation and mitigation measures.

Table 40. Main activities considered in the evaluation of CO_2 emissions.

General Activity	Sub-categories of each activity	Specific activity
Energy processing	Combustion activities	Energy Sector Industries
		Manufacturing and construction industries
		Transport

		Other Sectors
General Activity	**Sub-categories of each activity**	**Specific activity**
		Other
	Fugitive emissions from fuels	Solid fuels
		Oil and natural gas
Industrial Processes	Mineral Products	-
	Chemical industry	-
	Metallurgical production	-
	Non-energy products and solvent use	-
	Electronics industry	-
	Use of GHG substitutes	-
	Production and use of other products	-
	Other	-
Agriculture	Enteric fermentation	-
	Manure management	-
	Rice cultivation	-
	Agricultural soils	-
	Planned burning of savannahs	-
	Field burning of agricultural residues	-
	Limestone amendments	-
	Urea fertilisation	-
	Carbon fertiliser application	-
LU change & forestry	-	-
Waste treatment and disposal	Landfilling	-
	Biological treatment of solid waste	-
	Incineration of waste	-
	Waste water treatment	-
	Other	-
Other	-	-

It is necessary to highlight that a key category is a priority category in the National Inventory because it has a strong influence in the country's total greenhouse gas emissions inventory in terms of the absolute level, trend, or uncertainty of emissions and removals. Considering this, only the categories with significant emissions in the Region of Murcia were represented in Figure 164.

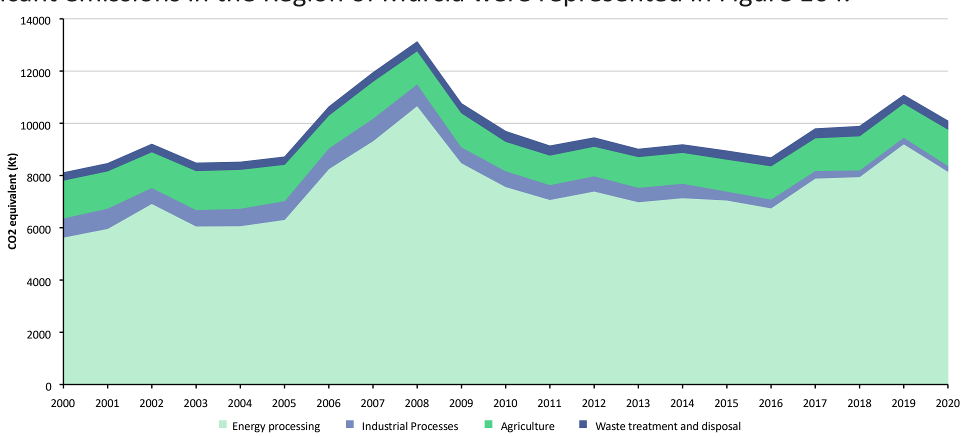

Figure 164. Evolution of the CO_2 eq/yr per category.

Energy processing stands out as the largest contributor to CO_2 emissions in the region, as it encompasses a wide range of human activities. Approximately the 80% of the total emissions can be attributed to this category. It is also necessary to highlight the agriculture with also a significant role in terms of CO_2 emissions, contributing approximately 10-15% of the total emissions. Emissions from agriculture are linked to various activities such as livestock farming, fertilizer use, and agricultural waste management. By categories, Figure 165, represent the evolution of emissions in the subcategory of energy processing in the assessment period.

