# Adapting to Climate Change in Time: Local Adaptation Plan

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# INDEX

# MAYOR'S FOREWORD

It is clear that our society is living fast changes in every matter. Our model of development shows strong signs of weakness which are meaning a non adequate use of our resources.

One of the problems that should make us be concerned is that of the climate change. Facing this phenomenon already revealed more than twenty years ago, we have two options: to ignore and elude our responsibility towards these facts or tackle them with all our energy.

Many different changes are happening and their effects can't be omitted. This concern about climate change is a global matter and it is necessary to join the efforts and collaboration of all the world's countries.

We must preserve and protect our biodiversity and the magnificent ecosystems present on Earth. I wander about the damage, many times irreparable, that our planet is suffering.

Indeed, we would like to contribute from our position to eradicate this mercantilist conception which gives priority to interests which are very harmful for our environment.

Under this idea we have participate in the ACT Project ("Adaptation to Climate Change in Time) belonging to the European Program LIFE+, with other European municipalities concerned about this issue.

All this developed work has enabled the identification of the actions of adaptation to climate change regarding the climate conditions of Bullas. It is a paper elaborated to fit with the features of our municipality and it is unique at national level. All this work has enabled the identification of the actions of adaptation to climate change applied to the climate conditions of Bullas. It is a study, unique in Spain, elaborated to fit with our municipality.

The measures or actions are regarding different areas or sectors linked to the progress and future of the people of Bullas. In this way there are guidelines in the field of tourism, agriculture and soil, health, infrastructures, etc.

This achievement will be a key element in the territorial configuration of our town. This means that the guidelines of this work should be present in the elaboration of our general town plan and in any other action developed by the local administration. In this way we have to change to a new energy model based in the efficiency, the saving and the promotion of clean energies respectful with the environment. This way will not be easy and we will have to cope with obstacles and difficulties.

To end with this brief presentation I wish to express my gratitude to all the people, institutions and enterprises that have participated actively to the configuration of all those measures which seek to contribute to a cleaner, healthier and more natural, more respectful with its biodiversity and natural resources, fairer and, in consequence, more committed with a sustainable development.

Our responsibility is waving the flag in defense of our environment. Our sons and grandsons will thank us for it.

# INTRODUCTION AND STRUCTURE OF THE PLAN

A proposed definition of adaptation is: *"Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"*. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous adaptation and policy-driven adaptation. Autonomous adaptation describes actions "taken 'naturally' by private actors, such as individuals, households, businesses in response to actual or expected climate change, without the active intervention of policy". In contrast, policy driven adaptation is "the result of a deliberate policy decision". Policy-driven adaptation is therefore associated with public agencies, either in that they set policies to encourage and inform adaptation or they take direct action themselves, such as public investment.[1]

Adaptation refers to all those responses to climate change that may be used to reduce vulnerability or to actions designed to take advantage of new opportunities that may arise as a result of climate change. The focus of these actions is on managing risk. Investments in risk-based actions are fundamental to reducing the environmental, social and economic costs of climate change.[2]

Uncertainty will affect the pace and degree of action; how should we act when we know that we will be able to learn more in the future, when some possible effects are irreversible and irrecoverable? The existence of major uncertainty implies that a successful plan needs to be reviewed periodically.

The primary objective of this plan is to identify climate change adaptation actions that are applicable to Bulla's climatic conditions and climate impact risks as currently predicted and that can be implemented by Bullas local government in other to make Bullas a resilient community.

[1] Source: "*The economics of climate change. The Stern review*" Nicholas Stern. 2006
[2] Source: "*The growth of adaptation capacity: practice and policy. In: Adapting to Climate Change: An International Perspective*". Burton et al.

The Plan is structured according to the main chosen fields that are more susceptible to climate change impacts: tourism, agriculture and soil, health and transportation infrastructure.

# VISION, GUIDING PRINCIPLES AND OBJETIVES OF THE PLAN

# 1


This chapter provides a vision and the guiding adaptation principles for the municipality as well as the desired aim of the adaptation Plan with the strategic objectives and targets.

The potential barriers to adaptation at local level are also considered here.

The main objective of this Adaptation Plan is to identify climate change adaptation actions that are applicable to Bulla's climatic conditions and climate impact risks as currently predicted and that can be implemented by Bullas local government. Nevertheless, it is necessary to bear in mind that adaptation is an ongoing process. This adaptation plan should be consider as an action framework to cope with climate change projected impacts. Thus, a deeply review must be done each year in order to enclose the specific actions that would be carried out.

Therefore, the purpose of this report is to identify climate change adaptation actions for Bullas' local government that produce benefits other than those that are strictly tied to climate change and in particular provide a net economic, social or environmental benefit no matter what level of climate change occurs, and to implement a periodical revision of the plan itself.

# CONTEXT FOR ADAPTATION IN BULLAS

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This chapter covers a general description of Bullas context (socio-economic conditions, environmental issues, etc) and it also provides an introductory compilation of existing adaptation policies and measures (potential synergies of sectoral or municipal policies with adaptation policy).

A mapping adaptation at local level – who is responsible for what – it is also show at the end of this chapter.

## 2.1 Location

Bullas is a municipality in the Region of Murcia, Spain. It's located in the Northwest Region. It is divided between the municipality's urban center and its only hamlet, La Copa de Bullas.

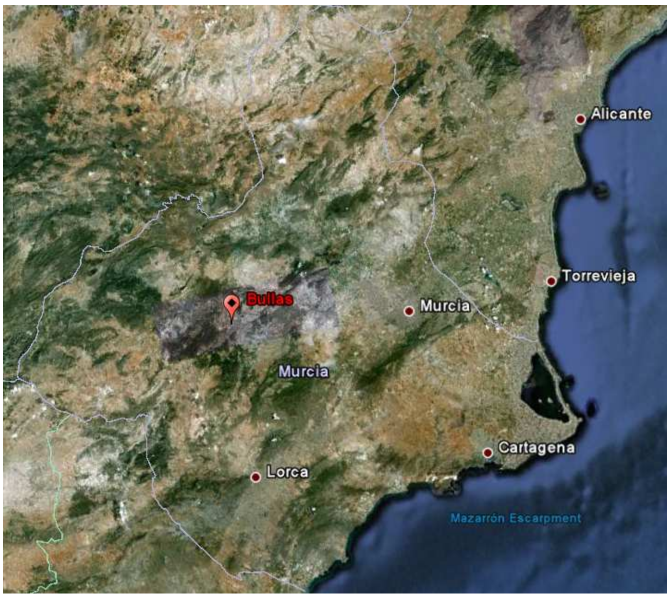


*Figure 1. Bullas' location. Source: Google earth.*

*Table 1. Bullas' coordinates*[3]

| BULLAS COORDINATES | |
|---|---|
| UTM System | Geodetic System |
| Datum: ED50<br>Projection: Zone number 30<br>X= 613181.92<br>Y= 4215679.04 | Datum: ED50<br>Latitude: 38º 02' 45'' mN.<br>Longitude: 1º 39' 57'' mE.<br>Altitude: 651 m. |

It has a municipal area of 82.1 square kilometers. It's the source of Mula River (a tributary of Segura River).

The city is located 651 meters above sea level, the second highest municipality in the Region of Murcia, after Moratalla. It is 52 kilometers from Murcia.

Their main communication networks are illustrated in the following image:


*Figure 2. Bullas' communication networks. Source: [www.bullas.es](www.bullas.es)*

[3] Coordinates are defined for the approximate city center. Source: Google Earth and http://www.cartomur.com/visorcartoteca/

## 2.2 Economy

Bullas possesses some particular natural, socio-economic and cultural features, where the vine and the wine are two of their main protagonists. Its economy is mainly agricultural, with the cultivation of olive, almond and apricot. In recent years, like many towns in the area, Bullas has begun to exploit the cultural and rural tourism. The valorization of these natural, historical and cultural resources is fundamental in order to develop all the economic potential of the area, which has to rival in more and more competitive markets.

Its economy is mainly based on:

✦ **Agriculture**

The region is characterized by a relative abundance of water, with an average annual rainfall of 390 liters per square meter, with extremes like 137 liters in 1970 and 965.5 in 1989 (INM), for their extensive type of agricultural crops and their forest landscapes (forests, gallery forests of Aleppo pine (*Pinus halepensis*), with a variety of mountain species).

*Figure 3. Bullas' agriculture. Source: Wine Route*

### ✦ Wine industry

Bullas leads a large territory wine with distinct characteristics derived from its geographical location and climate, which also include Cehegín, Mula, Pliego, Calasparra, Moratalla, Caravaca de la Cruz, Lorca and Ricote. All these municipalities make up the Designation of Origin "Bullas".

The existence in Bullas of over 2,500 Has devoted to wine production, as well as the presence of a Regulating Council for the Designation of Origin “Bullas” (an official certificate for wine quality standards), created in 1994, where eight municipalities are integrated, with over 5.500 Has of vineyards, as well as the significance of the wine growing traditions in the area, give us an idea of the importance of the wine for the promotion of this territory, therefore becoming the main differentiating and defining element of the space.

*Figure 4. Bullas’ wine industry. Source: Wine Route*

## ✦ Tourism

The local product market *Zacatín*, it's a traditional market where visitors can find a wide range of typical local products.

*Figure 5. Zacatín Bullas' traditional market. Source: [www.bullas.es](http://www.bullas.es)*

The Wine Route: the bet for wine tourism is complemented by a route through a number of locations (see next figure), both inside and outside the village, linked in some way with local vine-growing.


*Figure 6. Bullas Wine Route. Source: www.bullas.es*

The Wine Museum with all its historical, cultural and socioeconomic implications. On one hand, it is an important contribution to the persistence of memory of some life forms in danger of collapsing and knowledge of oenology and, and secondly, it's a tourist attraction for the town.

*Figure 7. Bullas' traditional winery. Source: Wine Route*

The town of Bullas is one of the five municipalities conforming the Northwest District in the Region of Murcia, and so it has been called the Northwest Gateway, since it its natural access point. Its geographic and cultural features have provided it with qualities and peculiarities that make it interesting as well as different, with positive consequences concerning tourism. The Town Council of Bullas was a pioneer in the development of rural tourism in the Region. Thus, in the summer of 1992, the Tourist Complex of La Rafa and in the autumn of that very year the first rural houses for accommodation inscribed in the Regional Tourism Council started to work. The Northwest Green Pathway is an important addition to Bullas tourism; it's a 48 Km., track, which offer the visitor the possibility to enjoy nature with badlands landscape and mountain areas with pines, and cultural heritage.

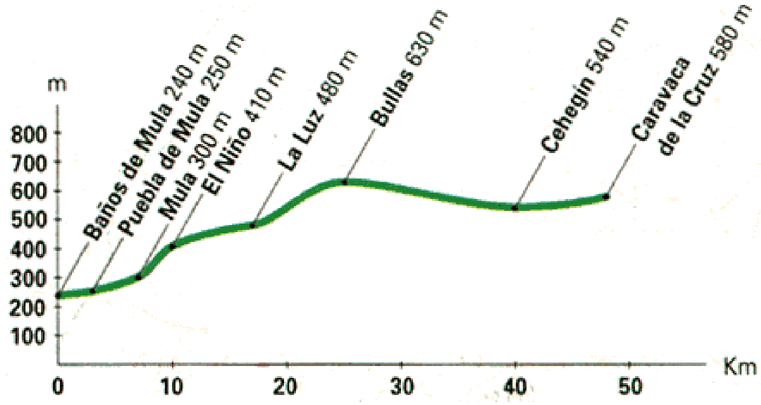


*Figure 8. The northwest green pathway.*

*Source: [www.bullas.es](http://www.bullas.es)*

Bullas celebrates its *Festivities in honor of Our Lady of the Rosary*, which was chosen as Bullas patron in 1723. The day of the Virgin is on 7 October, although tradition states that the festivity day is first Sunday of the month.

Ever since 2001, Bullas Wine Festivities are held last weekend of September, a prelude to patron saint's day and at the height of the harvest.

Saint Marc day is a clear evidence of town's agricultural tradition; it constitutes a true exaltation of rural life. Saint Marc day is 25 April, but his celebration was moved to the weekend after that.

La Copa de Bullas celebrates its festivities in honor of Our Lady of Consolation and Our Lady of Sorrows *("La Socorrica")* the first weekend of September. From Friday to Tuesday different activities are held, going from the Night of *Migas* (a typical dish) and Diana, which are purely festive, to religious events such as the solemn procession with the image of the patron.

# 2.3 Socio-economical characteristics

The following indicators are used to assess current Bullas' socio-economic characteristics.

**Demography**

- Population size[4]: The following figures show Bullas' population increase since 1986, as well as men and women distribution.

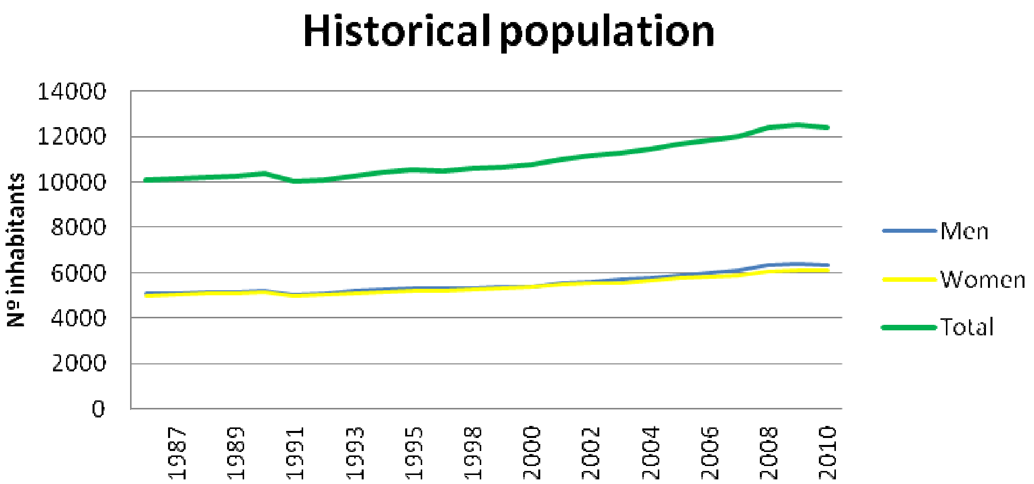


*Figure 9: Historical population*

*Table 2. Historical population*

| | Men | Women | TOTAL |
|---|---|---|---|
| **1986** | 5.081 | 4.999 | 10.080 |
| **1987** | 5.103 | 5.042 | 10.145 |
| **1988** | 5.124 | 5.085 | 10.209 |
| **1989** | 5.149 | 5.113 | 10.262 |
| **1990** | 5.197 | 5.143 | 10.340 |
| **1991** | 5.045 | 4.964 | 10.009 |
| **1992** | 5.064 | 5.009 | 10.073 |
| **1993** | 5.180 | 5.095 | 10.275 |
| **1994** | 5.250 | 5.155 | 10.405 |
| **1995** | 5.298 | 5.223 | 10.521 |
| **1996** | 5.293 | 5.195 | 10.488 |
| **1998** | 5.343 | 5.270 | 10.613 |
| **1999** | 5.349 | 5.328 | 10.677 |

[4] *Source: National Statistics Institute (INE ), (Spain)*

| | | | |
|---|---|---|---|
| **2000** | 5.389 | 5.364 | 10.753 |
| **2001** | 5.546 | 5.467 | 11.013 |
| **2002** | 5.617 | 5.547 | 11.164 |
| **2003** | 5.690 | 5.562 | 11.252 |
| **2004** | 5.791 | 5.644 | 11.435 |
| **2005** | 5.900 | 5.741 | 11.641 |
| **2006** | 6.021 | 5.831 | 11.852 |
| **2007** | 6.113 | 5.907 | 12.020 |
| **2008** | 6.305 | 6.069 | 12.374 |
| **2009** | 6.361 | 6.132 | 12.493 |
| **2010** | 6.322 | 6.102 | 12.424 |

From this information, we can infer that population in Bullas has increased an average of 25 % in the last 25 years.

- Age structure[5] (2010): Bullas' age structure is listed in the following tables and the figure showing the different distribution of population according the men and/or women category and the age range.

*Table 3. Age structure*

| Age structure (2010) | Total | Men | Women |
|---|---|---|---|
| **0-4** | 715 | 383 | 332 |
| **5- 10** | 689 | 351 | 338 |
| **10-4** | 697 | 350 | 347 |
| **15-19** | 750 | 370 | 380 |
| **20-24** | 792 | 393 | 399 |
| **25-29** | 877 | 481 | 396 |
| **30-34** | 965 | 508 | 457 |
| **35-39** | 974 | 506 | 468 |
| **40-44** | 993 | 547 | 446 |
| **45-49** | 939 | 478 | 461 |
| **50-54** | 814 | 418 | 396 |
| **55-59** | 601 | 310 | 291 |
| **60-64** | 528 | 249 | 279 |
| **65-69** | 531 | 261 | 270 |
| **70-74** | 466 | 221 | 245 |
| **75-79** | 506 | 226 | 280 |
| **80-84** | 383 | 182 | 201 |
| **>85** | 204 | 88 | 116 |

[5] *Source: National Statistics Institute, Spain (INE). Chart: personal compilation based on INE data*

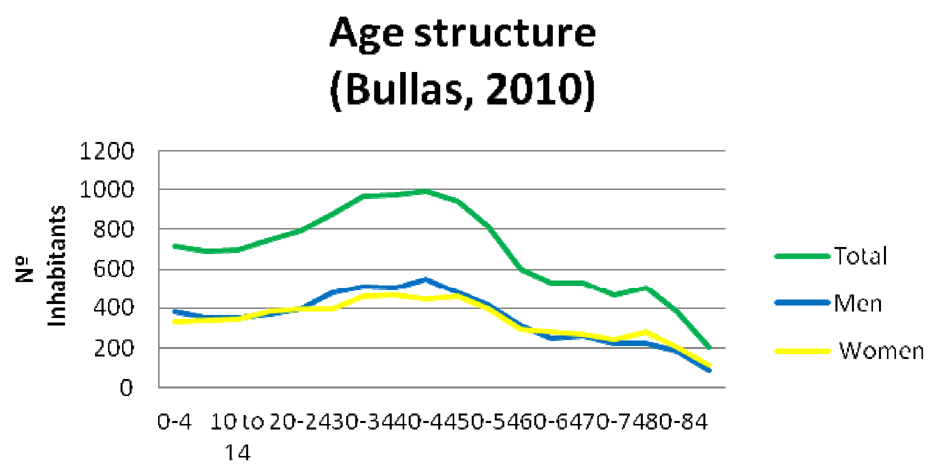


*Figure 10. Age structure*

The trend lines showed in the following figure indicate that Bullas has a relatively young population mostly in the ages between 20and 50 and that, in general, there are a few more young men than women, while elder population is predominant feminine.

- Population density (inhabitants/km$^2$)[6]:

*Table 4. Bullas' population density*

| 2010 | Population | Area | Population density |
|---|---|---|---|
| Bullas | 12.374 | 82,17 | 150,59 |

Bullas -which population density is 150 inh/km$^2$- is positioned in number 28 among the 45 municipalities of the Region, a little higher than the regional mean –129.2 inh/km$^2$– as it is shown in the next figure.

[6] *Source: National Statistics Institute (INE ), (Spain)*

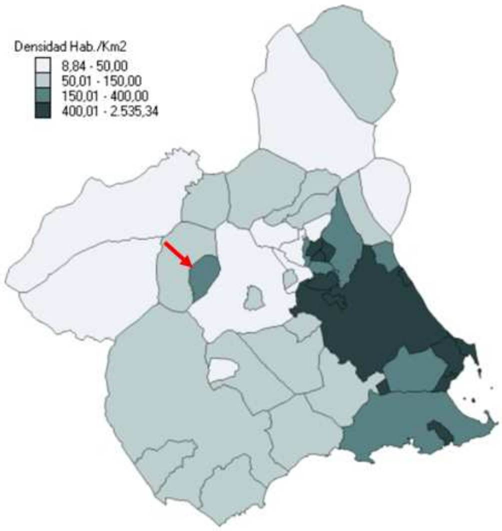


*Figure 11. Population density[7] (Region of Murcia)*

Spain's population density is 93.17 inh/km² and it is lower than that of most European countries. In recent years, following a longstanding pattern in the rest of Europe, rural populations are moving to cities. Urban areas are also experiencing a significant increase in immigrant populations, chiefly from North Africa, South America, and Eastern Europe.


*Figure 12. Population density[8] (Spain)*

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[7] *Source: Regional Statistics Centre (CREM), (Murcia)*

- Urbanisation[9]: Next table gives information about the type of residences in Bullas. From these data we can infer that 33% of the residences are secondary ones.