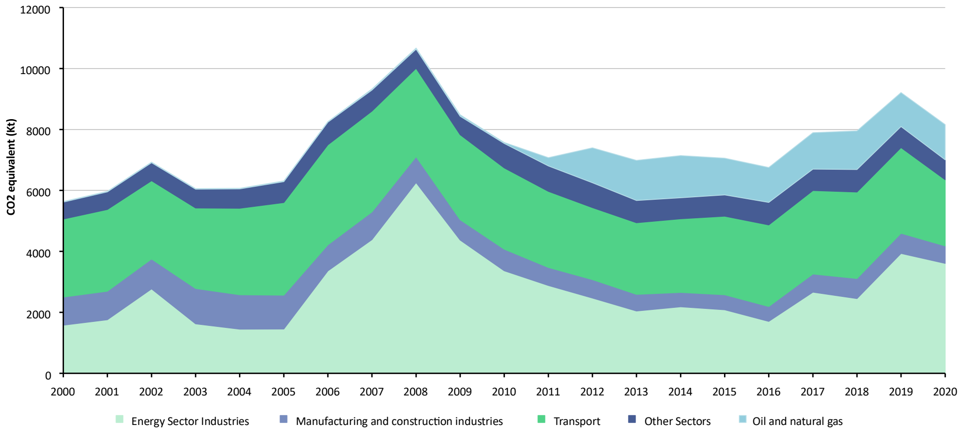

Figure 165. Evolution of the CO_2 eq/yr emissions per subcategory of energy processing.

Considering the energy processing activities, the majority of CO_2 emissions are attributed to combustion activities. However, starting from 2011, emissions from oil and natural gas, have a significant role in the emissions. It is necessary to highlight that the energy sector and the transport industries are the primary contributors to emissions, accounting approximately the 40-50% of the total emissions in the Region. Other activities such as the manufacturing and construction industries join "other sectors" involving combustion and energy processing activities, in which commercial and institutional, residential, and agricultural, forestry, and fishing sectors are involved, also have constant emission levels in the evaluated period. Figure 166 represent the evolution of emissions in the subcategory of industrial processes in the assessment period.

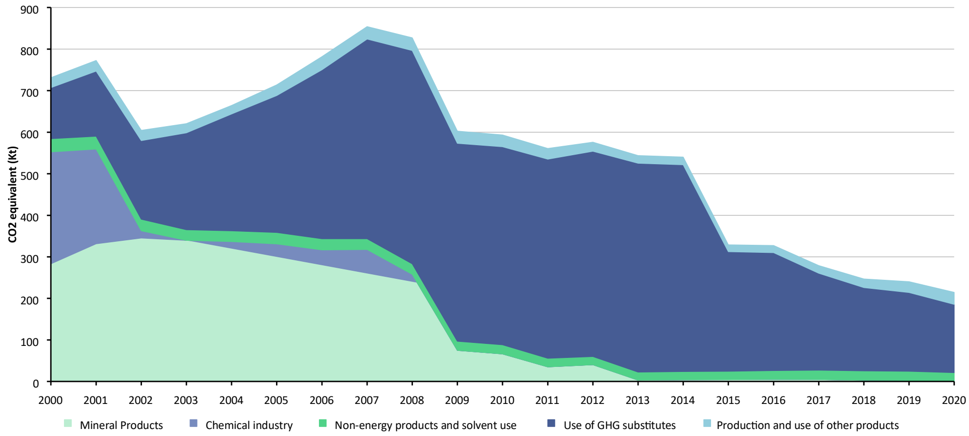

Figure 166. Evolution of the CO_2 eq/yr emissions per subcategory of industrial processes.

Industrial processes had a decreasing trend throughout the evaluated period, led by the use of GHG substitutes as the main CO_2 emitter. Initially, the extraction of mineral products stood out as the largest emitter within the industrial sector. However, with the onset of the economic crisis in 2007, this activity experienced a significant exponential decrease and ultimately ceased to exist in 2013. The chemical industry followed a similar trend, but approximately a decade earlier the emissions had already been eliminated. Emissions associated to obtain non-energy products, the use of solvents, and the production and utilization of other products are reduced in comparison with the use of GHG substitutes. Despite their relatively low emissions, it is important to monitor and manage these activities to ensure their sustainability and mitigate any potential environmental impacts. After that, Figure 167, represent the evolution of emissions in the subcategory of agriculture in the assessment period (2000-2020).