*Table 5. Urbanisation*

| | Total | Main residence | Not main residence. Total | Not main residence. Secondary residence | Not main residence. Vacant residences | Not main residence. Others |
|---|---|---|---|---|---|---|
| BULLAS | 4393 | 2951 | 1442 | 450 | 981 | 11 |

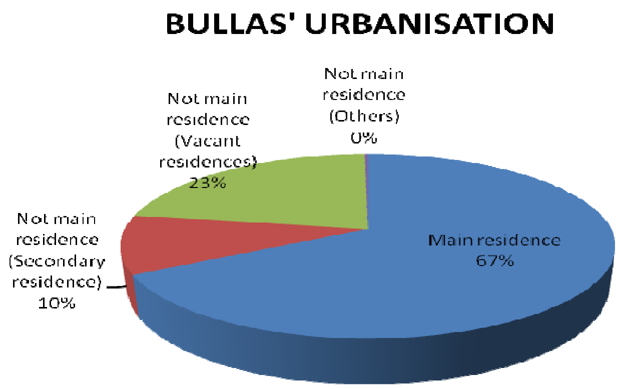


*Figure 13. Bullas' urbanisation*

- Education[10]:

*Table 6. Education (Region of Murcia)*

| Region of Murcia 2010 | Proportion of illiterate population older than 16 years old (without studies) | Proportion of population older than 16 years old with College Degrees | Proportion of population between 25 and 34 years old with College Degrees |
|---|---|---|---|
| Both sex | 16,96 | 19,58 | 30,13 |
| Men | 14,35 | 20,21 | 26,5 |
| Women | 19,61 | 18,93 | 34,26 |

- Hospitals: 1,97 hospitals per 100.000 inhabitants (Region of Murcia[11])

[8] *Source: National Statistics Institute (INE ), (Spain)*
[9] *Source: National Statistics Institute (INE ), (Spain)*
[10] *Source: National Statistics Institute (INE ), (Spain)*
[11] *Source: National Statistics Institute (INE ), (Spain)*

- Migration[12]: These days there have been a sharp increase in the number of foreign residents in Spain. Regarding to the European Union (EU27), foreign citizens made up 6.5% of the population in 2010, the largest numbers were recorded in Germany (7.1 million persons or 9% of the total population), Spain (5.7 million or 12%), the United Kingdom (4.4 million or 7%), Italy (4.2 million or 7%) and France (3.8 million or 6%). In total, more than 75% of the foreign citizens in the EU27 lived in these five Member States.

Next tables show the origin and the age of foreign people living in Bullas.

*Table 7. Migration I*

| 2010 | Total European Union (EU) | Total No EU Europe | Total Africa | Total America | Total Asia |
|---|---|---|---|---|---|
| Both gender | 610 | 13 | 96 | 524 | 7 |
| Men | 310 | 8 | 60 | 287 | 6 |
| Women | 300 | 5 | 36 | 237 | 1 |

*Table 8. Migration II*

| | Total | less than 16 years old | From 16 to 64 years old | More than 65 years old | Total | less than 16 years old | From 16 to 64 years old | More than 65 years old | Total | less than 16 years old | From 16 to 64 years old | More than 65 years old |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Both gender | 12.424 | 2.257 | 8.077 | 2.090 | 11.174 | 2.001 | 7.111 | 2.062 | 1.250 | 256 | 966 | 28 |

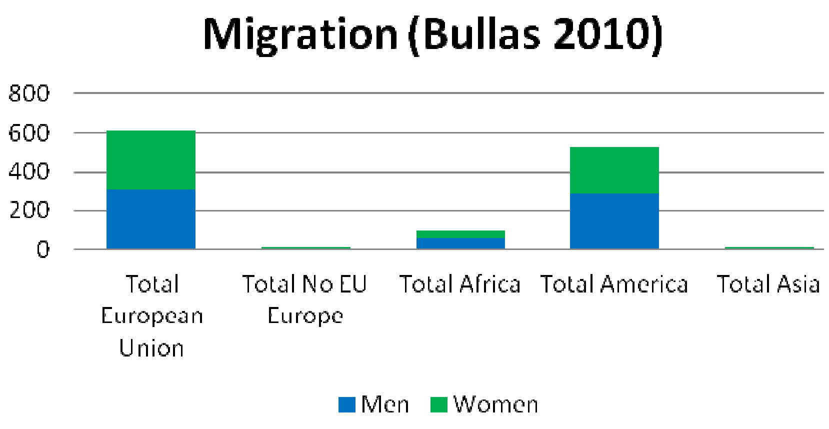


*Figure 14. Migration (Bullas 2010)*

[12] *Source: National Statistics Institute (INE ), (Spain)*

The assessed reasons behind the steep rate of migration to Bullas from Latin American people are the Spain's cultural bondage with the home countries.

## Economy

- Use of land[13]: Regarding to the following figure, which presents the use of land in Bullas, we can conclude that it is an extremely rural area, with a landscape that has high economic value for culture, heritage, agriculture and tourism.

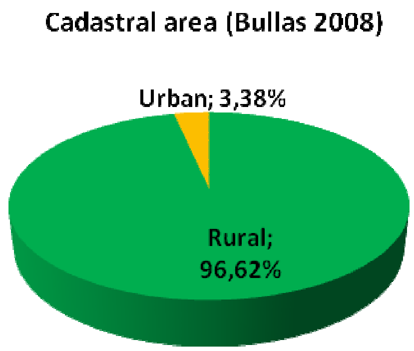


*Figure 15. Use of land*

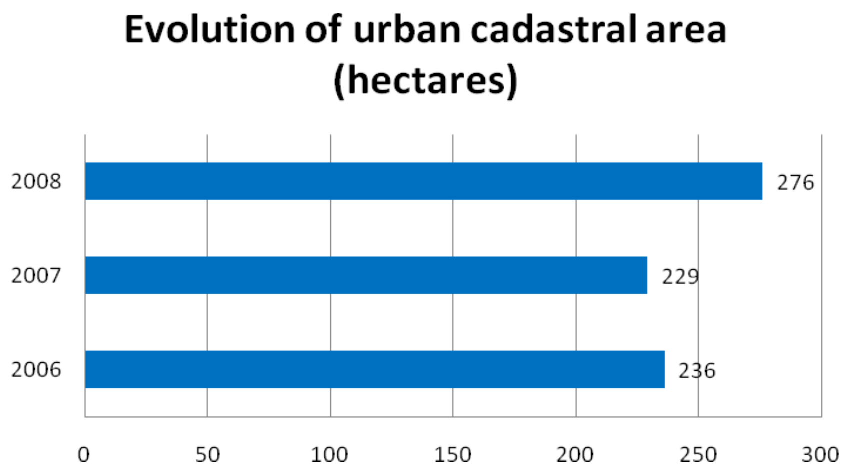


*Figure 16. Evolution of urban cadastral area*

[13] Source: *Municipal file 2009. Caja España.* www.cajaespana.es

- Level of investment in economic activity[14]: Next tables indicate the municipal level of investment in economic activity. From the year 2008, because of the global recession not only total incomes have decreased, but also total spends. Nevertheless, the fact that the main pillar of Bullas' economy is not construction, will probably allow Bullas to overcome the current crisis.

*Table 9. Level of investment in economic activity*

| Liquidation of municipal budgets | | | |
|---|---|---|---|
| | 2005 Budget | 2006 Budget | 2007 Budget |
| **Total income** | **7.306.269,38** | **11.020.306,29** | **12.102.967,54** |
| Direct taxes | 1.646.214,03 | 1.751.300,74 | 2.196.933,77 |
| Indirect taxes | 647.754,46 | 583.120,40 | 776.934,59 |
| Taxes and other incomes | 1.752.085,65 | 1.469.571,58 | 1,461.722,22 |
| Current transfers | 2.426.449,53 | 2.738.689,66 | 3.754.819,36 |
| Patrimonial income | 20.640,51 | 23.205,46 | 77.717,89 |
| Transfer of real investment | 19.901,48 | 577.101,75 | 570.112,56 |
| Capital transfers | 783.070,24 | 2.914.601,18 | 2.140.429,14 |
| Assets | 10.153,48 | 5.227,94 | 2.363,96 |
| Liabilities | --- | 957.487,58 | 1.21.934,05 |
| **Total spends** | **7.220.727,52** | **9.841.294,31** | **11.255.206,32** |
| Staff spends | 2.579.169,08 | 2.490.487,28 | 2.921.137,90 |
| Current goods and services expenditure | 2.683.368,78 | 3.212.615,90 | 4.061.278,40 |
| Financial expenditure | 67.134,20 | 42.466,91 | 83.389,50 |
| Current transfers | 532.689,45 | 724.098,52 | 715.046,87 |
| Real investments | 1.089.241,57 | 3.078.675,52 | 3.181.729,75 |
| Capital Transfers | 3.726,41 | 30.000,00 | 12.000,00 |
| Assets | 8.564,00 | 1.400,00 | 4.800,00 |
| Liabilities | 256.834,03 | 261.550,18 | 275.823,90 |

*Table 10. Fiscal indicators*

| Fiscal indicators (€/capita) | 2006 | 2007 | 2008 |
|---|---|---|---|
| Budget expenditure per inhabitant | 439,16 | 507,89 | 608,66 |
| Collection per inhabitant | 219,12 | 261,89 | 302,25 |
| Investment per inhabitant | 226,28 | 17,81 | 515,60 |

- Extent of industrialization[15]:

*Table 11. Industry and construction[16]*

[14] Source: *Municipal file 2009. Caja España.* www.cajaespana.es
[15] Source: *Municipal file 2009. Caja España.* www.cajaespana.es

| Industry and construction (2007) | | | | |
|---|---|---|---|---|
| | Workers | | Company | |
| Extractive industries | 37 | 1,26 % | 2 | 0,88 % |
| Manufacturing industries | 918 | 31,38 % | 55 | 24,34% |
| Production and distribution of electricity, water and gas | 4 | 0,14 % | 2 | 0,88 % |
| Construction | 1.966 | 67,21 % | 167 | 73,89% |

- Productive structure: Next table shows the proportion of workers per activity sector in Bullas.

*Table 12. Workers per activity sector*

| Workers per activity sector[17] | | |
|---|---|---|
| Agriculture | 288 | 6,32 % |
| Industry | 959 | 21,00 % |
| Construction | 1.966 | 43,15 % |
| Services | 1.343 | 29,48 % |
| No data | 0 | 0,00 % |
| **Total** | **4.556** | **100 %** |
| Self-employed | 778 | |
| Employed | 3.778 | |

*Figure 17. Workers per activity sector*

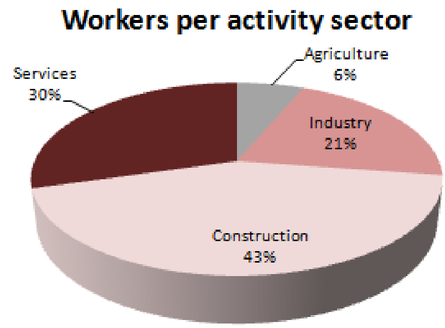


*Table 13. Enterprises per activity sector*

| Enterprises per activity sector | | |
|---|---|---|
| Agriculture | 42 | 7,94 % |
| Industry | 59 | 11,15 % |
| Construction | 167 | 31,57 % |
| Services | 261 | 49,34 % |
| No data | 0 | 0,00 % |
| **Total** | **529** | **100 %** |

[16] *Source: Ministry of Labour and Immigration. General Treasury of Social Security*
[17] Source: *Ministry of Labour and Immigration. General Treasury of Social Security*

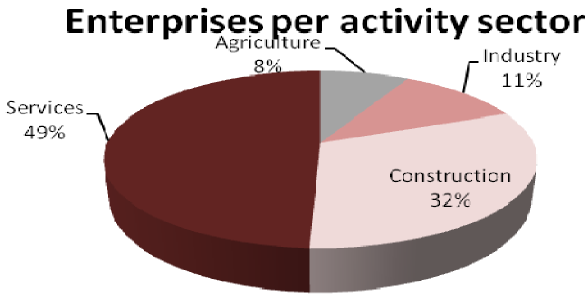


*Figure 18. Enterprises per activity sector*

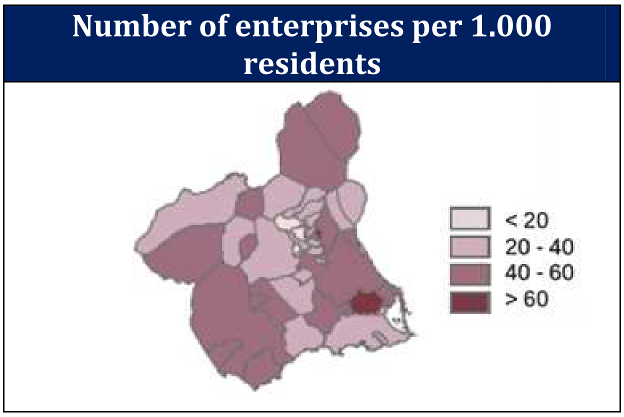


*Figure 19. Number of enterprises per 1000 residents*

- Registered unemployment: Registered unemployment in the population in 2010 (data published by the State Employment Service, April 2010) is 1,185 people, which means the 9.53% of the population.

- Extent of infrastructure[18]:

*Table 14. Extent of infrastructure[19]*

| Premises | | | |
|---|---|---|---|
| **Total** | **519** | Health equipments (outpatient clinic, hospital ...) | 12 |
| Inactive | 82 | Educational equipments (school, college, nursery...) | 10 |
| Actives | 437 | Social welfare facilities (club for the elderly, social service center, day center ...) | 5 |
| | | Cultural and sporting facilities (theater, cinema, museum, exhibition hall, sports center ...) | 14 |
| | | Business premises | 301 |
| | | Offices (includes the rest of services) | 54 |
| | | Industrial premises | 41 |
| | | Agricultural premises | 0 |

*Table 15. Social equipments*

| Social equipments | | | |
|---|---|---|---|
| **Health[20]** | | **Education, non-university education[21]** | |
| Practices | 1 | Academic year | 2007-2008 |
| Outpatient clinics | 1 | Educational estasblishment | 13 |
| Hospitals | 0 | Classroom | 127 |
| Hospital beds | 0 | Students | 2.778 |
| Basic health areas | 51 Bullas | Teachers | 193 |
| Health areas | 04 Northwest area | | |

# 2.4 Natural resource use

## 2.4.1 Natural heritage

The town of Bullas, with its 82 Km$^2$, is the smallest of the Northwest region of Murcia, but that does not stop to shelter a great diversity in climatic peculiarities, geological, botanical, zoological, etc., by a rugged terrain, where mountains around 1.000 m can be found near altitude plains, where traditional upland crops (cereals, vineyards and almond) are the protagonists, and a Mediterranean climate with continental features, that origins spaces and landscapes that deserve special

[18] Source: *Municipal file 2009. Caja España. www.cajaespana.es*
[19] *Population and housing census 2001*
[20] *Source: Health Ministry, Spain 2009*
[21] *Source: Education regional Ministry of Murcia.*

attention for being unique sites of great beauty and educational interest, culture and tourism. We can find this heritage under different legal forms of protection:

- LIG "Salto del Usero". Place of Geological Interest (LIG)

Mula river bed is located at north of Cerro El Castellar and a few kilometers away from the urban center. This is a place of great beauty, hydrological, geomorphologic and sedimentological interest, which erosion process creating formation of sandstone and travertine of considerable value can be observed.

Retrogressive erosion of these materials in the course of the river, has created its distinctive dome morphology, rushing water to the base in a cascade of several meters high and forming a fairly deep pool constantly filled with water, widely used by tourists and residents during summer.

*Figure 20. "Salto del Usero". Source: Wine Route*

- LIC "Río Mula y Pliego". Place of Community Interest (LIC)

Excellent representation of the riverside vegetation, formed by a strata tree (poplar, elm) and shrub with predominance of willow, pinkish thorny bushes, and a wide variety of climbing plants. It is also characterized by the presence of carbonated water dripping rocks (tuff and travertine) with associated plants such as maidenhair (Adiantum capillus-veneris) and brads widow (Trachelium caeruleum).

Among the wildlife, it highlights a fingered bat colony, large mouse-eared bat mouse-eared bat medium (-Annex II-Directive 92/43/CEE), and amongst plant species of interest it include: Poplar and Poplar (Populus x canescens, Populus alba, Populus nigra), Ash (Fraxinus angustifolia), Olmos (Ulmus minor), tinker (Celtis australis), Willows (Salix atrocinerea), Honeysuckle (Lonicera implexa), wild roses (Rosa sp. pl.) Blackberries (Rubus ulmifolius), hawthorne (Crataegus monogyna), Clematis (Clematis vitalba), sarsaparilla (Smilax aspera), Emborrachacabras (Coriaria myrtifolia), among others.

- ZEPA "Sierras de Burete, Lavia y Cambrón". Special Protection Area for Birds (ZEPA)

This ZEPA has an area of 21,482.22 hectares, occupying nearly a third of the municipally of Bullas and shares it with other municipalities such as Mula, Cehegín and Lorca.

As for the ornithological value, it achieves the numerical criteria established for designated ZEPA (under Directive 409/79/CEE) for European snake species as (Circaetus gallicus), booted eagle (Hieraaetus pennatus), eagle owl (Bubo bubo) and Chough (Phyrrocorax phyrrocorax).

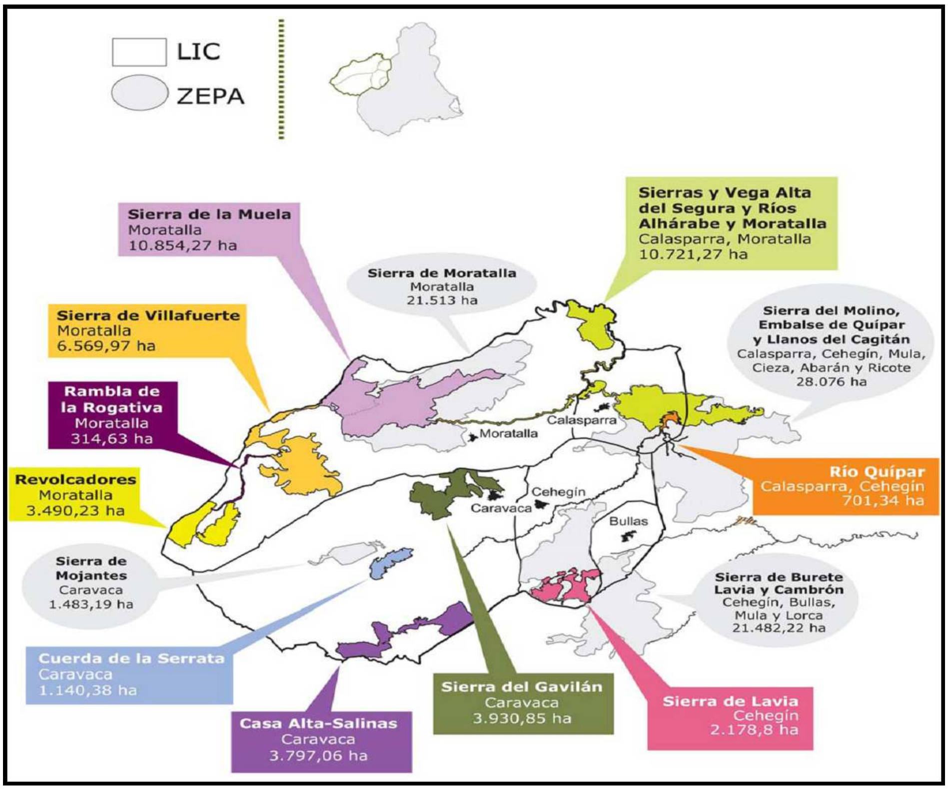


*Figure 21[22]. Protected areas*

◈ <u>Flora Protected by Decree 50/2003, May 30</u>

In these area we can observe 33 species of threatened flora, among two taxa listed endangered species: ash (Fraxinus angustifolia) and cottonwood bastard (Populus canescens), two others listed as vulnerable: gall (Quercus faginea) and elderberry (Sambucus nigra), and a number of species listed as of special interest and / or development (oaks, poplars, aspen, juniper, juniper, hawthorn, daffodils, etc.).

◈ <u>Wildlife threatened according by Law 7/95, April 21</u>

Among the threatened fauna, it have been listed about 24 species of vertebrates, among which Bonelli eagle (Hieraaetus fasciatus) listed as endangered species, the marsh harrier (Circus pygargus), the Little Bustard (Tetrax tetrax), the grouse (Pterocles Eastern) and the ibex (Capra pyrenaica), listed as vulnerable and cataloged a large number of special interest.

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[22] *Source: Autonomous Community of Murcia, CARM, Dirección General del Medio Natural*

- <u>onumental and/or Unique trees</u>

Both native, or introduced, it is therefore of real living monuments that deserve special protection because of its uniqueness, rarity or beauty, as defined in Law 4/89 of March 27, of Conservation of Natural Areas, Flora and Fauna.

Although many of our trees are gone by natural death, adverse weather conditions or by human hand, many trees still stand, so far 25 individuals listed by the Municipality of Bullas, as part of Heritage Natural and Cultural of this Municipality.

It can highlighted the pine bone structure, as one of the jewels of these inlands. The aleppo pine (Pinus halepensis), is considered among the 5-6 largest pine in the region. Its trunk is over 5 m of rope (5.10 m) and is one of the most remarkable for its size and vertical slender, with big arms multi-branched giving it a stately appearance. The other tree corresponds to Carrasco Romero (Quercus rotundifolia), a tree listed as one of the largest oaks in the Region of Murcia, with a trunk 6.20 m around the perimeter and unique natural heritage of Bullas.

### 2.4.2 Areas of scenic sightseeing

The altitudinal and topographical variety in a north-south direction, implies different landscape features from higher elevations (Aceniche, Garci-Sanchez) to the lowest levels (landscapes of La Copa de Bullas), where we find three groups of landscape :

- <u>Mountain hills</u>

They present medium height levels, highlighting among others, Garci Sánchez (1,026 m), Castello (993 m) and Sierra de la Silla (794 m), in which there's a predominance of litosoil and important high vertical cliffs and rocky landscape entity (shade of Castellar).