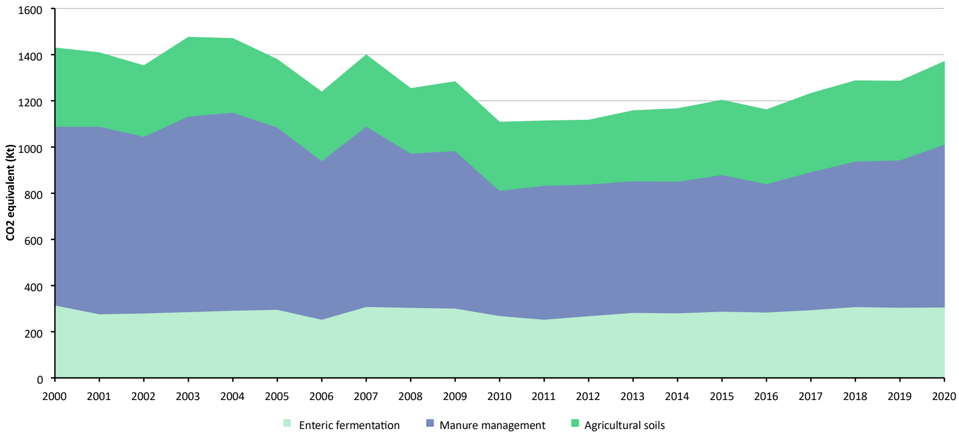

Figure 167. Evolution of the CO_2 eq/yr emissions per subcategory of agriculture.

The agricultural sector plays a high-contributing emissions role in the Region of Murcia. It is the second sector in emission levels. The emissions in these sectors primarily stem from activities associated with manure management, specifically the application of fertilizers to enhance land productivity and crop yield. In addition, the enteric fermentation and agricultural soils, also have consistent emission patterns between 2000 and 2013, with emissions and average around 300 kt of CO_2 equivalent. With a decrease in emissions towards the year 2010, emissions have once again increased significantly in recent years. Finally, Figure 168, represent the evolution of emissions in the subcategory of waste treatment and disposal in the assessment period (2000-2020).

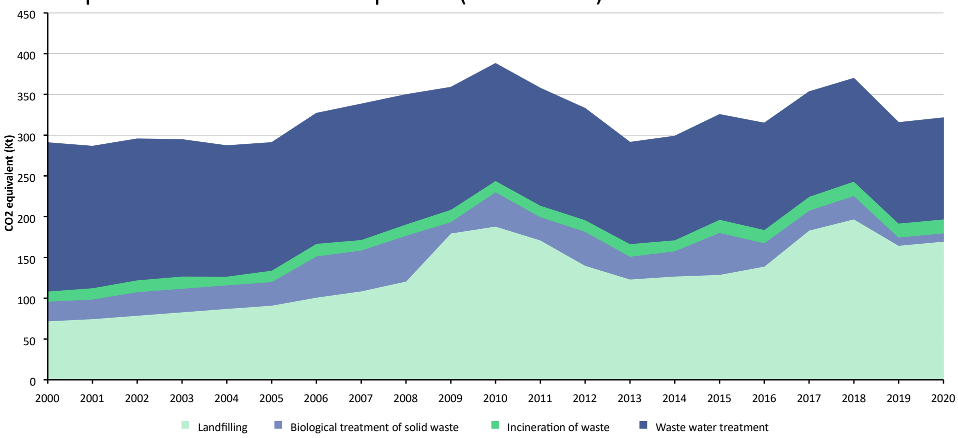

Figure 168. Evolution of the CO_2 eq/yr emissions per subcategory of waste treatment and disposal.

The waste treatment and disposal activities share a similar emissions level with the industrial processes. Over the period of 2000 to 2020, the emissions of this subcategory vary reaching its maximum values in 2010 and 2018 guided by the trend of incineration and wastewater treatment. In this sense, incineration of waste, is the higher emitter in this subcategory with more on less the 50% of the total emissions followed by wastewater treatment. The other categories are responsible of a less amount of emissions if compared with the two higher emitters.

To complement the emissions analysis, the carbon stock in vegetation and soil is provided (Figure 169) using geolocated data from ESA Biomass Climate Change Initiative[1] and Global Soil Organic Carbon Map (from FAO)[2], on soil organic carbon and biomass stock that were translated in carbon stock using default values provided by the IPCC. As a result, the carbon stock in soils is higher the 542,025 $MgCO_2$, while the carbon stock in the biomass increases to 2,426,766 $MgCO_2$. The evolution of carbon stock in biomass along the years with available data is represented in Figure 170. It is observed how the carbon stock in the biomass has been increased since 2010 reaching values higher than 2.4 million in 2020.

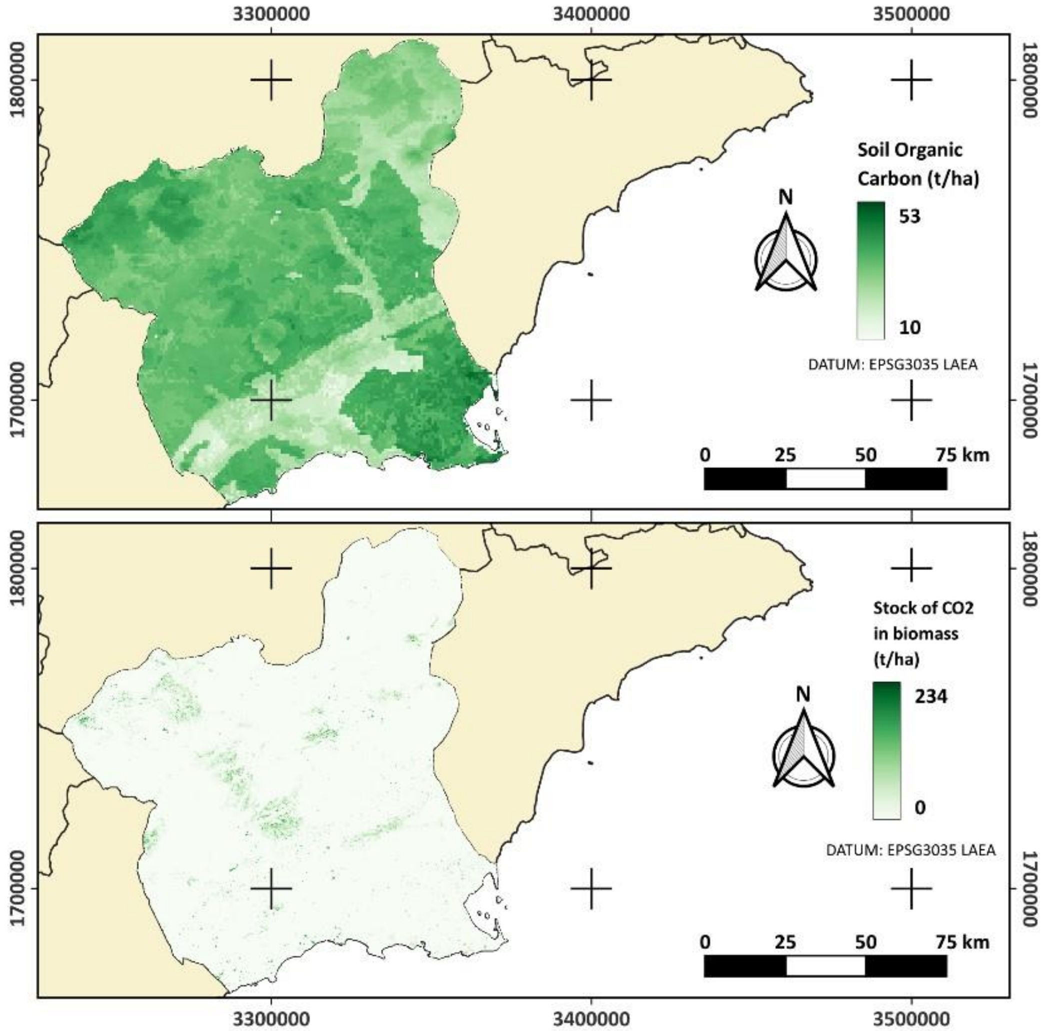

Figure 169. Carbon stock (tCO_2) in soils (top) and carbon stock (tCO_2) in biomass for the Region of Murcia in the reference year. Source: Own calculation based on ESA Biomass Climate Change Initiative and Global Soil Organic Carbon Map (from FAO) data respectively.