They locate most of the pine forests with aleppo pine (Pinus halepensis), and a bush-esparto in mainly sunny zones. Cacuminal areas appear with stunted oaks (Quercus rotundifolia).

There are few human activities, in any case we can find small tracks, that allow us to visit these sites of high landscape value.

- Intermountain depressions

These are areas of smooth relief, occupied mostly by traditional upland crops on calcareous soils and quaternary materials. Aceniche high plateau, the Carrascalejo-Ucenda-Fuente la Higuera steppes stand out. Between these landscapes arranged in mosaic we discover the vineyards, olive and almond trees that show the cultural and traditional entity of this land.

- Main township river basin and streams

If we walk along the water courses, it's easy to see spots of riparian vegetation in contrast to the forests and crops that limit them. We are required to mention Mula river, and of course Councillor gorge, passing through the area El Cristo (El Carrascalejo). Its peculiar boxing makes a greater water contribution through the soil, so they appear sub-humid forest species and hybrids of this gall with oaks. It can be found in their forest riparian species such as braziers, elm, ash, black poplars and willows. And in drier areas, the oaks are being replaced by scrub, which appear with mastic, thorns, as well as esparto, grass and thyme. Among the boulevards, more open and with less dense vegetation, highlight the Rambla del Ceacejo, Rambla de Ucenda, also two major streams, although of intermittent water are the Chaparral and Los Muletos.

## 2.5 Governance and development policies

There are two main studies, the Strategy of the Region of Murcia for the Climate Change 2008/2012 and the National Adaptation Plan developed by the Ministry of Environment. Within Spain, the Region of Murcia and then Bullas is considered a very vulnerable area to climate change, conditioned by its geographical location and its social and economic structure. In this context the draught risk increases, affecting to sectors such as agriculture (reducing its development) and economic structure, being the most relevant factors the water supply and rainfall tendency. An increase of the temperatures is also foreseen during summer.

## 2.6 Culture

The settlement and development of the northwestern Region of Murcia and in particular the town of Bullas has been linked to agriculture.

This region has always been known for making a sustainable use of soil and water resources and traditional contribute to the conservation of biodiversity. Currently they are producing land-use changes such as introducing new irrigation systems or the expansion of urban and industrial areas.

# UNDERSTANDING CLIMATE CHANGE IN BULLAS

3


[23]

This chapter is about current climate observed trends and climate change projections in the municipality of Bullas and the Region of Murcia.

It also deals with the uncertainties inherent to any data, in particular the results of downscaling.

## 3.1 Climate context

For its low latitudinal position (38.05° N), and more specifically in the southeast Iberian peninsula, on the shores of a sea as warm as the Mediterranean, Bullas would fall in all its essence the typical Mediterranean climate, but to be a remarkable altitude (654 meters) and to have a straight-line distance to the nearest coastal point about 70 km, together with the influence of moderately vigorous relief that hamper the maritime influence Bullas climate should be defined as a continental Mediterranean climate .[24]

It is a Mediterranean climate, mainly by the amount and spatial distribution of rainfall; they are scarce (365 mm) and irregular with a marked summer drought, typical of all Mediterranean climates. As for temperatures, the altitude conducive to the average temperature of Bullas drop to 15 º C, with cool winters and hot summers, typical of that continentalization.

[23] Source: Photo: David Espín Sánchez http://bullasmeteo.blogspot.com.es
[24] Source: http://climadebullas.blogspot.com/2010/01/caracteristicas-del-clima-de-bullas.html

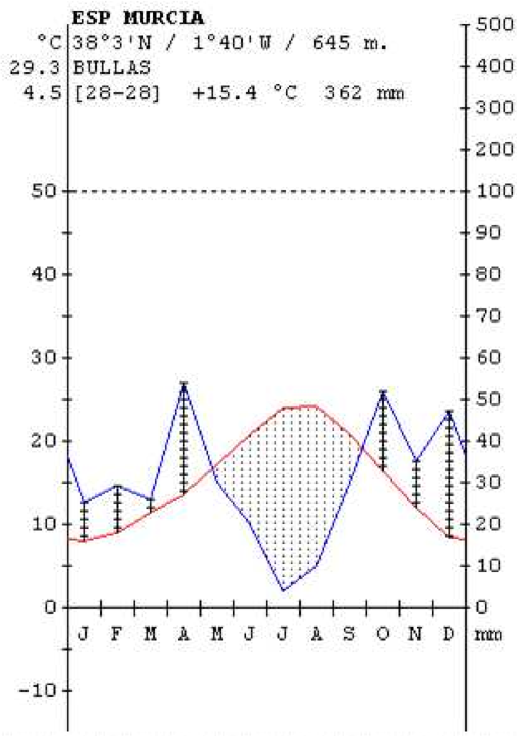



*Figure 22. Climate diagram for Bullas.*[25]

## 3.1.1 Temperature

Since Bullas municipality it's not really an extent one (87 Km$^2$), there're no excessive altitude differences, and the ones that are present cover a very little land area. Thus we find a first zone that would include Bullas urban center and surrounding area, with an altitude range between 550-700 meters, and that would spread throughout much of Bullas municipality. A second zone, which encompassed the southernmost of the municipality, from 700 meters to 1000 meters of altitude (highlights of Bullas higher reliefs) and would encompass the valleys of Aceniche, Portugalés,...), and finally the northern Bullas area, with altitudes less than 550 meters.

January it's the coolest month, with a mean temperature around 7ºC in the urban center, decreases in higher altitudes, up to 4 º C average in the higher areas of the municipality, and reaching to 8 º C in the lower areas. The maximum mean

[25] Source: http://www.ucm.es/info/cif/plot/es-bulla.htm

temperature is at about 13 º C in winter (El Chaparral has 15 º C), while the average minimum is around 5 º C, the Chaparral, thermal inversion is about 0-1 º C.

July it's the warmer month, a merely 0.5ºC higher than august, which coincide with 55% meteorological observatories of AEMET (National Agency of Meteorology) in Spain, hence the imposition of July as the hottest month on the peninsula.

Mean July temperature in Bullas urban center rise only to 24.3ºC, been the municipality in the Region of Murcia with mildest summer. This happens thanks to its relatively altitude, but especially because Bullas is sheltered from southerly winds by the mountains of Cambrón, Pedro Ponce, and Lavia. The mean maximum temperature in summer rises to 30.1ºC (El Chaparral has about 33.5 ° C), while the minimum mean temperature is around 18 º C, with values "relatively mild" compared to other parts of the region.

In the lowest areas, mean temperature rise to 26ºC, while in the highest areas rises till 23ºC.

### 3.1.2 PRECIPITATIONS

The distinguishing feature of all Mediterranean populations is the rainfall shortage. The average rainfall of Bullas rises to 365 mm, the upper register of the lower territories of the Region of Murcia.

Also highlights the irregularity of rainfall, giving the maximum rainfall at the equinoxes, in autumn (34.15%) and spring (32.79%), followed by winter (24.59%), leaving the minimum in summer, with a very prominent drought, with only 8.47% of rainfall.

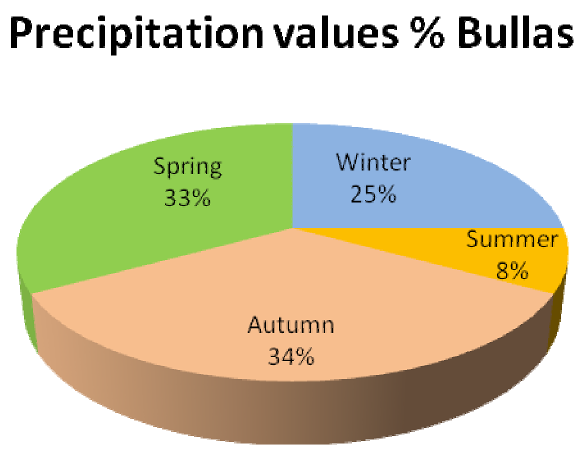



*Figure 23. Precipitation values*

Snow isn't an unusual phenomenon in the municipality, but it can't either be considered as frequent. Only areas situated higher than 1.000 m have snow several days. In Bullas, the average of snows days it's around 1.8 days.

### ✦ Thornthwaite's hydric balance for Bullas

Summer high temperatures along with the limited and sometimes nonexistent rainfall, lead to a very important evapotranspiration, which produces soil water deficit. The total potential evapotranspiration of 809 mm is one of the lower ones of the Region of Murcia. From April the temperatures are increasing while rainfall decreases, leading to hydric stocks depletion, till an accumulated water deficit of approximately 450 mm. Only in the months from November to March rainfall exceed potential evapotranspiration (the amount of water that would be evaporated if we had infinite reserves), which causes it to generate a stock about 71 liters, which is used in April, May and June.

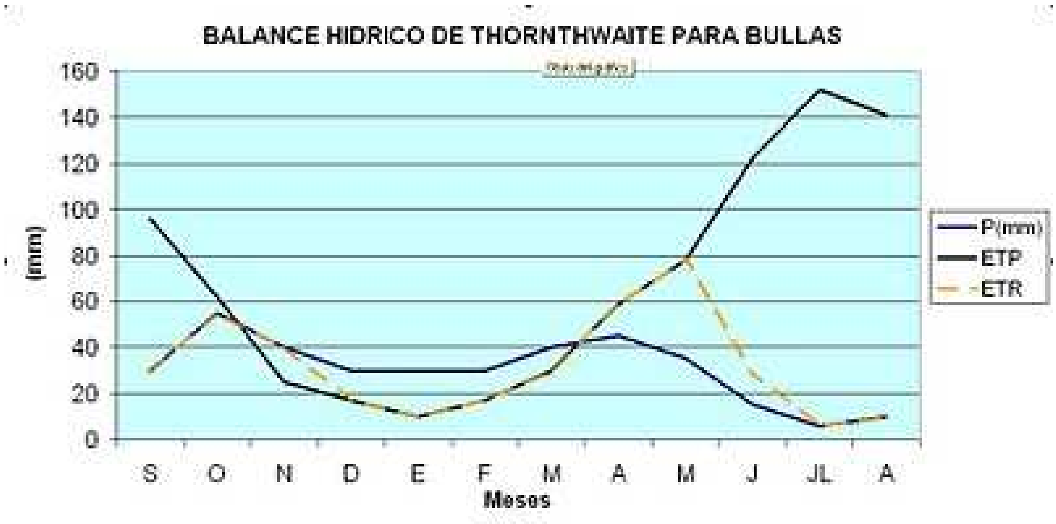



*Figure 24. Thornthwaite's hydric balance for Bullas*

Where: ETP: Potential evapotranspiration (mm/month); ETR: Real evapotranspiration (mm/month).

The effective rainfall exists only when the actual evapotranspiration equals the potential evapotranspiration that is when the upper limit of precipitation is higher than the ETP.

## 3.2 Climate model projections[26]

Both temperature and precipitation projections for Bullas were extracted from the gridded fields generated by three Regional Climate Models (RCM) and two high-resolution Global Climate Models (GCM). Such projections were downloaded from the website of the PCMDI (http://www.pcmdi.llnl.gov/) and of the ENSEMBLES project (http://ensemblesrt3.dmi.dk/). From each gridded field, the grid point closest to Bullas was considered.

The results for the RCM are available only for the "intermediate" emission scenario A1B; for the GCM, the results are also available for the A2 (pessimistic)

[26] Source: Baseline climate scenario-Climate trends and projections. Franco Desiato, Andrea Toreti, Guido Fioravanti, Piero Fraschetti, Walter Perconti (ISPRA, Climate and Applied Meteorology Unit). LIFE "ACT" Project. No LIFE 08 ENV/IT/000436. Rome, July 2010.

and B1 (optimistic) scenarios. The RCM which provided the projections were selected according to the following criteria:

1) High spatial resolution.

2) Number of output parameters.

Furthermore, the priority was given to the models characterized by easy and clear procedures for the extraction of gridded data. With regards to the GCM, the two models with a spatial resolution closer to the spatial resolution of the selected RCM were chosen. The information provided by the GCM allows to evaluate:

1) The range of the projections for the climatic variables according to different emission scenarios.

2) The differences between the GCM and RCM projections for Bullas.

### 3.2.1 TEMPERATURE

The results from 2010 to 2100, in terms of anomalies 1961-90 and using samples 10 years long are shown in the next figures.

The three RCMs estimate a rise of the mean air temperature at the end of the century between 3.7ºC (SMHIRCA) and 4.0ºC (RM5.1 and RACMO2). The most intense warming is in summer (between 4.9ºC and 5.6ºC), the least intense in spring (between 2.0ºC and 3.3ºC).

For the A1B scenario, the INGV estimates a warming at the end of the century equal to 2.8ºC, while the CNRM estimate is a 3.8ºC. The warming predicted by GCMs in the A1B scenario is lower than that predicted by RCMs. In the A2 scenario, the GCMs predict a warming between 3.8ºC and 4.8ºC, while in the B1 scenario the CNRM estimate is 2.5ºC. This means that the uncertainty due to the two opposite scenarios (i.e. A2 and B1) is something around 2.0ºC. This uncertainty is likely to be wider when more GCMs are considered.

With regards to the GCMs projections, the maximum increase for the mean temperature (6.5ºC) is predicted by the CNRM model in the A2 scenario, while the minimum increase (1.6ºC) is predicted by the INGV model in the A1B scenario.