1 https://data.ceda.ac.uk/neodc/esacci/biomass/data/agb/maps/v4.0
2 https://data.apps.fao.org/glosis/?share=f-6756da2a-5c1d-4ac9-9b94-297d1f105e83&lang=en

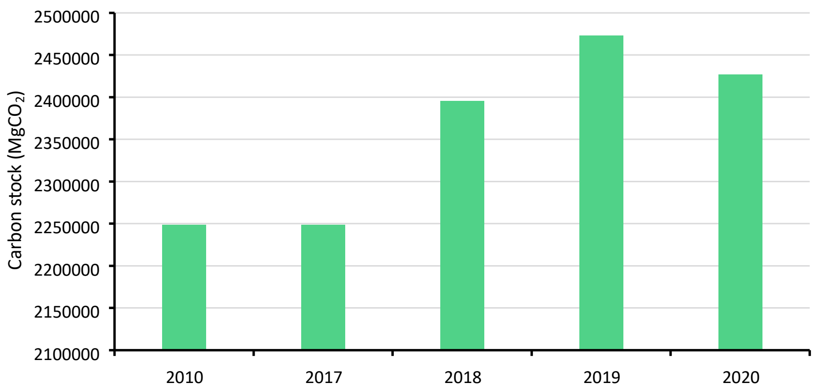

Figure 170. Carbon stock in biomass ($MgCO_2$) for the Region of Murcia between 2010 and 2020. Source: Own calculation based on Global Soil Organic Carbon Map (from FAO) data.

6.1.3. Past experience and legal framework analysis

For the past experience and legal framework analysis of Murcia Case Study, 21 documents were identified and high-level characterised within key fields. From them, 8 were selected as the most relevant and interesting ones, and were further analysed.

The detailed information of this analysis can be consulted in Annex 4 in section 11.7. The following Table 41 includes the relation of those documents analysed deeply and few key aspects on them. This legal framework will help to define the starting point for policy implementation considering the most important sectors and the associated climate change impacts.

Table 41. Relevant documents analysed for CS4 Murcia Region

#	Name of the document	Type	Scope	Year	Main sectors
1	**Climate Change in the Region of Murcia: from the Paris Agreement to the climate emergency**	Roadmap	Regional	2021	• Agriculture, forestry and fishing • Water and waste • Biodiversity and natural heritage
2	**Strategy for Mitigation and Adaptation to Climate Change in the Region of Murcia**	Strategy	Regional	2019	• Society • Water and waste • Energy • Biodiversity and natural heritage • Transport
13	**Integrated National Plan for Energy and Climate 2021-2030 (NECP)**	Plan	National	2020	• Energy

14	**National Plan for Adaptation to Climate Change (NAP) 2021-2030**	Plan	National	2021	• Waste and waste • Biodiversity and natural heritage • Agriculture, forestry and fishing • Tourism, cultural heritage • Energy • Transport • Industry and commerce
15	**Energy Plan for the Region of Murcia 2016-2020**	Plan	Regional	2016	• Energy
16	**Special Civil Protection Plan against the Risk of Flooding in the Autonomous Community of the Region of Murcia**	Plan	Sectoral	2007	• Water and waste
17	**Emergency Civil Protection Plan for Forest Fires in the Region of Murcia**	Plan	Sectoral	2021	• Agriculture, forestry and fishing
19	**Strategic Plan for the Agrifood Sector of the Region of Murcia**	Plan	Sectoral & Regional	2007	• Agriculture, forestry and fishing • Industry and commerce

6.2. PESTLE results for the local ecosystem drivers' analysis

This section discusses how the impact of climate change, and adaptation and mitigation policy implementation are affecting the Murcia region based on political, economic, social, technological, environmental and legal factors. Table 42 below provides details of the key items collected for each PESTLE factor. The sources for the information provided in the table are from the data collection results which came from the different exercises with stakeholders, the case study leader and supporter to identify the main drivers and the data sources to understand the local ecosystem (reported in section 11.8 Annex 8. Case Study 4 – Mediterranean Region (Murcia): PESTLE results for the local ecosystem drivers' analysis). The process to complete this PESTLE was explained in the methodological part of this document (section 2.2).