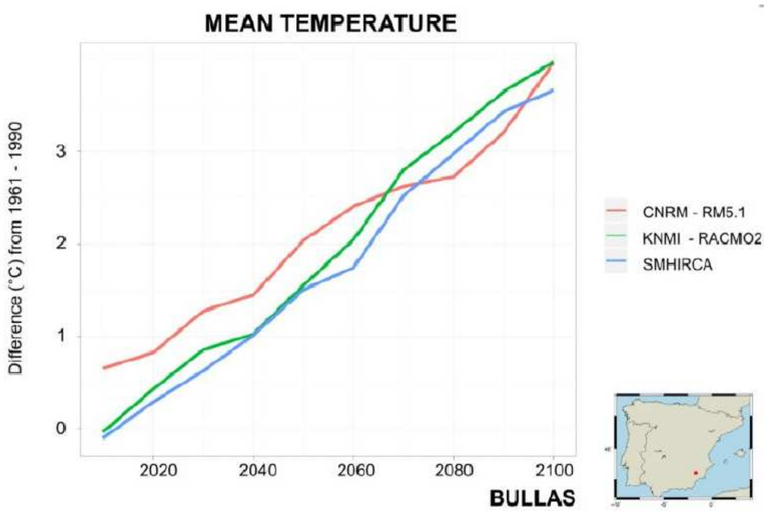



*Figure 25. Annual mean temperature variation predicted by RCMs (ºC)*

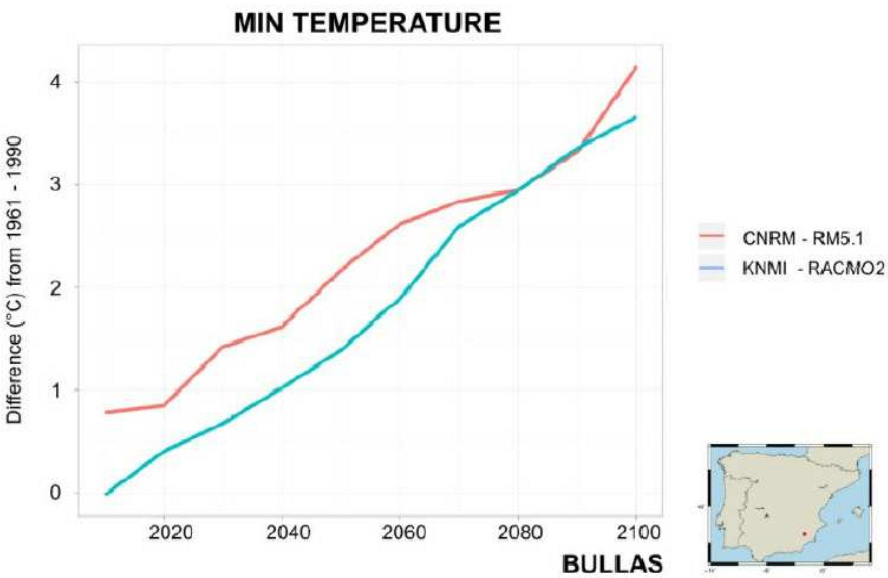



*Figure 26. Annual minimum temperature variation predicted by RCMs (ºC)*

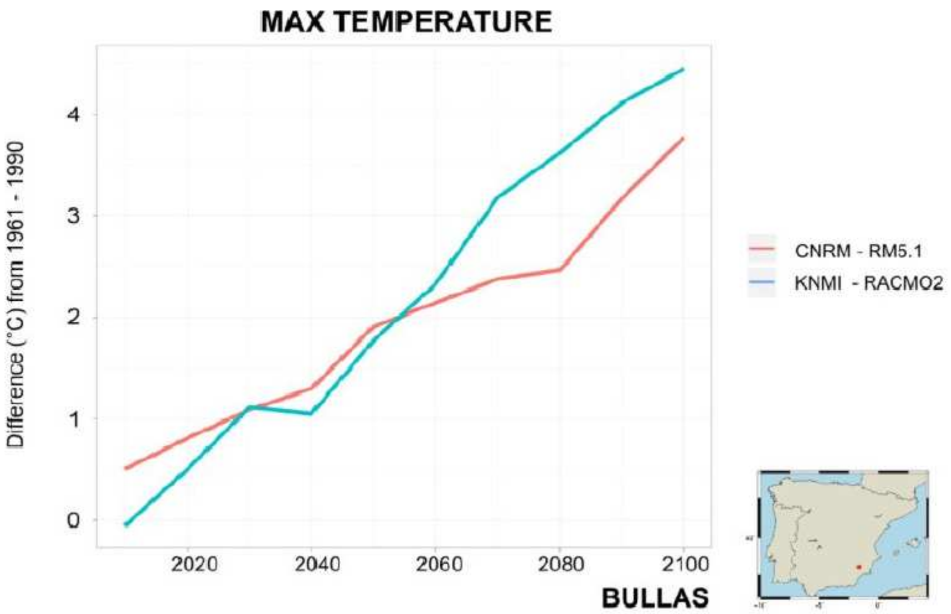



*Figure 27. Annual maximum temperature variation predicted by RCMs (ºC)*

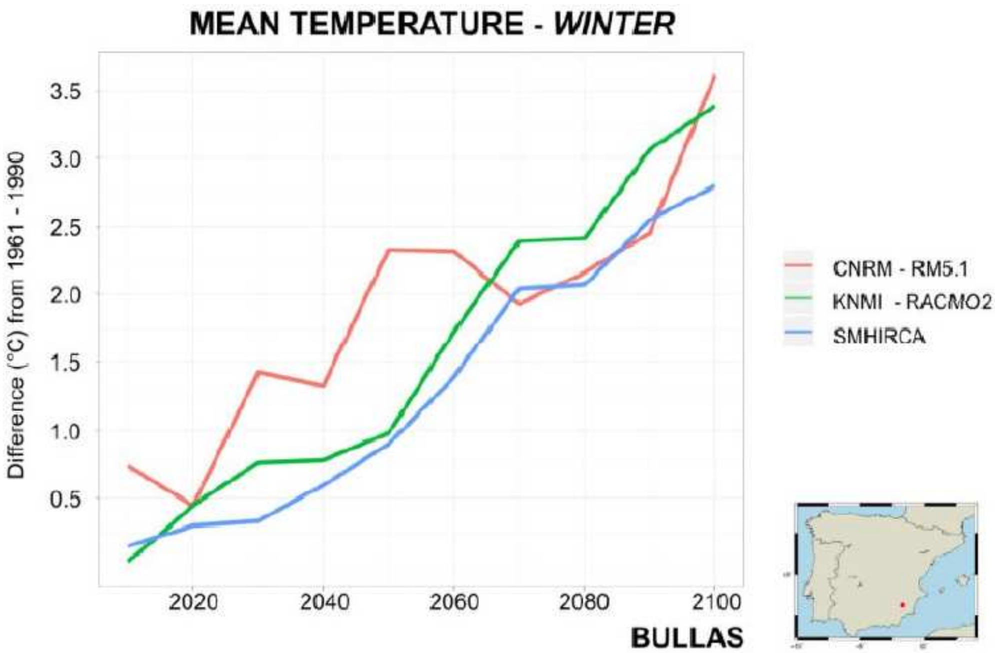



*Figure 28. Winter mean temperature variation predicted by RCMs (ºC)*

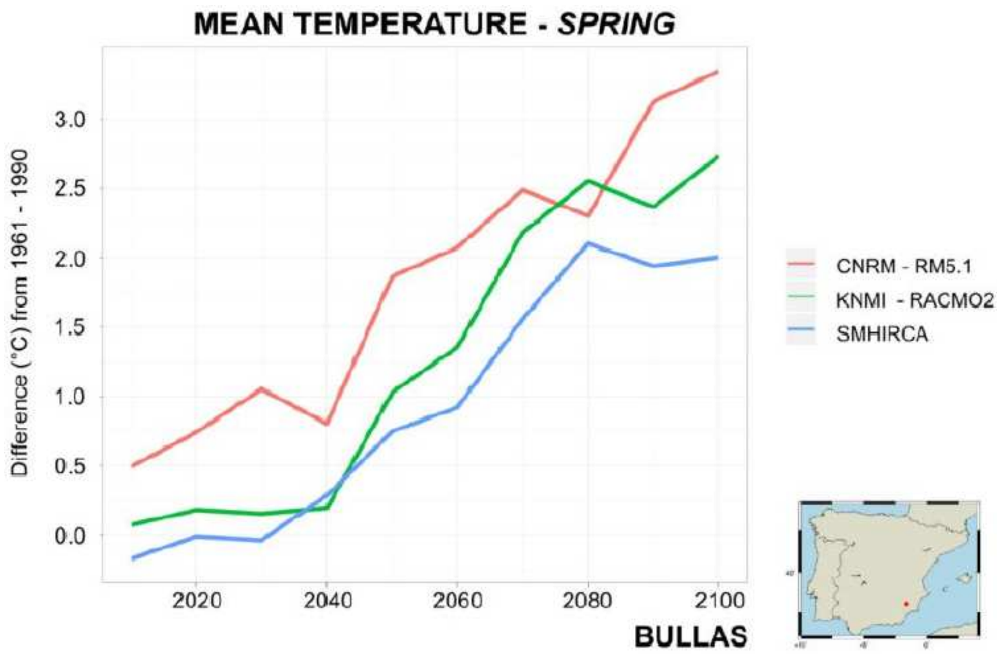



*Figure 29. Spring mean temperature variation predicted by RCMs (ºC)*

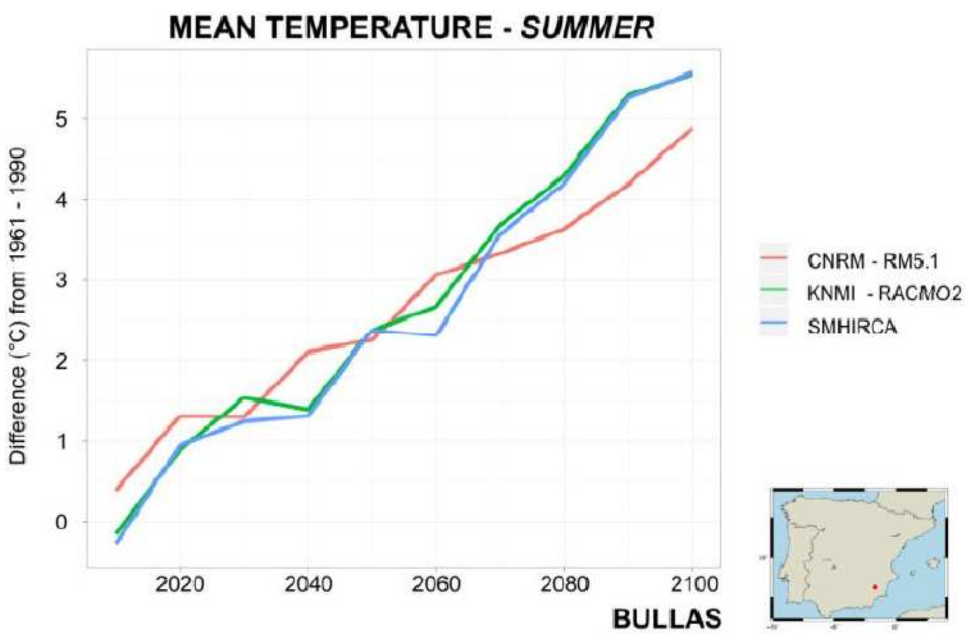



*Figure 30. Summer mean temperature variation predicted by RCMs (ºC)*

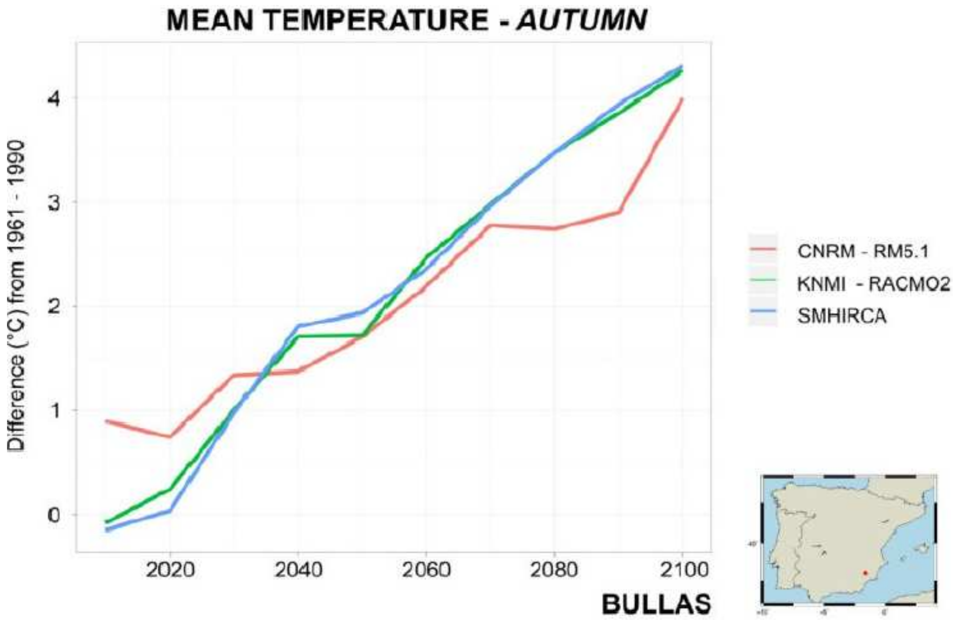



*Figure 31. Autumn mean temperature variation predicted by RCMs (ºC)*

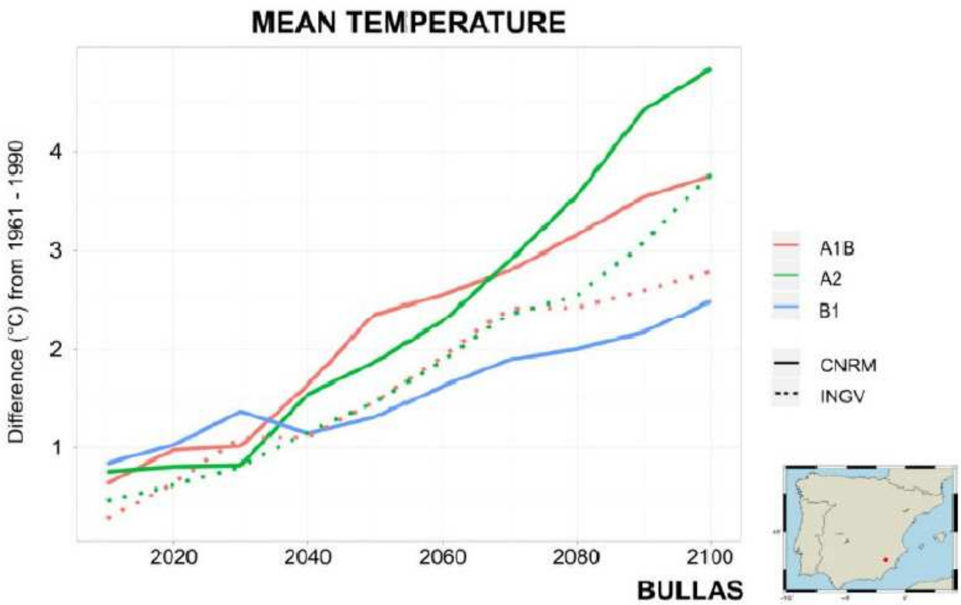



*Figure 32. Annual mean temperature variation predicted by GCMs (ºC)*

## 3.2.2 PRECIPITATION

These figures present the results from 2010 to 2100, as percentage variation with respect to the period 1961-90.

The three predict a reduction of the annual cumulated precipitation at the end of the century, ranging between -29.7% (SMHIRCA) and -39.0% (RACMO2). The relatively wide range of the variation reflects the high uncertainty which characterizes the precipitation projections. All the RCMs show a quite stable decrease over the whole century for the seasonal and annual precipitations, with two models out of three predicting a relative maximum in the middle of the century occurs; such a reduction ranges between -34.6% and -50.0%. Finally, the RCMs do not predict an increase in seasonal precipitations. With regards to the GCMs, in the A1B scenario the CNRM model estimates a drop of the precipitation of -32.7%, while the INGV estimate is of -30.7% for the last ten years of the period. In the A2 scenario, the GCMs predict a drop of the annual precipitation between -37.1% and -37.8%, while in the B1 scenario the global CNRM model predicts a -26.3%.

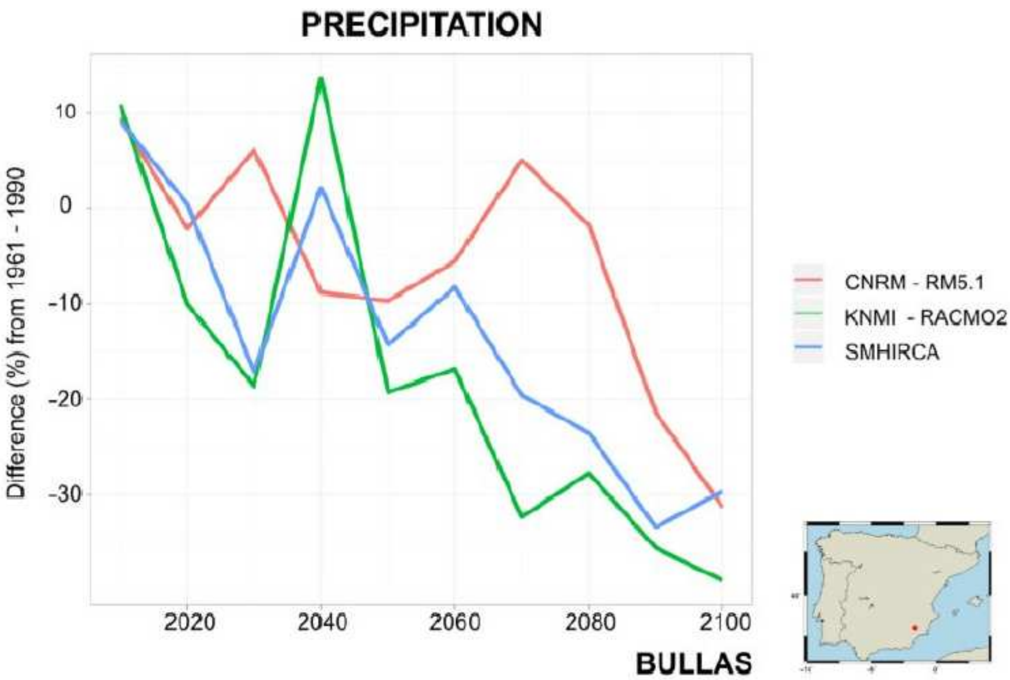



*Figure 33. Annual mean precipitation variation predicted by RCMs (%)*

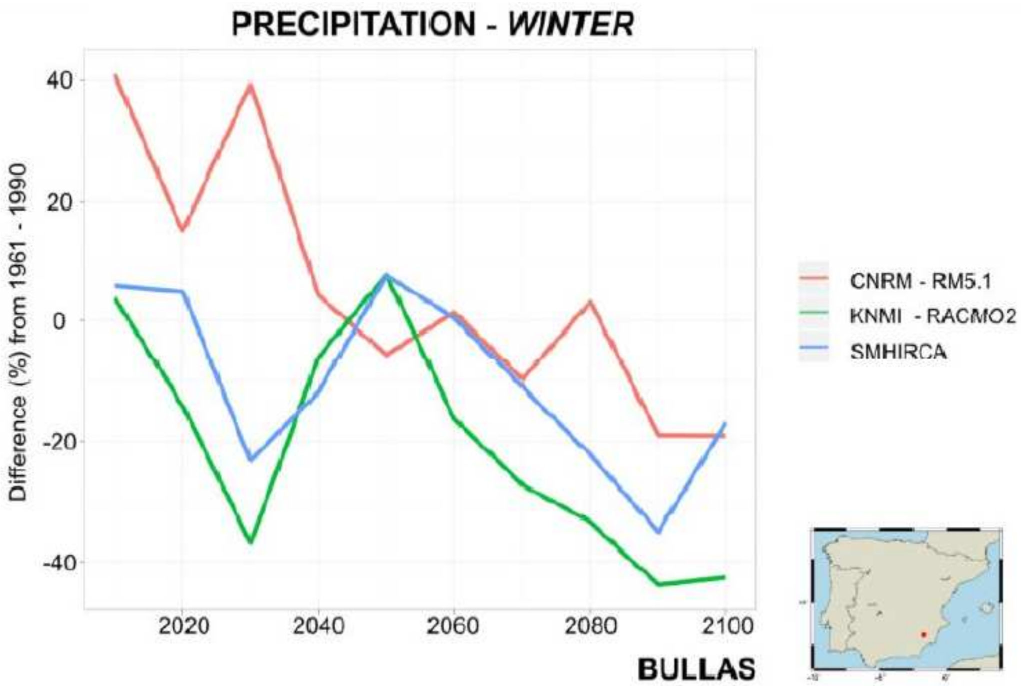



*Figure 34. Winter cumulated precipitation variation predicted by RCMs (%)*

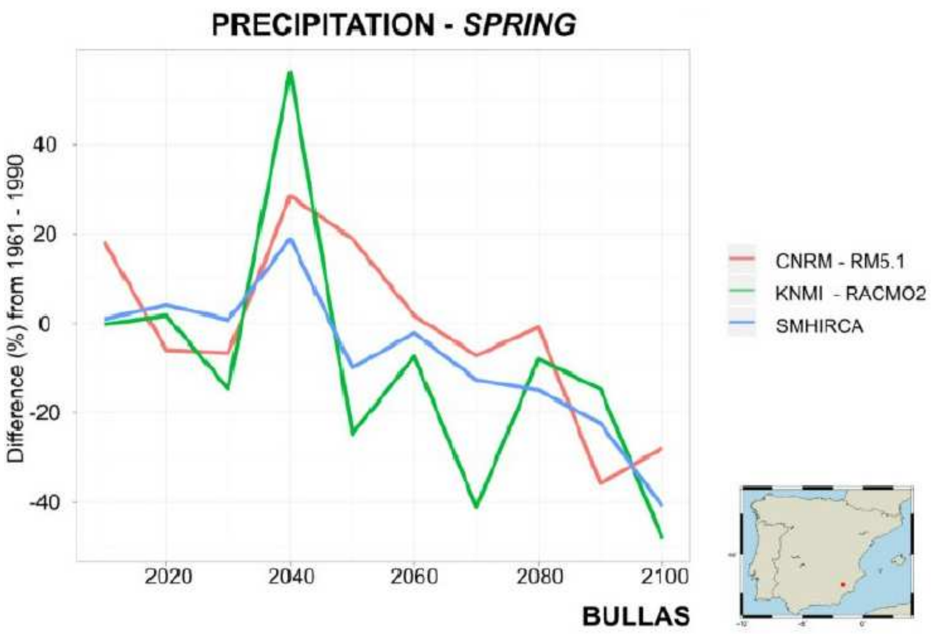



*Figure 35. Spring cumulated precipitation variation predicted by RCMs (%)*

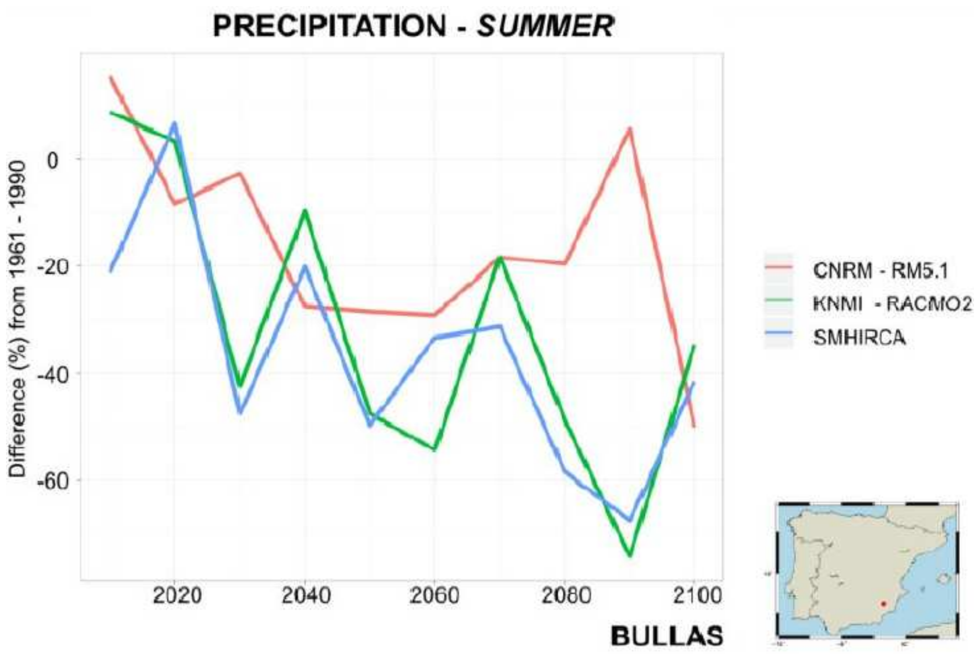



*Figure 36. Summer cumulated precipitation variation predicted by RCMs (%)*

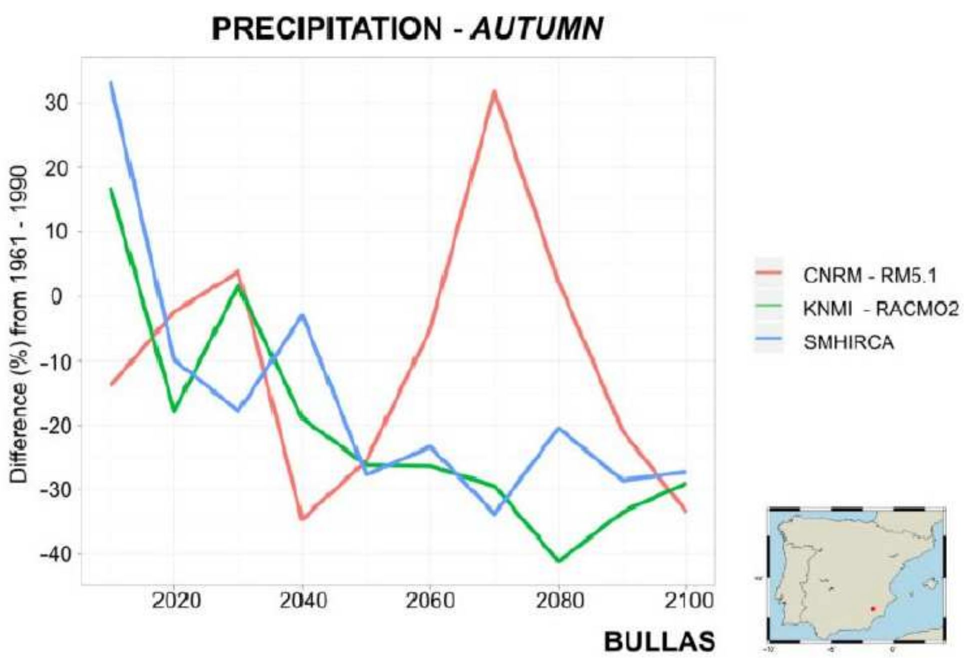



*Figure 37. Autumn cumulated precipitation variation predicted by RCMs (%)*

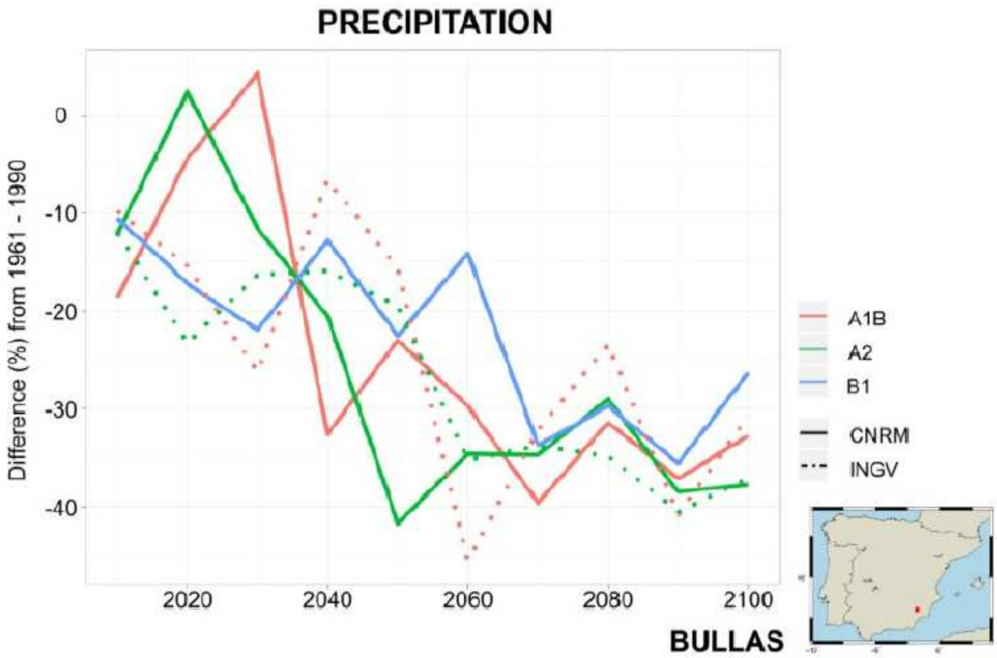



*Figure 38. Annual cumulated precipitation variation predicted by GCMs (%)*

# ASSESSING VULNERABILITY AND THE IMPACTS OF CLIMATE CHANGE

# 4


[27]

This chapter provides the vulnerability and adaptation baseline for Bullas against climate change and digs into current and potential impacts resulting from climate change and the challenges and opportunities that it can also provide.

In Chapter 2 a detailed image of Bullas socio-economic context has been created and that special context and its nature it's the justification for choosing the priority study areas that are the central line of this Adaptation Plan.

Bullas is a rural area characterized by agricultural and tourist activities that may be very vulnerable to climate change. In particular, grapevine (for wine) and olive are two of the main agricultural crops in Bullas. The former is very important for the economic role that wine producers' play at national and international levels, whilst, the latter is important not only for the income that it generates but also for its contribution to landscape.

Both crops are perennial, which makes them more vulnerable to climate change due to their growing season is carried out mostly during the spring summer, in which major climatic anomalies are found; so the selection of the most appropriate crop management techniques is fundamental and may be considerably affected by expected changes in climate.

[27] Source: Photo: David Espín Sánchez http://bullasmeteo.blogspot.com.es

Besides, rural tourism has increased in Bullas and now it represents an important income for many farmers and other MSE (small and medium-sized enterprises) from different sectors, such as hotel business, rural houses, restaurant business, outdoor activities, etc. Most of them belong to the "Wine Route".

The expected changes in temperature and precipitation may have negative effects (hazards) such as increasing management cost (water supply, electricity for air conditioning, etc.), health cost (tourism) and reducing the production of traditional local crops.

All in all, both areas - agriculture and tourism - have been chosen, because they are considered as "key sectors" due to their influence in Bullas economy and its sustainable development.

## 4.1 Tourism

### *4.1.0 Introduction. Tourism in Bullas*

Bullas' main tourist attractions are:

- The **"Don Pepe Marsilla House Museum, Bullas 1900"** seeks to rescue an important part of the local culture of Bullas, recreating the way of life from the beginning of the 20th century.

The museum also wants to preserve the town's historical heritage.

- **Wine Feast**

Bullas has been celebrating the Wine Feast the last weekend of every September since the year 2001, just before the Patronal Feast and during the vintage time.

Several activities are centered around the main product of the town: Wine Route's guided tours, commented tastings, award of the Master of Wine that every year goes to a person devoted to the viticulture and oenology.

Some other events are held in the central square of Bullas on Sunday morning, such as the inauguration of the Wine Fountain, the traditional grape treading and the First Juice's Blessing that can be sampled by the people. Music and traditional dances are also held during these special moments.

Some other initiatives such as the Tapa Fair make this festival even more special during these days when the unbreakable union between Bullas and its starring product, wine, is celebrated.

### Holy Week in Bullas

Holy Week is a deeply-rooted celebration in Bullas. The processions, the main characteristic of these days, go beyond religion to become a cultural sign that shows the identity of the celebrating people, like in many other parts of Spain. Hundreds of inhabitants of Bullas (old people, young people, children) participate as brotherhood members, nazarenos, bearers of the images, drummers or simply as spectators of these processions that involve everyone.

The Holy Week brotherhoods of Bullas are the main protagonists during these days and they have their origin some centuries ago in the groups created to worship a particular religious image.

Nowadays there are five brotherhoods that participate in the processions of Bullas. They each have a nickname related to their tunic color.

*Figure 39[28]. Holy week in Bullas*

### Wine Museum

The Wine Museum has historic, cultural and socioeconomic implications. On one hand, it’s an important contribution to the persistence of memory of some life forms in danger of collapsing and knowledge of oenology and, on the other hand, it’s a tourist attraction for the town.


*Figure 40[29]. Wine museum*

### Patronal Feast of Our Lady of the Rosary

Bullas celebrates its main Feast honoring Our Lady of the Rosary, who was chosen as patron by the inhabitants of the town in 1723. The holiday is on October 7th, but according to an old tradition, the actual Feast’s day falls on the first Sunday in October.

### Feast of Saint Mark

Bullas has been an agricultural town and the celebration of Saint Mark is a clear sign of this tradition as it is a real exaltation of the rural world. Saint Mark's day falls on April 25th, but the celebration is held the following weekend. The feast began at the end of the 19th century and its origins can be found in a popular praying procession to ask for rain. There is no image of Saint Mark in Bullas, so it is

[28] *Source:* www.bullas.es
[29] *Source:* www.bullas.es

that of Saint Isidore which participates in the procession. This is one of the odd aspects of the celebration: one saint replaces another in the town's own feast.

- **Patronal Feast of La Copa**

La Copa celebrates its Patronal Feast on September's first weekend honoring Our Lady of the Consolation and Our Lady of Sorrow ('La Socorrica'). Many different activities and events take place from Friday to Tuesday (ranging from the festive Migas Night and the Diana feast to the solemn processions with the image of the Patron in the religious one).

- **Feast of Saint Anton (in La Copa)**

La Copa celebrates the Feast of Saint Anton (patron of the animals) on the first weekend following January 17$^{th}$. Several interesting events are organized every year by the Brotherhood of Saint Anton, such as the great fire on Saturday evening where the people from La Copa and also the visitors can enjoy eating local products. This fire is built in remembrance of those fires that the local people built to ask for protection or give thanks to the saint. On Sunday, after the Holy Mass, the traditional "auction" of typical products takes place and the collected money is destined to pay the expenditures of the Feast. The popular 'Innocent's Dance' (a true relic of the regional folklore) is held in the afternoon. It is a traditional 'bidding dance' where a character wearing an old dress encourages the public to dance, participating in this really old tradition. The last event of the Feast of Saint Anton is the procession with his image. When it arrives to the Llano de la Fuente area, the animals are blessed by the priest.

- **Feast of the Immaculate Conception in La Copa**

Every December, on the event of the Feast of the Immaculate Conception of the Holy Virgin, the "auroras" become the protagonists in La Copa, recovering an old tradition which has been preserved in the village. The "auroras" visit all the streets of La Copa on the eve of December 8$^{th}$, singing and praying. The songs have a wide range of topics, depending on the soul offered in each house. They are verses dedicated to a Saint, the long 'Credo' or the nice "Salve" to the Holy Virgin.

## 4.1.1 EXPOSURE

### 4.1.1.1 EXPOSURE INDICATORS

Climate can influence tourism through a variety of mechanisms. On one hand, it exerts a direct influence by determining weather conditions at places of origin and destination. On the other hand, it affects tourism indirectly, for instance by influencing agriculture, wine production, biodiversity and water supply. The tourism industry depends more strongly on climate than most others.

What links tourism to climate are the preferences of tourists for certain conditions. Naturally, different tourism types require different climatic conditions, in general, the more fundamental climate requirements are:

- Safety: regarding extreme events, strong winds, storms.
- Pleasantness: meaning sunshine and absence of rain; as well as
- Comfort or health: referring to thermal wellbeing, and the absence of skin cancer, heat shocks, etc.

The tourism exposure main indicators are:

- Annual visitor flow

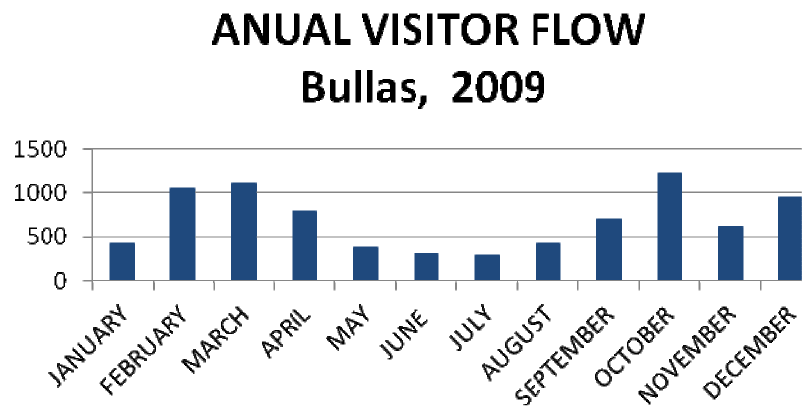



*Figure 41. Annual visitor's flow. Bullas 2009*

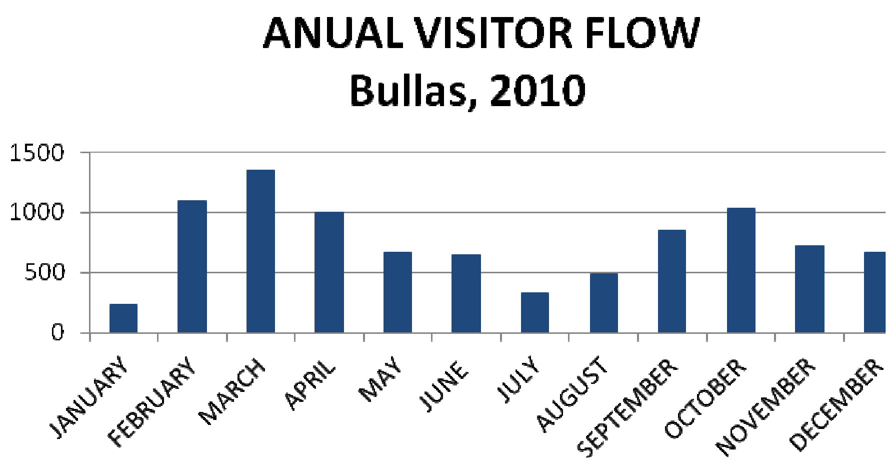



*Figure 42. Annual visitor's flow. Bullas 2010*

- Share of tourist arrivals in the summer season

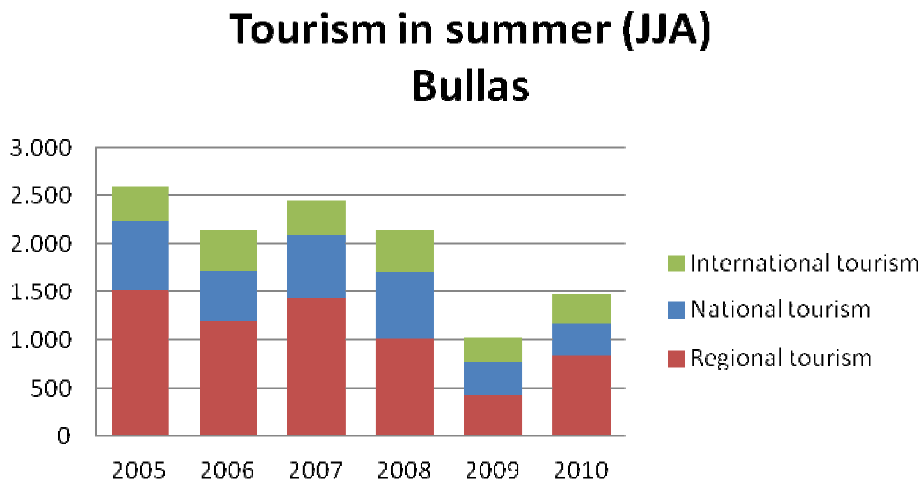



*Figure 43. Share of tourist arrivals in the summer season (June, July and August)*

- Number of tourist facilities and infrastructures that might be affected by extreme weather events.

Any incident recorded.

- Number/area of tourist protected areas and/or tourist natural sites
  - Wine route
  - Nature landscapes (mountain areas, river banks, ravines and stream areas, fauna)
  - Northwest green pathway
  - Short walking tracks (Romero, Mula river banks, La Rafa-Castellar, Atalayas)
  - The river watermills

- Number of employees in the tourism sector.

Around 300 employees during the high season.

### 4.1.1.2 EXPOSURE ASSESSMENT

*Table 16. Exposure assessment*

| EXPOSURE | | | |
|---|---|---|---|
| **Impact** | **Factors influencing the exposure of a system/sector** | **Exposed elements/groups** | **Level of exposure** |
| Change in seasonal tourist flow | Changes in temperature, precipitation and extreme events can modify the annual distribution of tourists (too hot summers, strong rains in September – October which are the most popular tourist months in Bullas). | Hotel business (occupancy and employment)<br>Rural housing (occupancy and employment)<br>Restaurant Business<br>Outdoor activities<br>Wine industry<br>Museums | Medium |
| Damages in tourist infrastructures due to more frequent extreme events | Changes in frequency and intensity of extreme events related to the tourism industry<br>Suitability of rural accommodations due to extreme events.<br>Sensitivity of the grape vine to extreme events. | Rural housing<br>Wine industry | Medium |
| Tourists' health problems | Vulnerability of outdoor-tourists to heat waves (primarily those that come from cooler climates).<br>Increased frequency of insect outbreaks due to warmer weather.<br>Spread of infectious diseases/vectors borne illnesses in summer. | Hospitals and health services | Medium-high |

| | | | |
|---|---|---|---|
| Water shortages | Changes in precipitation, evaporation and factors that affect water consumption.<br>Drying climate might lead to water supply problems for tourists.<br>Water quality and/or quantity might not satisfy future tourism's increased demand. | Hotel Business<br>Restaurant business<br>Wine industry<br>Rural-housing | Medium-high |
| Problems with energy supply | Increased demand of energy due to increased cooling needs in summer. | Hotel business<br>Rural housing<br>Restaurant business<br>Museums | Medium-high |
| Impact on biodiversity.<br>Changes in flora, fauna and landscape. | Loss of native plant and animal species (extinction or migration) and/or increase in invasive species due to more favorable climate. (This can have a positive or a negative impact on tourism). | Outdoor activities<br>Rural housing<br>Wine industry | Medium-low |
| Impact on agriculture, forestry and wine production | Grape vine phenology, quality and yield are very dependent on climate. Consequently winery level impacts are expected.<br>Stress on crops because of extreme weather conditions and chronic effects on crop growth and development of continuously warmer temperatures.<br>Warmer and drier conditions may produce: 1) Increases in frequency and intensity of fires due to hotter and drier seasons; 2) Increases in pests and pathogens. | Wine industry<br>Rural housing<br>Hotel business<br>Restaurant business<br>Museums | Medium-high |

## 4.1.2 SENSITIVITY

### 4.1.2.1 SENSITIVITY INDICATORS

- Share of arrivals visiting for leisure, recreation and holiday purposes

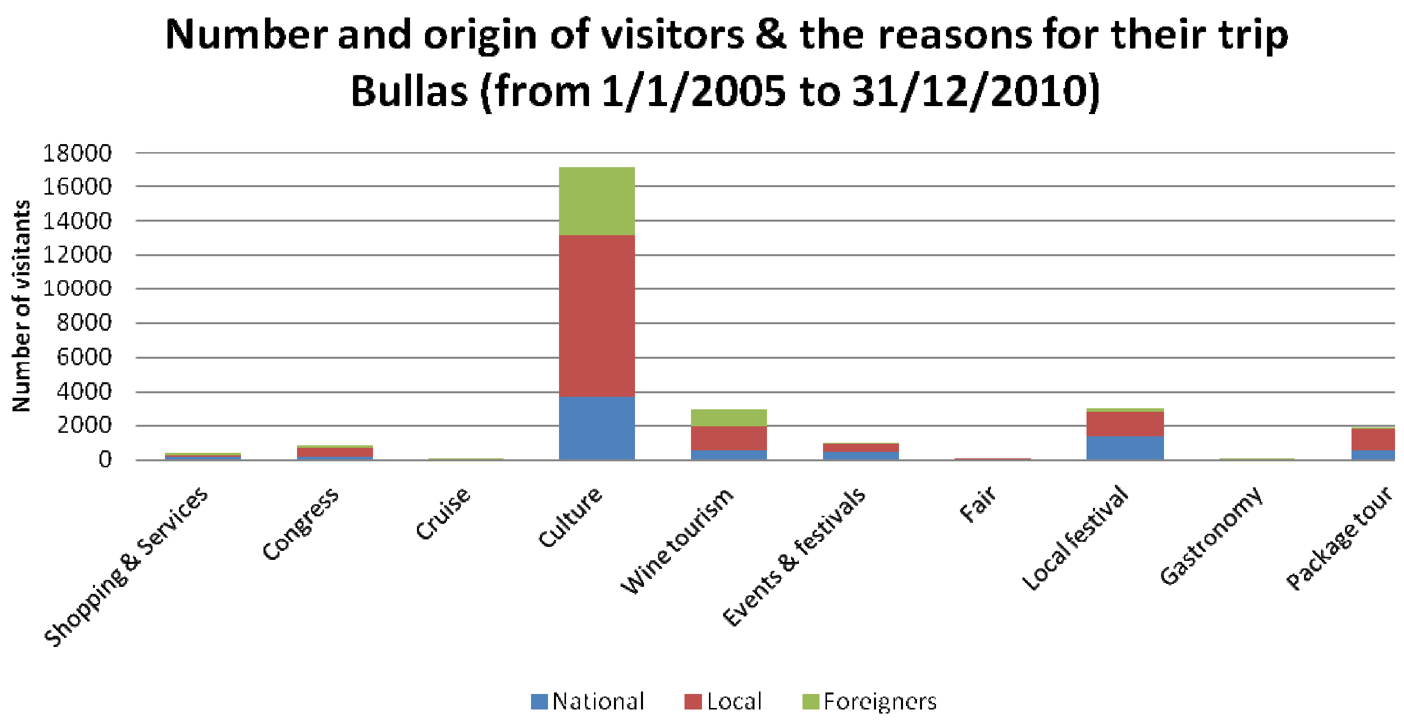



*Figure 44. Number and origin of visitors and the reasons for their trip (from 1/1/2005 to 31/12/2010)*

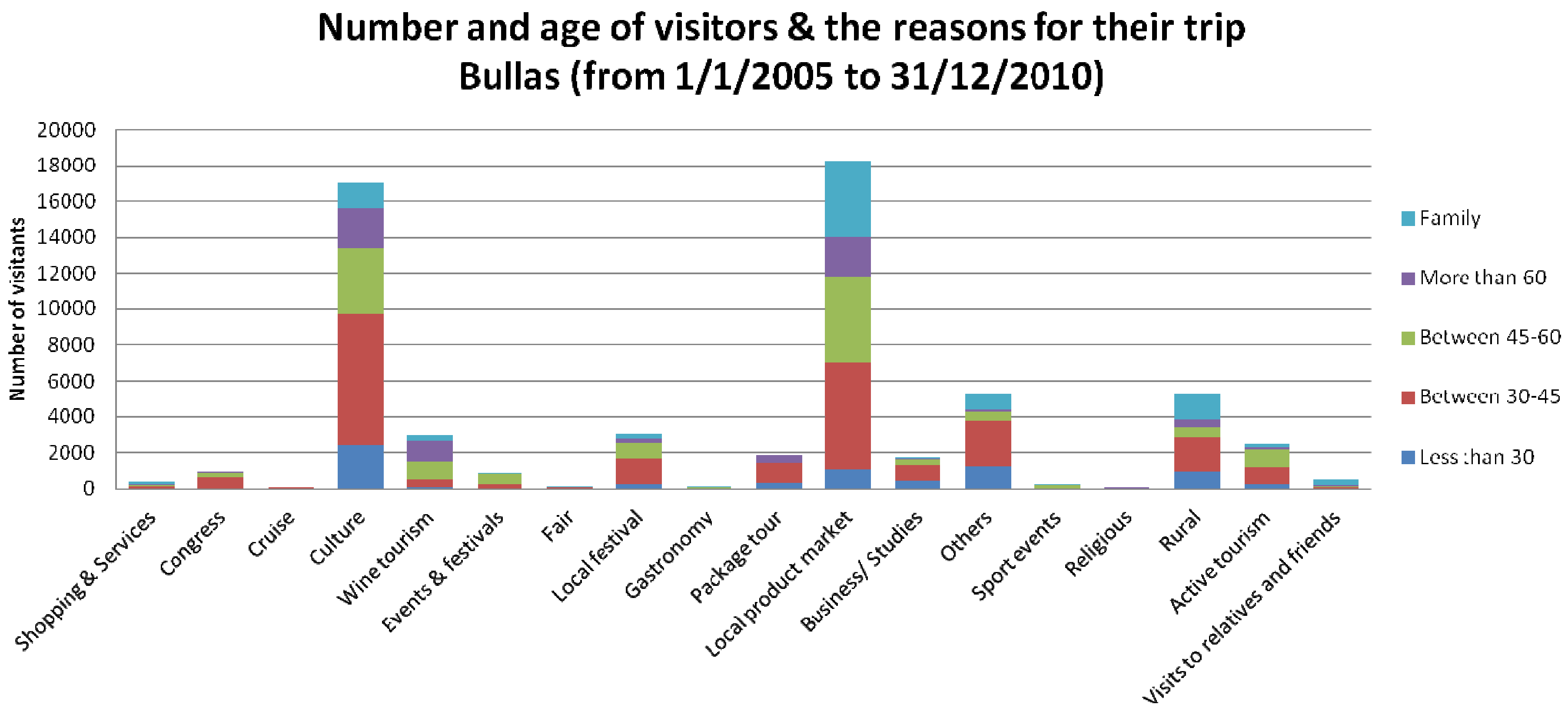



*Figure 45. Number and age of visitors and the reasons for their trip (from 1/1/2005 to 31/12/2010)*

NOTE: Before 2009, “wine tourism” was included in “culture”.