Table 42. Results from Murcia PESTLE analysis.

Factors	Category	Details	Impact status
Political	Governmental policy	Urban Plan ▪ Regional Strategy on mitigation and adaptation to climate change ▪ Urban Agenda 2030 ▪ Sustainable Master Plan of Villa de Fuente Álamo Master Plan	Positive
	Tax Policy	Green taxation policy ▪ Local policies promoting ecotourism	Negative
	Environmental policy	Life Adaptate measures ▪ Political context in favour of carrying out actions aimed at fighting climate change	Positive
	Funding grant/initiatives	Regional incentives to buy electric cars or install PV panels ▪ Economic incentives for industry to calculate the CO_2 and water footprint ▪ Sustainability voucher: external service to calculate and get the ISO certificate ▪ FEDER incentives of the central state administration: EDUSI for climate resilience actions ▪ Initiatives that promote healthy living, for example zero-emission transport	Positive
Economical	Economic growth	Active promotion of local green employment in the region ▪ Robust primary sector and local companies to boost the economy	Positive

	Economic investment	Powerful business ecosystem and high investment in PV solar energy, both in large plants and self-consumption	Positive
	Financing capabilities	Emission trading of diffuse sectors and industries	Positive
	Disposable income	Relevant disposable income level	Positive
Social	Population	Population growth due to labour migration ▪ Ageing population	Negative
	Health	Awareness on climate change	Positive
	Trends	Sustainable tourism, sustainable transport and energy efficiency ▪ Public awareness ▪ Fight against forest fires and pollution of aquifers ▪ Employment and training program for “Auxiliary activities in forest conservation and improvement”	Positive
	NGOs	SOS Mar Menor ▪ Hippocampus association for the sea conservation in Murcia	Positive
	Climate change	Public Authorities, city Council, local institutions promoting actions against climate change	Positive
Technological	Production	Water management techniques: hydroponics, drip irrigation	Positive

Factors	Category	Details	Impact status
	Training	ADAPTECCA website ▪ Energy data and relevant information on climate change ▪ Avoid the use of nitrates in agriculture ▪ Network of technology centers and universities ▪ Local actors on R&I	Positive
	Potential investment	Strong industry in efficient water irrigation ▪ Scarce participation of actors from the region in calls related to technology, R&D from the EU ▪ ICT solutions at local level (for example, 5G networks)	Positive
	Cost and tax	Circular economy initiatives ▪ Action plans promoting technological research	Neutral
Environmental	Emissions	Covenant of Mayors for Climate and Energy ▪ Bike lanes ▪ PV panels ▪ Public lighting LED (efficient)	Positive
	Sustainability	Ojos Naturalized Viewpoint Project for Nature-based Solutions implementation ▪ Enhancement of the Natural area of Majal de Gracia and a green lung in the Old speed circuit of Fuente Álamo ▪ Ecological green corridors ▪ Clean the Segura river (2000)	Positive
	Positive business	Biogas plant construction ▪ Biomass use promotion ▪ Desalination plants, for human consumption and for agriculture	Neutral
	Carbon footprint	Circular economy activities ▪ Urban gardens	Positive
	Adaptation	Urban areas shadowing ▪ Reduce the overexploitation of aquifers ▪ Vulnerability to DANA events	Positive
Legal	Renewables legislation	Regional Strategy for Mitigation and Adaptation to Climate Change ▪ Order of June 28, 2021, to achieve climate neutrality in the business sphere ▪ Business Plan for Climate and Energy	Positive
	Health and safety	Reuse of grey water, reinjection after debugging ▪ Legislation regulating rural housing ▪ Climate Emergency Declaration approved on June 4, 2020 ▪ Regional Park of the salts and falts of San Pedro del Pinatar	Positive
	Equal opportunities	Municipal equality plan ▪ Gender equality and non-discrimination	Positive
	Environmental legislation	Environmental impact declarations ▪ Law on Integrated Environmental Protection ▪ Law for protected areas ▪ Action plan of the Mar Menor	Positive