- Range of visitors' age

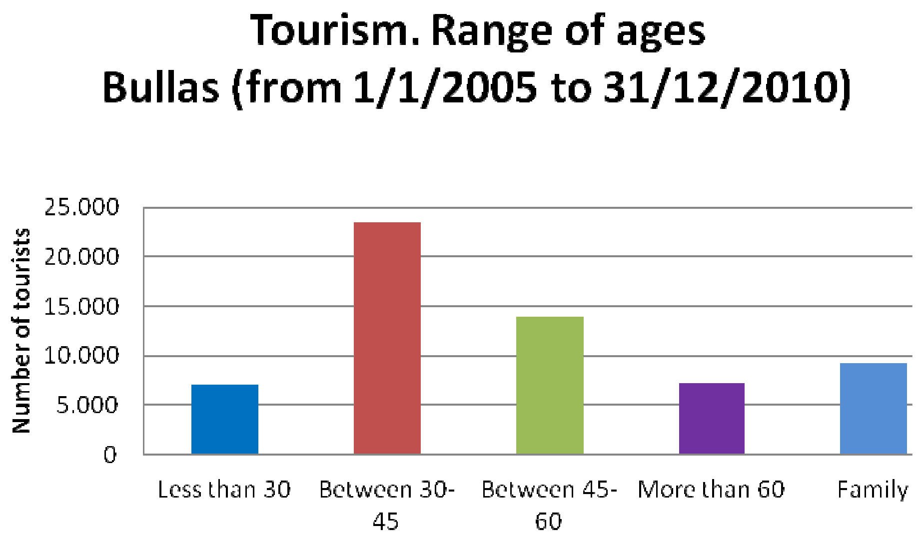



*Figure 46. Range of visitors' age (from 1/1/2005 to 31/12/2010)*

- Origin of visitors


*Figure 47. Number and origin of tourists (from 1/1/2005 to 31/12/2010)*

#### 4.1.2.2 SENSITIVITY ASSESSMENT

*Table 17. Sensitivity assessment*

| SENSITIVITY | | | | |
|---|---|---|---|---|
| **Impact** | **Existing stress unrelated to climate** | **Sensitive elements/groups** | **Factors influencing the sensitivity of a system/sector** | **Sensitivity** |
| Change in seasonal tourist flow | Currently the majority of tourist flows occur in spring and autumn.<br>Tourists are expected to be at greater risk to extreme events than residents because they are unfamiliar with the zone. | Hotel business (occupancy and employment)<br>Rural housing (occupancy and employment)<br>Restaurant Business<br>Outdoor activities<br>Wine industry<br>Museums<br>Health facilities | Dependence on tourism that relies on climate:<br>- Outdoor tourism is currently the main type.<br>- Strong rains are expected in September and October which are currently the most touristic months in Bullas.<br>Longer hot periods will increase the population trend of moving to summer houses on the coast, resulting in the closure of establishments and services in Bullas, which will make the area less attractive.<br>Future socio-economic situation of potential visitors. | S4- Yes. Functionality will get worse |
| Damages in tourist infrastructures due to more frequent extreme events | The most tourism heavy months coincide with the rainiest months; nevertheless, there aren't remarkable consequences. | Rural housing<br>Wine industry | This sector is dominated by small and medium-sized enterprises which make the tourism sector more vulnerable to extreme events.<br>The most tourism heavy months coincide with those months when extreme rains are expected. | S2- Unlikely. Functionality will likely stay the same |

| | | | | |
|---|---|---|---|---|
| Tourists' health problems | - | Hospitals and health facilities | Age and origin of future tourists: High percentage of visitors older than 60 and from cooler climates. | S3- Yes. Functionality is likely to get worse |
| Water shortages | The Region of Murcia currently has serious water supply problems. | Hotel Business<br>Restaurant business<br>Wine industry | The Region of Murcia currently has serious water supply problems.<br>Tourists typically use relatively more water than local inhabitants (in part because of additional water uses such as garden and golf irrigation, cleaning, swimming pools, etc.) | S4- Yes - Functionality will get worse |
| Problems with energy supply | Nowadays, most of the energy consumed in Spain comes from fossil fuels (72% in 2009).<br>Our modern lifestyle's high dependence on energy (i.e. cooling/heating systems, poorly insulated houses, etc.) | Hotel business<br>Rural housing<br>Restaurant Business<br>Museums | Tourist facilities usually require more energy than local ones. | S3- Yes. Functionality is likely to get worse |
| Impact on biodiversity. Changes in flora, fauna and landscape. | There are many endangered species due to human action. | Outdoor activities<br>Rural housing<br>Wine industry | Nature-based tourism is an important and growing type of tourism in Bullas.<br>Ignorance about the attractiveness of expected new flora & fauna. | S2- Unlikely. Functionality will likely stay the |
| Impact on agriculture, forestry and wine production | Ecosystem fragmentation.<br>There is a trend of fewer people working on farms due to many factors: it is a difficult and poorly-paid job, | Wine industry<br>Rural housing<br>Hotel business<br>Restaurant business | Grape vine phenology, quality and yield are very dependent on climate. Consequently winery level impacts are expected.<br>Stress on crops because of extreme weather conditions and chronic effects on crop growth | same<br>S4- Yes - Functionality will get worse<br>S3- Yes. Functionality is likely to get worse |

| | | | | |
|---|---|---|---|---|
| | suppliers get most of the benefits, there aren't enough grants, etc. | Museums | and development of continuously warmer temperatures.<br>Warmer and drier conditions may produce: 1) Increases in frequency and intensity of fires due to hotter and drier seasons; 2) Increases in pests and pathogens. | |

### 4.1.3 Potential impacts

#### 4.1.3.1 POTENTIAL IMPACTS INDICATORS

- Change in seasonal tourism flow:

Statistics from Bullas Tourism Office (based on 2009-2010 period) indicate that an average of almost 8,500 people visit Bullas each year. The following graphs show the annual distribution of tourism in Bullas from 2009 and 2010. The observed differences in tourist arrivals to the area are due to several factors:

1. On one hand, tourism in autumn-winter is greater than in spring-summer.
2. High temperatures in Bullas' summer result in a large number of people closing their establishments (bars, restaurants, shops, etc.), and going to the coast, generally to their second homes.

In August there is a slight increase in tourist arrivals, which can be explained by the attraction of some tourists to the cooler night-time temperatures and the return of those natives that currently live in other locations.

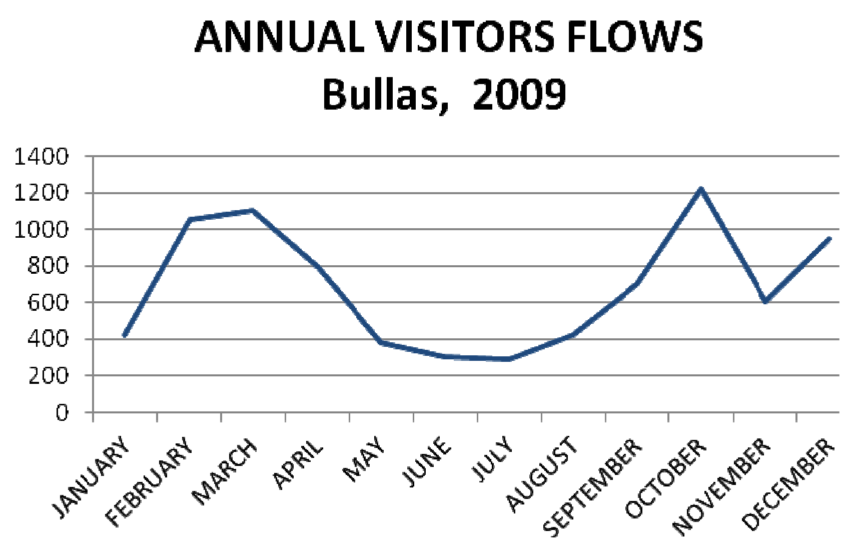



*Figure 48. Annual visitors' flow (Bullas 2009)*

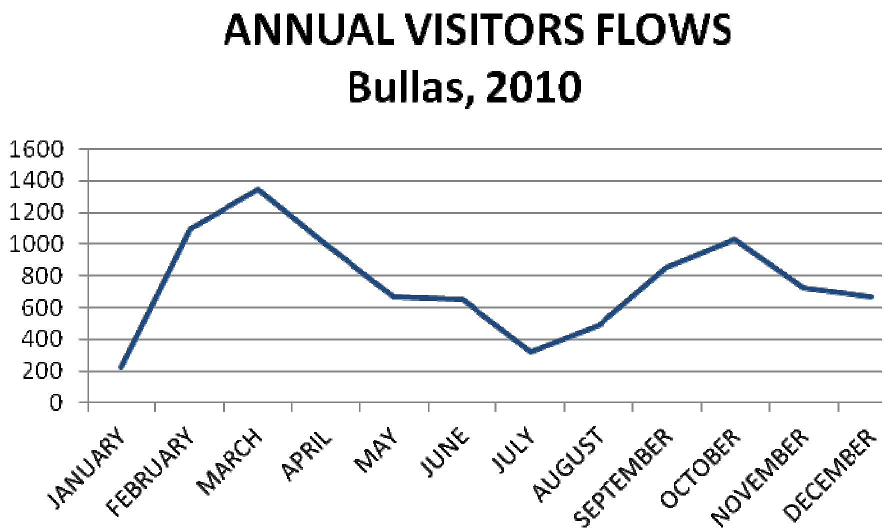



*Figure 49. Annual visitors' flow (Bullas 2010)*

### Tourism Climate Index of Mieczkowski (1985)

The Tourism Climate Index (TCI) is the most common index used to analyze the potential impacts of climate change on the number of tourists visiting a specific region. This index is based on the notion of "human comfort" and consists of five sub-indices, each represented by one or two monthly climate variables.

The climate variables used by Mieczkowski in the TCI are: monthly mean for maximum daily temperature, mean daily temperature, minimum daily relative humidity, mean daily relative humidity, total precipitation, total hours of sunshine, and average wind speed.

Mieckowski gave relative weight to the climate variables in the TCI formula, thus, TCI takes on the following expression:

$$\boxed{TCI = 2\,[(4 \times CID) + CIA + (2 \times P) + (2 \times S) + W\,]}$$

The index used a standardized rating system, ranging from 5 (optimal) to –3 (extremely unfavourable) to provide a common basis of measurement for each of the climate variables. The total range of TCI values is –30 to 100.

*Table 18. Rating categories in the Tourism Climate Index.*

| Numerical value of indices | Descriptive category |
|---|---|
| 90-100 | Ideal |
| 80-89 | Excellent |
| 70-79 | Very good |
| 60-69 | Good |
| 50-59 | Acceptable |
| 40-49 | Marginal |
| 30-39 | Unfavourable |
| 20-29 | Very unfavourable |
| 10-19 | Extremely unfavourable |
| 9- -9 | Impossible |
| -10- -20 | Impossible |

*Table 19. Classification of TCI distributions*

| | All months | Spring | Summer | Autumn | Winter |
|---|---|---|---|---|---|
| **Optimal** | ≥ 80 | -- | -- | -- | -- |
| **Poor** | ≤ 40 | -- | -- | -- | -- |
| **Summer peak** | -- | -- | 1st highest TCI | -- | -- |
| **Winter peak** | -- | -- | -- | -- | 1st highest TCI |
| **Bimodal** | -- | 1st or 2nd highest TCI | -- | 1st or 2nd highest TCI | -- |
| **Dry season peak** | -- | 1st highest TCI (or Autumn) | -- | 1st highest TCI (or Spring) | -- |
| **Spring peak** | -- | 3rd or 4th highest TCI | -- | 3rd or 4th highest TCI | -- |
| **Autumn peak** | -- | 1st or 2nd highest TCI | -- | 1st highest TCI | -- |

First of all, and in order to get an overview of the current situation, the TCI index has been calculated for the year 2010, as it is shown in the next figure.

According to this graph, Bullas achieves higher TCI scores between April to October but above all in May and June (rating=ideal) and in September and October (rating= Excellent). As for tourist flows, the real data obtained from the Bullas Tourist office show that tourists arrive in this region above all in autumn (September-October) and early spring (March).

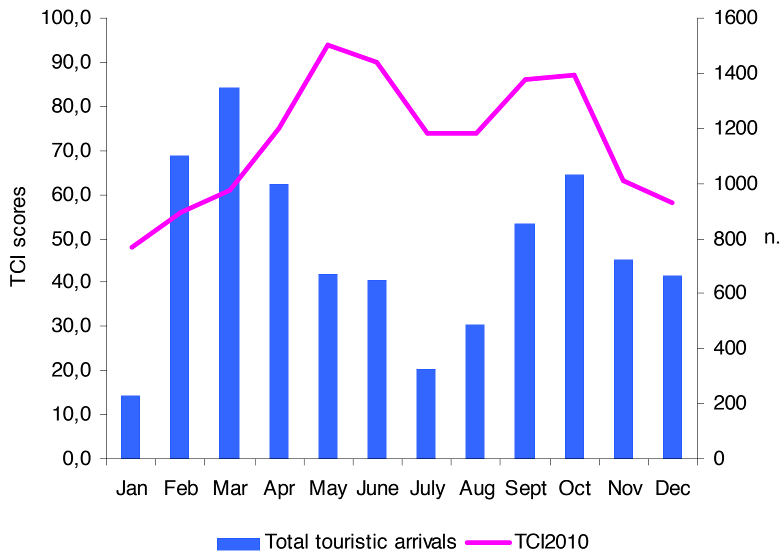



*Figure 50. Relation between the TCI and the visitors' flow*

The relationship between the TCI index and the different climate variables is described below:

✦ **Temperature and Humidity**

The relationship between temperature and humidity parameters, which are among the climatic values, determines the thermal comfort. Thus, the relation between these two values in the TCI formula is put forth by the parameters of CID and CIA. Maximum daily temperature and minimum daily relative humidity values are used in calculating the CID parameter (day time comfort index). This parameter has a weighting of 40 % in the formula. In the calculations of CIA (daily comfort index), the mean daily temperature and mean daily relative humidity values are used. This parameter is determined to have a weighting of 10%. The values of parameters ascend or descend according to the interaction between temperature and humidity values.

In Bullas, winter months show the lowest values in terms of the maximum daily temperature, the mean daily temperature, and the TCI.

✦ **Precipitation**

The rainfall factor, which is one of the most important climatic parameters, is determined to have a weighting of 20% in the TCI formula. An increase in the amount of precipitation generally reflects a decrease in tourism.

✦ **Sunshine**

Sunny conditions are generally regarded as positive factors in human climatic comfort. In Bullas, July is the month when the mean daily sunshine period is the highest. Although the sunshine period has high values during the summer months, it has a weak influence on the score as its weighting in the TCI formula is low.

✦ **Wind**

Wind plays a critical role because it accelerates the transfer of heat by evaporative cooling. Winds in Bullas reduce the negative effects of high temperatures on human beings during the summer months. Wind has a negative effect during cold months.

**PREDICTIONS OF TOURIST CLIMATE INDEX**

Finally, and in order to illustrate the potential future change of monthly comfort conditions, TCI scores have been calculated considering precipitation, sunshine, wind and humidity as constant variables (in these cases predictions are unreliable) and using temperature projections for Bullas, extracted from the statistical downscaling elaborated by ISPRA, for two periods 2046-2065 and 2081-2100 and for different scenarios.

In details for the period 2046-2065 we used as maximum values the results obtained with the model "NN" for Winter (December, January and February), the results obtained with the model “SDSM” for Spring (March, April and May), the results obtained with the model “NN” for Summer (June, July and August), and the results obtained with the model “SDSM” for Autumn (September, October and November).

For the same period but as minimum values we used the results obtained with the model “CLIM” for Winter (December, January and February), for Spring (March, April and May), for Summer (June, July and August), and for Autumn (September, October and November).

For the period 2081-2100 we used as maximum values the results obtained with the model “NN” for Winter (December, January and February), the results obtained with the model “SDSM” for Spring (March, April and May), the results obtained with the model “NN” for Summer (June, July and August), and the results obtained with the model “SDSM” for Autumn (September, October and November).

Always for the period 2081-2100 we used as minimum values the results obtained with the model “CLIM” for Winter (December, January and February), the results obtained with the model “CLIM” for Spring (March, April and May), the results obtained with the model “SDSM” for Summer (June, July and August), and the results obtained with the model “CLIM” for Autumn (September, October and November).

The different TCI scores for the two different periods and two scenarios (maximum and minimum) are illustrated in the graph. With the increase of temperature and the decrease of precipitation (which has not been considered in the statistical downscaling models, but values can be derived from RCM climatic models), for the future (2046-2065 and in 2081-2100) the months between June and September show less attractive climatic conditions, compared to the same months of the baseline year 2010 (which are not anyway the most comfortable months during the year). In synthesis, climatic conditions of the summer period will worsen significantly in the future.

The remaining months will maintain the same conditions, with the peak of climatic comfort in May.

In general, climatic conditions show always TCI scores higher than 50 (acceptable) except in January (about 48-49 TCI score) and during the summer period for the maximum scenario of 2081-2100 in July (49) and August (41).

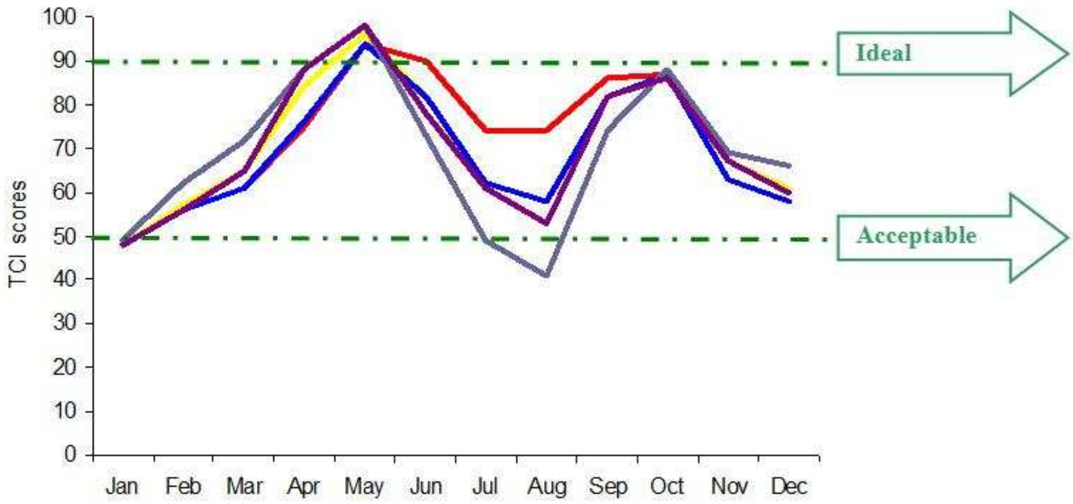



*Figure 51. Prediction of Bullas' TCI*

As illustrated in the figure 51 the worsening of climatic conditions will occur during the summer season, while Spring and Autumn will have excellent and even ideal climatic conditions. Furthermore, as summer is the period in which the lowest tourist flows are registered, the impact of climate change on tourism in Bullas will be likely scarcely significant.

In general it's useful to underline that the climatic conditions of Bullas are by no means the only attraction in the area. Attractive landscapes, cultural heritage, wine tourism and traditional lifestyles, among other factors, make Bullas an interesting tourist destination.

Moreover, tastes and fashion are unstable over extend periods of time. The modern habit of sunbathing, for example, was not part of popular culture until relatively recently. Many things may change over the next decades that increase or decrease the relevance of the climatic resources for tourism in general and of the TCI index in particular. Sunbathing is for example now seen as a potential health risk.

For this reason, tourist developments are shaped by an amalgam of factors, including political, economic growth, technological advances, and demographics. In the day-to-day practice of the tourist industry, climate factors are overwhelmed by all kinds of other influences that require immediate action: fashion, trends, terrorism, etc. The weather's effects on the climatic resources for tourism will perhaps not be so evident, but the compound effect of years of slow change can have quite dramatic long-lasting effects.

### 4.1.4 Adaptive capacity

#### 4.1.4.1 ADAPTIVE CAPACITY INDICATORS

- Diversification touristic activities (%):

Most of touristic activities are related to wine, so they are not really diversify.

- Sectoral Plans or programs

Bullas is developing an adaptation plan to climate change.

- Plans or programs including climatic variable in its programming

National hydrographic plan

Common agricultural policy

- Resources for adaptation politics:

At this moment there isn't a specific budget to deal with climate change apart from the ACT Project.

- Availability of early warning systems:

There aren't any known early warning systems

### 4.1.4.2 ADAPTIVE CAPACITY ASSESSMENT

*Table 20. Adaptive capacity assessment*

| Impact | Adaptation baseline (Underway and planned adaptation actions, etc) | Factors determining the adaptive capacity of the system/sector | Is the system already able to accommodate changes in climate with minimal costs and disruption? | Can the system/sector adjust to the projected impact with minimal cost and disruption? | Barriers to the system's ability to accommodate changes in climate | Existing stress unrelated to climate that limit the system's ability to accommodate changes in climate | Rate of projected climate change compared to the adaptability of the system | Adaptive capacity |
|---|---|---|---|---|---|---|---|---|
| Change in seasonal tourist flow | Seasonal tourist offers. | Although the sector is formed by both small and medium sized enterprises, the system has flexibility to respond and adapt to climate stimuli. Willingness to change and adapt. Awareness. | Yes | Yes-It's possible to implant some reduced-cost measures to adapt | Economic barriers and politic/citizens awareness | Small town citizens are usually narrow minded | Slower than the adaptability of the sector/system | AC4: Yes. But will require some slight costs ($$) and staff interventions |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Damages in tourist infrastructures due to more frequent extreme events | Emergency Plan | High investments required. Businesses are usually not well prepared for hazards (large businesses are generally better prepared than smaller ones, making the sector usually more vulnerable because it's traditionally dominated by small and medium sized enterprises) | No, because it requires a high level of investments. | No, it will require significant cost and staff intervention | Economic (sector dominated by small and medium-sized enterprises). | No, there aren't big damages from previous disasters | Faster than the adaptability of the sector/system | AC3. Maybe. Will require some costs ($$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tourists' health problems | Advertising campaigns from Health Minister about how to deal with heat waves. | Tourist access to useful information. Special vulnerability of tourists. | Maybe since tourist normally do not read foreign information and/or don't care about it. | Maybe, but it requires some costs and staff intervention. | Social | Pollution (more allergies). Higher age of incoming tourists. | Faster than the adaptability of the sector/system | AC3. Maybe. Will require some costs ($$$) and staff intervention |
| Water shortages | National hydrological plan. | People awareness. | No, it requires high level of investments, and political implication. | No, it requires high level of investments, and political implication. | Economic and political barriers. | Problems with water supply and resources overexploitation. | Faster than the adaptability of the sector/system | AC2 No. Will require significant costs ($$$$) and staff intervention |
| Problems with energy supply | National energetic plans. | Availability of technical tools. Problems with fossil fuels suppliers. | Maybe, although it requires some investments and staff intervention. | Maybe, although it requires some investments and staff intervention. | Political and economic barriers. | Most fossil fuels suppliers are currently immersed in political problems that lead to an important insecurity which causes a rise in fuel price. | Faster than the adaptability of the sector/system | AC2 No. Will require significant costs ($$$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Impact on biodiversity. Changes in flora, fauna and landscape. | Yes, there are national plans, such as mark the zones as ZEPA, LIC, etc... (for further information see STEP 2). | Ability for species to migrate or for ecosystems to expand/shift gradually. | Maybe | Maybe | Human action (urbanization). Biological. | Presence of invasive species. Urbanization. | Faster than the adaptability of the sector/system | AC3. Maybe. Will require some costs ($$$) and staff intervention |
| Impact on agriculture, forestry and wine production | European plan of agriculture crops (CAP) | Crops vulnerability. Forestry fires. Human action. Ecosystem fragmentation. There is a Regulating Council of the 'Bullas' Origin Denomination. | No. | No. | Biological. Geographical. Economic. | Ecosystem fragmentation. Each time there are less people working in farms due to many factors as: it is a hard-working and bad-paying job, suppliers get most part of benefits, there aren't enough grants, etc. | Faster than the adaptability of the sector/system | AC2: No. Will require significant costs ($$$$) and staff intervention |

## 4.1.5 VULNERABILITY ASSESSMENT

*VULNERABILITY = function [exposition (+); sensitivity (+); adaptive capacity (-)]*

*Table 21. Sensitivity and adaptive capacity matrix. Vulnerability scale*

| SENSITIVITY AND ADAPTIVE CAPACITY MATRIX | | | | | |
|---|---|---|---|---|---|
| | **S1** | **S2** | **S3** | **S4** | **S5** |
| **AC1** | V2 | V2 | V4 | V5 | V5 |
| **AC2** | V2 | V2 | V3 | V4 | V5 |
| **AC3** | V2 | V2 | V3 | V4 | V4 |
| **AC4** | V1 | V2 | V2 | V3 | V3 |
| **AC5** | V1 | V1 | V2 | V3 | V3 |

**VULNERABILITY SCALE:**
**V1: Low vulnerability**
**V2: Medium-Low Vulnerability**
**V3: Medium Vulnerability**
**V4: Medium-High vulnerability**
**V5: High vulnerability**

*Table 22. Vulnerability ratings*

| High vulnerability (S5-AC1)=V5 | Medium-High Vulnerability (S4-AC2)=V4 | Medium Vulnerability (S3-AC2 or S3-AC3)=V3 | Medium-Low Vulnerability (S2-AC3 or S2-AC2)=V2 | Low Vulnerability (S1-AC5)=V1 |
|---|---|---|---|---|
| **Impact** | **Impact** | **Impact** | **Impact** | **Impact** |
| | Water shortages | Tourists' health problems | Damages in tourist infrastructures due to more often extreme events | |
| | Impact on agriculture, forestry and wine production | Problems with energy supply | Impact on biodiversity. Changes in flora, fauna and landscape. | |
| | | Change in seasonal tourist flow | | |

# TOURISM IN BULLAS
# VULNERABILITY ASSESSMENT

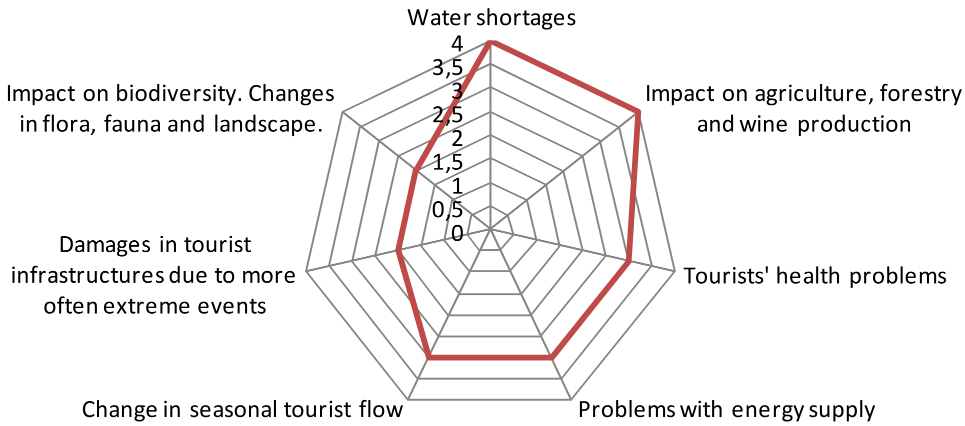



*Figure 52. Vulnerability assessment of Bullas' tourism*

# 4.2 Agriculture

## 4.2.0 Introduction. Agriculture in Bullas

The town of Bullas, which gives its name to the Denomination of Origin has existed since Roman times and achieved a certain importance during the Arab dominance. Then, after the reconquest in the 13th century, the area prospered thanks to agriculture and wines were produced for subsequent marketing, for this reason wine has a remarkable role among agricultural products in the region.

Bullas is a municipality with 61% of total land occupation dedicated to agriculture. This is mainly rain-fed agriculture (86%), where the main crops are vines, almond trees, and olive trees, other fruits like peaches and in a minor amount cereal.

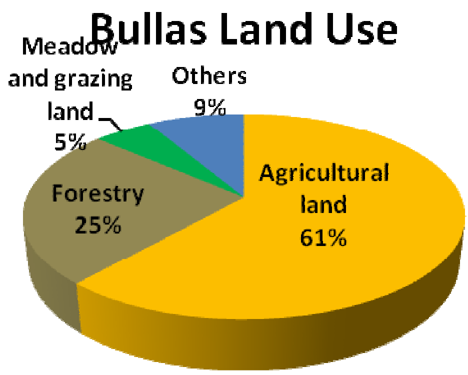



*Figure 52. Bullas' land use distribution*

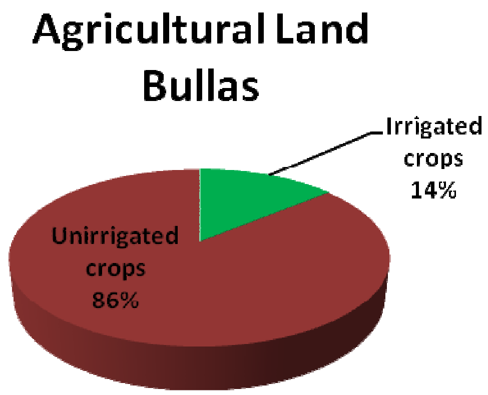



*Figure 53. Bullas' agricultural land distribution*

Bullas' agricultural land distribution is caused by water availability in the area as well as the natural crop diversification, produced by farmers. With a higher percentage of unirrigated areas, such as vineyards, as it is show in the following table.

*Table 23. Bullas land use[30]*

| BULLAS LAND USE | 2009 | | | 2010 | | |
|---|---|---|---|---|---|---|
| | **Unirrigated** | **Irrigated** | **Total** | **Unirrigated** | **Irrigated** | **Total** |
| Other areas | 701 | 0 | 701 | 833 | 0 | 833 |
| Rivers and lakes | 52 | | 52 | 100 | | 100 |
| Non agricultural area | 461 | | 461 | 475 | | 475 |
| Unproductive area | 188 | | 188 | 258 | | 258 |
| Meadow and grazing land | 415 | 0 | 415 | 23 | 0 | 23 |
| Forest area | 2.049 | 0 | 2.049 | 2.512 | 0 | 2.512 |
| Crop areas | 4.344 | 708 | 5.052 | 4.062 | 787 | 4.849 |
| **Total areas** | **7.509** | **708** | **8.217** | **7.430** | **787** | **8.217** |

Among these crops, the dominant one in Bullas is the wine grape, with a Denomination of Origin itself and is an important engine for the town's economy. The area of production of wines under the Denomination of Origin "Bullas" consists of land located in the towns of Bullas, Calasparra, Caravaca de la Cruz, Cehegín , Lorca, Moratalla, Mula, Pliego, Ricote, Cieza and Totana in the Region of Murcia.

[30] Source: Bullas Board of Denomination of Origin

The cultivation of wine grapes in Bullas is mainly made as field graft (1 to three years after planting pattern).

The number of buds is limited by the Rules of the DO Bullas to:

- DRY: 16,000 maximum per hectare

    - Or glass: up to 10 buds per plant order,

- IRRIGATION: 30,000 maximum per hectare

    - Or glass: more than 15 buds per plant order,

    - Or trellis: up to 16 view buds per vine.

Training in glass will have a maximum of 5 thumbs and planting density will be a minimum of 2,200 vines per hectare.

Due to different soil types, rainfall and climate, both the Denomination of Origin “Bullas”, as the municipality itself are divided into three geographical sub-areas:


*Figure 54[31]. Denomination of Origin «Bullas »' sub-areas*

- First sub-area, **the West and Northwest**, include 52% of vineyards in the Denomination of Origin, and is the area par excellence of the

[31] *Source: http://www.vinosdebullas.es*

Denomination of Origin "Bullas". It is situated at altitudes ranging between 500 and 810 meters above sea level at the mountains base. Includes towns of Bullas and Cehegín, part of the towns of Caravaca, Moratalla and high hamlets of Lorca. The wines of this subarea are considered the best of the denomination. The average yield is 45 hl. per hectare.

- The vineyards of the second subzone, **Central**, account for 40% of the denomination and are at altitudes of between 500 and 600 meters. Are divided into three municipalities (Mula, Bullas and Cehegín). Production varies between 13 and 25 Hl. per hectare.
- In the third sub-area, **north-east**, the vineyards are between 400 and 500 meters high and represent only 8% of the cultivated area of the denomination. Understand the municipalitys of Calasparra, Ricote, Bullas and Mula. The average production of 5-13 hl per hectare.

The following figures show the main crops in the municipality of Bullas.

- Unirrigated crops:

Particularly, vineyards in Bullas have been one of the most important crops for its economy during the last years. The figure 55 shows crop's area trends.

On the one hand, farmers are betting on quality instead of quantity that is one of the reasons why the crop area is being reduced; on the other hand, within the framework of the Common Agricultural Policy (CAP) farmers are receiving grants for pulling up the vineyards.

The historical background of this measure comes from European Union wine regulations which are common legislation related to wine existing within the European Union (EU). These regulations form a part of the Common Agricultural Policy (CAP) of EU, and regulate such things as the maximum vineyard surface allowed to individual EU member states, allowed winemaking practices and principles for wine classification and labelling. The wine regulations exist to regulate total production in order to combat overproduction of wine and to provide an underpinning to Protected Designations of Origin (PDOs), among other things. In a sense, the wine regulations therefore try to protect both the producer and the consumer.

From the 1980s, there was a marked reduction in the total demand, in terms of quantity, despite the fact that the wine-importing countries of northern Europe have increased their consumption. Increasing wine exports from America, often in a style arrived at by market research rather than long tradition, also meant increased competition and changing tastes among wine consumers. As a result, the reduced total demand also included a shift in the demand towards higher quality level. Since it was realised that the vineyards in some locations would be unlikely to yield wines of the necessary quality to be considered within the parameter of Bullas Denomination of Origin, increased financial incentives for giving up vineyards, so-called grubbing-up schemes or vine pull schemes, were introduced in the late 1980s.This led to reduced overproduction, but a complete balance has so far never been achieved.

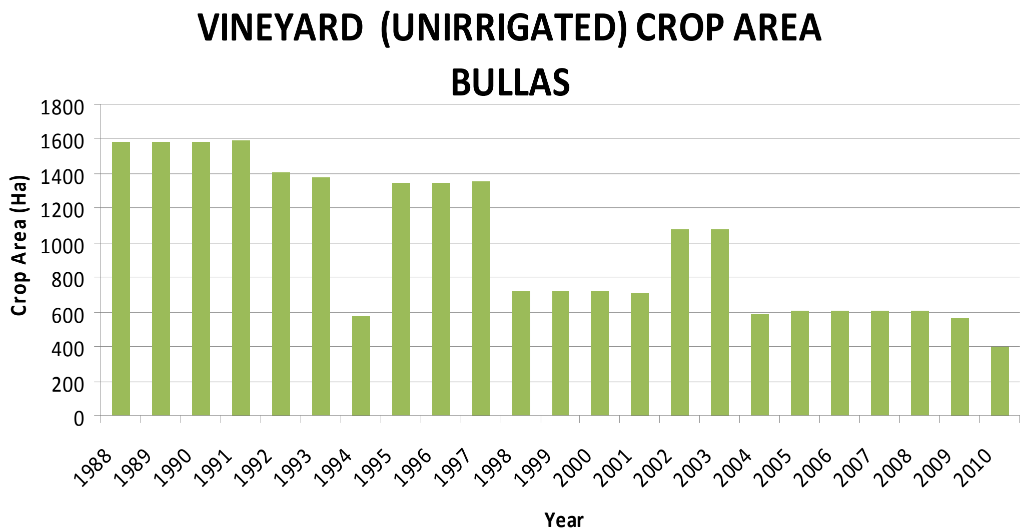



*Figure 55. Unirrigated Vineyard's crop area (Bullas)*

Appart from vineyards, there are other unirrigated crops in Bullas, that is the case of Almond trees, Olive groves and Peach trees. There are also some more crops in Bullas but less important, as it shows in the following figure.

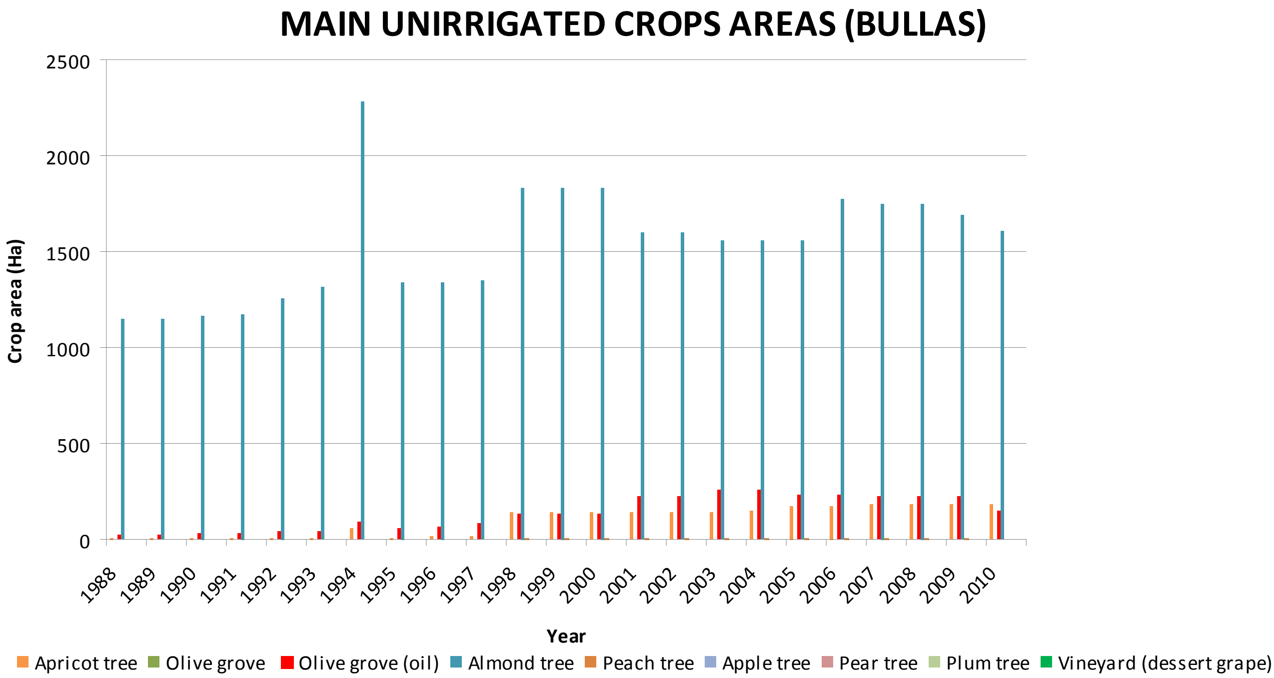



*Figure 56. Main Unirrigated crops areas (Bullas)*

Next figure shows the cereal's areas in Bullas, with barley being the most one followed by wheat.

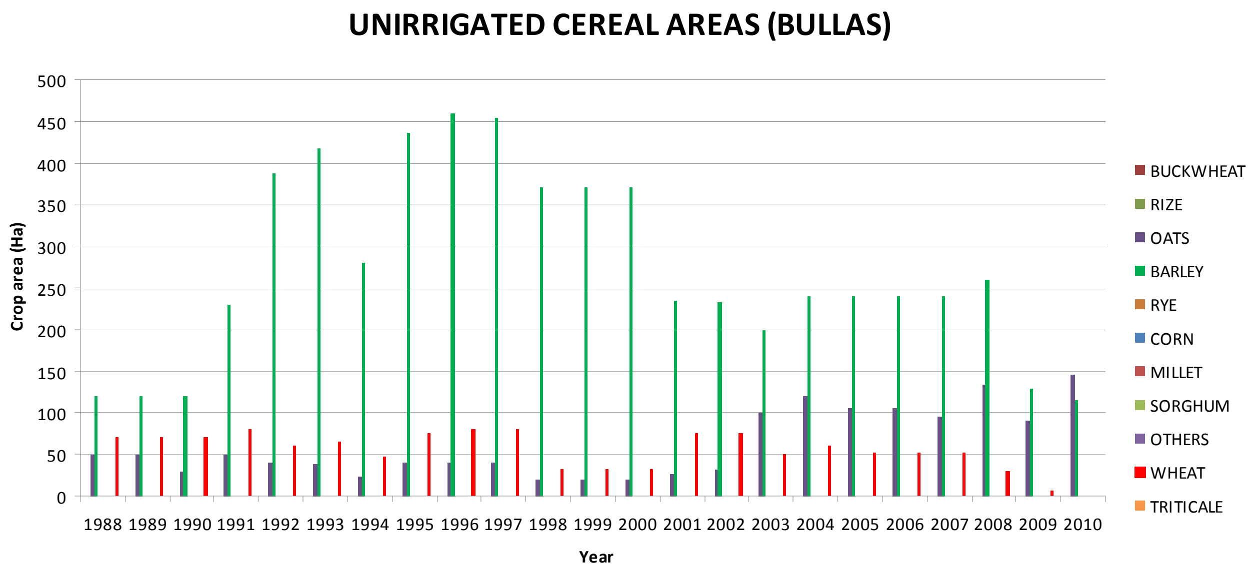



*Figure 57. Unirrigated cereal areas (Bullas)*

- Irrigated crops:

Only the 14% of the crops in Bullas are irrigated. Next figures show the distribution of the main irrigated crops areas in Bullas, and vineyard ones.