If we consider the **political factors**, we can see the relevance of plans and strategies as factors that help to stimulate the adoption of measures to reduce the impact of climate change through the reduction of emissions and the improvement of adaptation to climate change. Initiatives and incentives to promote renewables can also be key to contribute to the sustainability of the region, its resilience and decarbonization. Green taxation could be a problem limiting the economic activity. Considering the perception of the population about the politicians and the policy status of the region, the 37.2% has the perception of a good or very-good situation being the higher value since 2019. Citizens (45.6%) have the idea of the political situation will be the same in the next years while the 28.3% of the citizens thinks that the situation will get worse[3].

If we analyze the **economic factors**, investment in industry and in the improvement of business models, can serve to guide the population's capacity to become climate aware and advance in the decarbonization of the region's economy through the improvement in the use of resources. It must be considered that the GDP per capita in 2021 was 21,236 €, highlighting its increase of 7.8% compared to the previous year. However, its value in 2021 had not yet recovered the values prior to the pandemic caused by COVID-19 (21,617 €). The regional GDP value is significantly lower than the national average (25,498 €), which may be indicative of the need for incentives for the population to implement measures or invest money in training and environmental awareness so that the population becomes aware of climate change.

Social factors in the region of Murcia are influenced by the population, its evolution and the equality aspects. The population has increased slightly in recent years, reaching 1,531,878 inhabitants in 2022.

[3] https://www.cemopmurcia.es/wp-content/uploads/2022/07/BAROMETRO-PRIMAVERA-22.-WEB.pdf

9. Conclusions

The report is a comprehensive characterisation of the five case studies of the NEVERMORE project, developed in collaboration between the case study leaders and supporters, as well as technical partners to carry out the most detailed analysis of the sectors, climate, policies and drivers that play a relevant role in the evaluation of the effects of climate change in the different regions of the case studies, in order to define feasible adaptation and mitigation pathways.

The methodology followed to the characterisation includes the analysis of vulnerable sectors, the current and future climate, the definition of the baseline in adaptation and mitigation, and the analysis of the legal framework that directly affects the identification and selection of the policies to be implemented in each case study. In addition, the methodology included a PESTLE analysis to identify the most relevant drivers considering the view of the stakeholders of each area through consultations.

From the analysis of the climate and weather under historical conditions and in projection to a future period, the mean annual daily temperature is expected to increase in around 5ºC for all the case studies in the most unfavourable scenario. Resulting in mean annual daily temperatures in 2100 higher than 24ºC for the CS Sitia, more than 10ºC for the Trentino CS, more than 7ºC for the Norrbotten CS, higher than 20ºC in the CS of Murcia, and more than 5ºC for the Danube Delta CS.

Key vulnerable sectors in each case study were pre-identified and then validated through consultations with the NEVERMORE Local Councils of Stakeholders through an activity of identification of challenges, sectors affected and priorities in their areas. The result is that agriculture, forestry and fishing sector is a key vulnerable one for four out of the five case studies (CS1, CS3, CS4 and CS5), water and waste is a vulnerable sector for four case studies (CS1, CS4 and CS5, and for CS2 as secondary priority), tourism, leisure and cultural heritage is a key vulnerable sector for all the case studies, for three of them with high priority (CS2, CS3 and CS5), and the other two as secondary vulnerable sector; biodiversity is a vulnerable sector for three case studies (CS1 and CS3 with high priority, CS2 as secondary), energy sector is vulnerable for two case studies (CS2 and CS5), and industry and commerce has a second priority as vulnerable sector for two case studies (CS4 and CS5).

Agriculture is a key economic sector for Sitia case study, with a great percentage of land areas cultivated, and the increase of temperature, the lightening of dry periods, decrease in precipitation, sea level rise in coastal agricultural lands, among other climate hazards, will affect this sector. Water scarcity is also a vulnerability in Sitia, due to drouths and affecting at the same time the key sectors of agriculture and tourism (as it affects people). Biodiversity has a high relevance for Sitia too, which counts with one of the most important environmental areas in the Mediterranean: Sitia's Geopark, with floral interest, hundreds of species, and large number of characteristic animals of the island. Finally, economy is also strongly dependent on tourism, that can be affected by climate and weather conditions change.

In Trentino, tourism and its related activities are mainstay of the local economy, very relevant in relation of the number of certified facilities and workers involved. It is largely affected by a marked seasonality of the tourism, as it is mainly related to ski and to enjoy the snow and fresh mountain temperatures in summer. So, climate hazards have a critical impact if temperatures are rising and there is not enough snow. Energy is also a key economic sector in the region, as there is an important share of renewable production: hydroelectric mainly (76%). Actually, electricity production exceeds consumption in the region, and it is a risk also related to tourism sector if more energy is spent in ski resorts and artificial snow production is needed. In relation also with both tourism and energy sector, the water sector is also a vulnerable one for Trentino, as per the water resources, which are part of the touristic attractive and hydroelectric generation. It also has a very extensive and articulated system of protected areas, with a 30% of its territory protected, which makes the biodiversity sector a vulnerable one, especially for the risk of biodiversity loss due to climate change impacts.

For the Norrbotten case study, reindeer husbandry is an important economic sector, especially for the Sami population, all reindeer in Sweeden are domesticated and they graze in forests and mountains. Forests, part also of the agriculture, forestry and fishing sector, are also relevant, as they cover 40% of the surface of the County. Tourism (nature-based) is a key sector for the case study too, very much linked with the other vulnerable sector of biodiversity, as for the national parks and nature reserves. Coastal and marine environments are unique in a European perspective, as the special climate and weather conditions create that special ecosystem, which would be largely affected by climate change. As secondary vulnerable sectors, both mining and energy should be considered. There are five (metal) mines, whose production is increasing. Renewable energy use is growing and hydropower accounts for nearly 90% of the electricity produced.

Murcia Region is 50% covered by agriculture, and 45% by forest which makes it a key vulnerable sector for this case study. Climate hazards impacts in the type of crops that can be cultivated and largely affect the production of this key economic sector, with important social implications as well (in employment, not only in the primary sector but in the other related subsectors too). The scarcity of water is also a great vulnerability in the region, very much related to the agriculture sector, as water limitation affects irrigated crops, besides domestic activities. In relation to agriculture, industry and commerce sector has also quite relevance in the region, mainly food industry. Last but not least, as Mediterranean area, tourism is also a relevant sector with high potential to attract visitors to the coast location and warm climate, affected especially by the temperature increase and sea level rise.

The economic development in Tulcea County is highly influenced by the Danube Delta Natural Reserve in the immediate neighbourhood, and the agriculture sector should comply with the environmental restrictions of that protected areas. Agriculture is the main economic sector, characterised by extensive production and dominated by cereal. Energy is also a productive sector, with great number of transformer stations in the region and high wind potential, which is translated in a big number of turbines and parks in the area. Water sector is relevant as well, the region has a lot of surface water bodies, mainly related with the Danube Delta. Danube Delta is declared biosphere reserve, so it is also important in an ecosystem point of view. It relates also with the biodiversity, including several types of ecosystems, species of flora and fauna, and for being one of the largest areas’ wetlands in the world. Tourism sector is growing in relation to this unique ecosystem. Industry sector has also quite relevance, also in relation with an increasing in construction of quarries for rock exploitation.