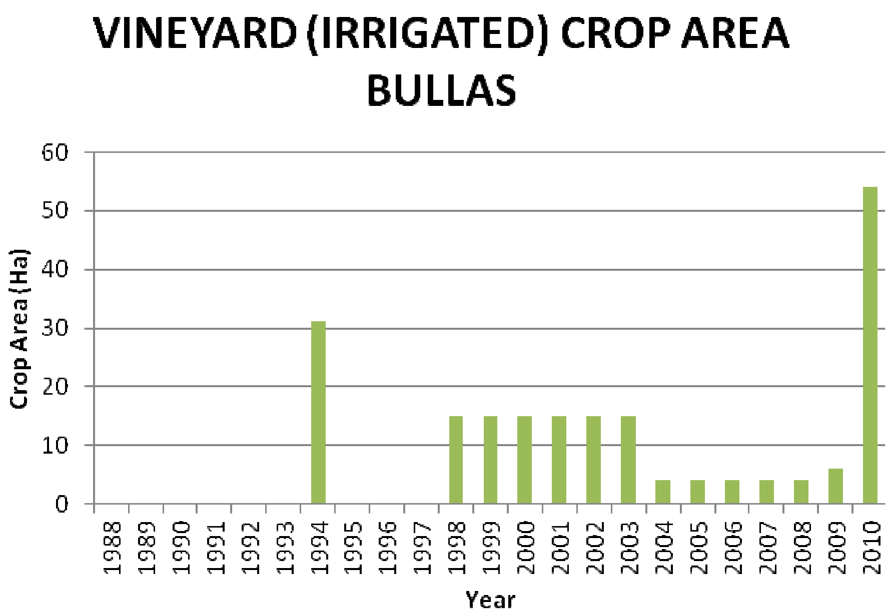


*Figure 58. Irrigated Vineyard's crop area (Bullas)*

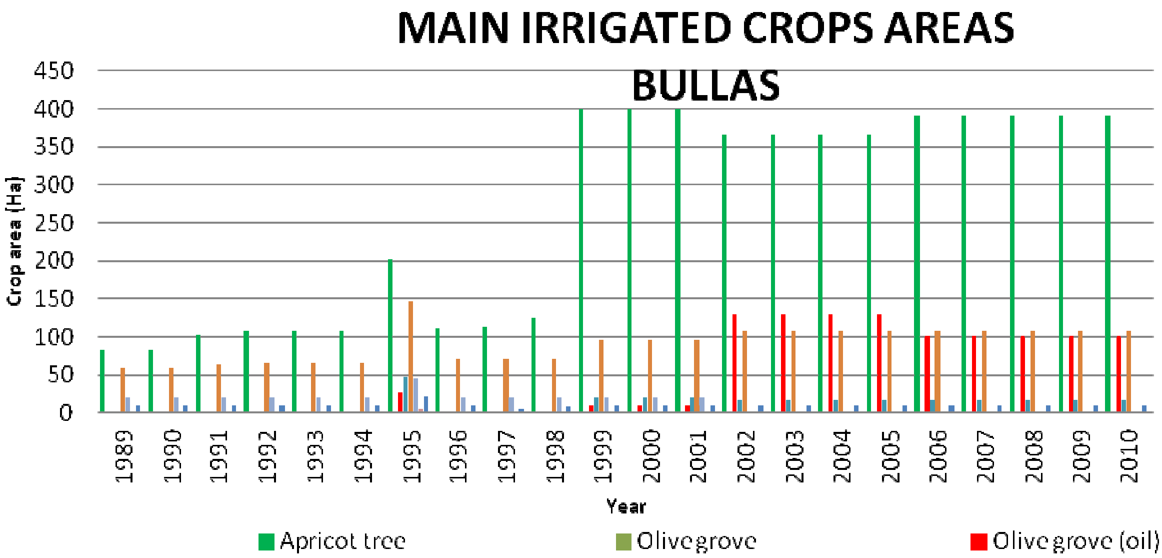



*Figure 59. Main Irrigated crops areas (Bullas)*

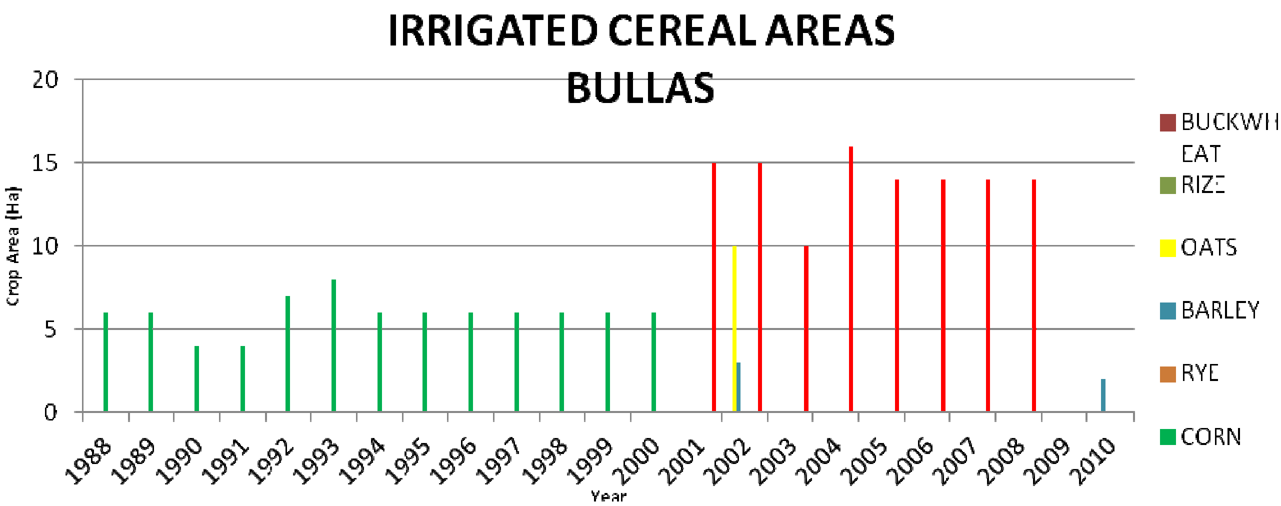



*Figure 60. Irrigated cereal areas (Bullas)*

To summarise Bullas agriculture, and regarding to its economy and because of the high production and quality of wine grapes in the area, Bullas is a major wine industry with its own Denomination Origin, including the following among the top wine cellars:

- Winery Balcona
- Winery Carrascalejo
- Cooperative winery Nuestra Señora del Rosario
- Cooperative winery San Isidro
- Winery García Noguerol
- Winery Los Ceperos
- Winery Madroñal
- Winery Molino y Lagares de Bullas
- Winery Monastrell
- Winery Tercia de Ulea
- Winery Begastri
- Winery Carreño
- Winery Contreras
- Mundo Enológico Q & M

Apart from these wineries, there is also "Atalaya oil", which produces extra virgin olive oil from the olive variety Cuquillo.

At the middle of the 20th Century began the creation of cooperative-societies concerning vine and wine sector and, consequently, small traditional cellars were abandoned and those tools which were used in these cellars became useless. The great quantity of small owners of vineyards and cellars became, from that moment, partners of these cooperatives-societies. Little by little new technologies were introduced in order to increase the production and cheapen prices.[32]

Nowadays, modernization of industry concerning vine and wine cultivation and the profit of technological advances has favoured the increase of the qualities of wines and its prestige. These all conditions have allowed the official concession of *Bullas Origin Denomination* for the wines, which are cultivated and produced in this land (Ministerial order 5-9-1994).

The Denomination of Origin Bullas is characterized by being composed of small parcels owned by elderly farmers. Most of these growers are engaged in other jobs, and agriculture is a hobby and a supplement of their income (or it was before) because the price of grapes is so low in recent years, which will provide

[32] Source: *“Bullas: wine history and culture”.* Salvador Martínez Sánchez. Vinest Project.

resources for keep these crops. With regard to winemaking in the area, the wineries belonging to the Denomination of Origin are:

- One large and foremost is made by most winemakers of the DO (280 out of 400). Most of the grape, in addition to market a percentage of wine DO Bullas estimated 70% of total.
- A cooperative, which consists of about 100 growers. Some of these growers are enrolled in the two cooperatives. This winery sells about 10% of the total wine DO Bullas.

These growers have their crops by field technicians advised of cooperatives. They take their grapes to produce wine in the warehouses of the cooperatives.

Cooperatives market several lines of wines, from normal ones, affordable to all budgets to wines of higher quality and higher prices.

The other wineries are small wineries, which produce very little wine, and trying to get the highest quality wines in price, and whose selling prices are high in general. These wineries are among the remaining 20% of the total marketing of the DO Bullas.

Most of the vineyards from which these wineries get their grapes are their own, or leased, bringing themselves the direction of the crop. A small group buys grapes to individuals.

Seeing that wine production is the main pillar of Bullas agriculture – as it was stated in the introduction of this section - and consequently an important one in the Municipality economy, from now on this study is going to be focused in wine grape crops, giving, in some cases, a little insights about the other secondary crops.

**Climate change and agriculture**

It is well known that agriculture is a climate sensitive sector. The combination of long-term changes and the greater frequency of extreme weather events are likely to have adverse impacts on the agricultural sector. Changes in hydrological regimes will directly impact agricultural production and production methods. Reductions in crop yield and quality as the result of reduced water availability and precipitation variability could result in a loss of rural income.

This loss of income will be further exacerbated by the need for increased spending as a result of damage caused by extreme weather events[33].

For this reason, present projections including increased temperatures, decreased precipitation and an increase in the number of extreme events pose a risk to agriculture production, water availability and economic growth for rural livelihoods in Bullas.

It is important to know in deep future possible risks and impacts for agriculture in order to evaluate the vulnerability of Bullas' agriculture sector. A lot of studies developed this subject in a general overview.

In this section, a general study is done -using available bibliography- to know the future risks forecasted for agriculture, in order to assess it for Bullas' agriculture.

- Climate change qualitative general implications (hazards):

The following are the general impacts prognosticated for universal agriculture if weather future predictions carry out. The former two tables explain it at a global scale while the latter is focus on the Mediterranean area, where Bullas is located.

i. Climate change and related factors relevant to agricultural production at the global scale

[33] *Source: Adaptation to climate change in the agricultural sector, AEA Energy and Environment and Universidad Politécnica de Madrid.*

*Table 24[34]. Climate change and related factors relevant to agricultural production at the global scale*

| Climate factor | Expected direction of change | Potential impacts on agricultural production and food security | Confidence level of the potential impact |
|---|---|---|---|
| Atmospheric $CO_2$ | Increase | Increased biomass production and increased potential efficiency of physiological water use in crops and weeds.<br>Modified hydrologic balance of soils due to C/N ratio modification.<br>Changed weed ecology with potential for increased weed competition with crops | Medium |
| | | Agro-ecosystems modification | High |
| | | N cycle modification | High |
| | | Lower yield increase than expected | Low |
| Atmospheric ozone | Increase | Crop yield decrease | Low |
| Extreme events | Poorly known, but significant increased temporal and spatial variability expected.<br>Increased frequency of floods and droughts. | Crop failure.<br>Yield decrease.<br>Competition for water | High |
| Precipitation | Intensified | Changed patterns of erosion | High |

[34] *Source: Iglesias, A. et al., 2007. Adaptation to Climate Change in the Agricultural Sector, AEA Energy & Environment, Didcot.*

| | | | |
|---|---|---|---|
| intensity | hydrological cycle, but with regional variations. | and accretion.<br>Changed storm impacts.<br>Changed occurrence of storm flooding and storm damage.<br>Increased water logging.<br>Increased pest damage. | |
| Temperature | Increase | Modifications in crop suitability and productivity.<br>Changes in weeds, crop pests and diseases.<br>Changes in water requirements.<br>Changes in crop quality. | High |
| | Differences in day-night temperature | Modifications in crop productivity and quality. | Medium |
| Heat stress | Increases in heat waves | Damage to grain formation, increase in some pests | High |

ii. Effects of climate changes on main agricultural determinants and expected consequences for agro-ecosystems and rural areas

*Table 25[35]. Effects of climate change on main agricultural determinants and expected consequences for agro-ecosystems and rural areas*

| Main agricultural determinant | Expected intensity of negative effects | Potential consequences for agro-ecosystems and rural areas | Confidence level of the potential agricultural impact |
|---|---|---|---|
| Water resources | Changes in hydrological regime. | Variations in hydrological regime. | High |

[35] *Source: Iglesias, A. et al., 2007. Adaptation to Climate Change in the Agricultural Sector, AEA Energy & Environment, Didcot.*

| | | | |
|---|---|---|---|
| | Differences in water needs.<br>Increased water shortages. | Decreased availability of water.<br>Risks of water quality loss.<br>Increased risk of soil Stalinization.<br>Conflicts among users. | |
| | | Groundwater abstraction, depletion and decrease in water quality. | High |
| Irrigation requirements | High in areas already vulnerable to water scarcity | Increased demand for irrigation.<br>Decreased yield of crops. | High |
| Changes in agricultural pests and diseases | Changes in distribution, introduction of new varieties. | Reduced water quality from increased use of pesticides.<br>Decreased yield and quality of crops.<br>Increased economic risk.<br>Loss of rural income. | Medium |
| Changes in soil fertility, salinity and erosion | High | Decrease in water quality from nutrient leaching.<br>Decreased crop yields.<br>Land abandonment.<br>Increased risk of desertification.<br>Loss of rural income. | High |
| Changes in crop productivity | Imbalances between regions | Decreased food security in areas with low economic | High |

| | | | |
|---|---|---|---|
| | | development.<br>Increased world food prices.<br>Increased agricultural trade. | |
| Changes in crop growth conditions | High for some crops and regions. | Pollution by nutrient leaching.<br>Loss of indigenous crop varieties.<br>Seed production and seedling recruitment. | High |
| Land use | Depends on region | Shift in optimal conditions for farming.<br>Deterioration of soils.<br>Loss of rural income.<br>Loss of cultural heritage.<br>Land abandonment.<br>Increased risk of desertification. | High |
| Changes in crop distribution | High for areas where current optimal farming systems are extensive. | Changes in crop and livestock production activities.<br>Relocation of farm processing industry.<br>Loss of rural income.<br>Economic imbalances.<br>Increased economic risk. | Medium |
| Increased expenditure in emergency and remediation actions | High for regions with low adaptation capacity | Loss of rural income.<br>Economic imbalances. | Medium |

| | | | |
|---|---|---|---|
| Biodiversity loss | High for vulnerable regions | Loss of natural adaptation options.<br>Modified interaction among species. | Medium |

iii. Effects of climate changes on main agricultural determinants and expected consequences for Mediterranean areas

Decreases in crop yields are forecast for this zone, together with greater yield variability. A significant reduction in water availability is predicted together with an increase in water demand, leading to potential conflict between users. Decreasing water resources are likely to damage soil structure while reduced soil drainage may lead to increased salinity. These changes are expected to reduce the diversity of Mediterranean species.

- Risk and opportunities for the Mediterranean South Zone:

General Circulation Model (GCMs), Regional Circulation Model (RCMs) and Empirical Downscaling (ED) climate outputs indicated for the Mediterranean basin a gradual increase of temperature and lower rainfall by the end of this century. Moreover, at a finer resolution (RCM), increased average temperatures were coupled to an increase in extreme events frequency and magnitude (heat waves and dry spell). [36]

A recent report undertaken on behalf of the European Commission evaluated the risks and opportunities for agricultural production in nine zones across Europe. This was done within a risk management framework looking at the risks and opportunities for the agricultural sector, the magnitude of the impact, the likelihood of the impact, and the priority given for investment and action. The challenge for the Southern Mediterranean zone (including Bullas) is stark with

[36] Source: "Impact of climate change on the phenology of typical mediterranean crops", Moriondo M. and Bindi M. Italian Journal of Agrometeorology

nine downside risks, but no upside opportunities identified. Seven of the risks identified are classified as high priority in terms of investment and action. It is clear that focus on the development and adoption of adaptation measures is required to ensure that agricultural systems remain resilient in the face of a changing climate.

*Table 26[37]. Risks and Opportunities for the Mediterranean South zone*

| Mediterranean South Zone | Detail of Risk/Opportunity | Magnitude | Likelihood | Priority |
|---|---|---|---|---|
| RISK | Crop area changes due to decrease in optimal farming conditions | HIGH | HIGH | HIGH |
| | Crop productivity decrease | LOW | HIGH | MEDIUM |
| | Increased risk of agricultural pests, diseases, and weeds | HIGH | MEDIUM | HIGH |
| | Crop quality decrease | MEDIUM | HIGH | HIGH |
| | Increased risk of drought and water scarcity | HIGH | HIGH | HIGH |
| | Increased irrigation requirements | HIGH | HIGH | HIGH |
| | Soil erosion, salinization, and desertification | HIGH | HIGH | HIGH |
| | Deterioration of conditions for livestock production | MEDIUM | MEDIUM | MEDIUM |
| | Sea level rise | HIGH | HIGH | HIGH |
| OPPORTUNITY | None | NONE | NONE | NONE |

This report analyses the main risks to agricultural production imposed by climate change. These include risks resulting from changes in:

- water resources and irrigation requirements;
- agricultural pests and diseases;
- soil fertility, salinity and erosion;
- crop growth conditions, crop productivity and in crop distribution;
- optimal conditions for livestock production;

[37] *Source: Iglesias, A. et al., 2007. Adaptation to Climate Change in the Agricultural Sector, AEA Energy & Environment, Didcot.*

- land use; and,
- increased expenditure in emergency and remediation actions.

**Climate change and wine production**

Wine grapes are particularly challenged not only by the expected increased incidence of extreme weather-related events (heat, drought, frost, wind, hail, bushfires) but also by the expected higher temperatures in the growing season that will bring forward the harvest date to a hotter month. The temperature rise in the critical harvest month for wine grapes may therefore be two or three times greater than the expected temperature rise in the current harvest month.

Grapevine phenology, quality and yield are very dependent on climate at a regional scale, a local scale (mesoclimate: altitude, slope aspect and nearness to water, wind) and a microclimate scale (influenced by vine spacing, reflectance of radiation from soil, and canopy management)[38]

While the industry is highly sensitive to the effects of climate change the complexities of the grape-growing and wine-making system, and the stages of production involved, also open up a wide range of options for adaptation, even then, options for adaptation at the vine, vineyard, winery and consumer levels need to be explored, and choosing the best ones will take time and require significant research and development expenditures[39].

- <u>Climate change general associated effect on grape and wine quality and production</u>

Temperature has the most influence on grapevines. The sensitivity occurs through three interrelated effects of temperature on the vegetative and reproductive growth:

- timing of key events in the annual cycle of growth and reproduction (*phenology)*

[38] *Gladstones, 2004.*
[39] *Kym Anderson et all, 2008*

- other reproductive effects
- photosynthesis, respiration and transport of assimilated carbon
- biochemistry and transport of flavor molecules and precursors in the berry.

The physiological and morphological differences between varieties (genotypes) enable wine grape production over a relatively large range of climates than otherwise would occur with a more restricted range of genotypes. However, there are many obstacles to establishing a new variety and obtaining consumer acceptance[40]. For each variety it is possible to define climates for premium wine production[41].

There are different kinds of impacts that can be classified as:

i. Direct impacts. The key direct effects of climate change include:
    - Higher temperatures across the growing season will bring forward the wine grape harvest date to a hotter month, so the warming effect of climate change will have a double impact in lowering the quality of wine grapes.
    - Differences in harvest dates between early and late-harvesting varieties will be compressed due to late varieties being more sensitive to warming than early varieties, which will strain the logistics of harvesting and winery intake.
    - That impact on the logistics of harvesting and winery intake will be compounded by greater volatility in future weather patterns.
    - Quality of grapes will suffer as a consequence and, despite higher potential yields, gross margins in most areas are expected to fall.

[40] *Rose, 2008*
[41] *Jones, 2008*

- Re-locating vineyards to cooler locations (to lower latitudes and higher altitudes) could help but overall there will be a reduction in suitable areas for growing quality wine grapes in Bullas.
- An increased frequency of extreme heat days and greater constraints on water supplies in the wake of more-frequent droughts will exacerbate the above trends.

ii. Indirect impacts:

- The water and nutrients derived from the soil by the vine, combined with the climate, can strongly influence the ratio of vegetative to reproductive growth (vine balance), and it is this that the viticulturist is largely trying to manage to achieve the optimum for fruit quality and yield[42] .
- Pest and disease pressure is likely to increase and also shift to new areas further south with warmer winters and warmer night temperatures.
- There is an increased risk of phylloxera spread based on the increased rate of emergence of the insect from the soil with warming, and making the spread of the insect more probable[43].

iii. Winery level impacts: The major impact to wine quality and production with change in climate will be largely the result of impacts on the grapevine. Winemaking in theory may be undertaken in a variety of climates without a significant impact on the resulting wine, though costs may differ across climates related to refrigeration and requirements. There are adjustments required in the wine making process that result from the particular climate from which grapes are sourced. One notable example of this is the addition of tartaric acid to address the imbalance of acidity caused by warm/hot

[42] *Dry et al. 2005*
[43] *Dr Kevin Powell, DPI Victoria, Pers. Com.*

climates that decrease acidity in grapes. Another aspect is the difficulty of fermentation to dryness with high sugar concentrations.[44]

## CURRENT AND POTENTIAL IMPACTS

The role of climate change on current impacts is not always evident, but it is always present, from water scarcity, soil erosion to soil fertility loss, etc. Climate changes add up during a long time until human beings realize them.

### 1. Water scarcity

In order to assess current and potential impacts affecting Bullas agriculture due to water availability, the Water Exploitation Index is used.

The water exploitation index (WEI[45]) is the mean annual total abstraction of freshwater divided by the mean annual total renewable freshwater resource at the country level, expressed in percentage terms.

Monitoring the efficiency of water use by different economic sectors is important for ensuring that rates of extraction are sustainable over the long term. As a consequence, water abstraction as a percentage of the freshwater resource provides a good picture, at the national level, of the pressures on resources in a simple manner that is easy to understand, and shows trends over time. The indicator shows how total water abstraction puts pressure on water resources by identifying countries with high abstraction in relation to resources and therefore prone to water stress. Changes in the WEI help to analyze how changes in abstraction impact on freshwater resources by increasing pressure on them or making them more sustainable.

It isn't available the WEI for Bullas. Nevertheless, we can use as a reference that index at a country level as is showed in the figure.

[44] *Kym Anderson et all, 2008*

[45] Water exploitation index - WEI (%); water abstraction for irrigation, public water supply, manufacturing industry and energy cooling (mio. $m^3$ per year).

That figure shows the annual total water abstraction as percentage of available long-term freshwater resources around 1990 (WEI-90) compared to latest year available (1998-2007) (WEI-Latest year), meaning water removed from any fresh water source, either permanently or temporarily. Mine water and drainage water as well as water abstractions from precipitation are included, whereas water used for hydroelectricity generation (in situ use) is excluded.

The warning threshold for the water exploitation index (WEI), which distinguishes a non-stressed from a stressed region, is around 20 %[46]. Severe water stress can occur where the WEI exceeds 40 %, indicating unsustainable water use.

In Europe there are five countries that can be considered water-stressed based on the Eurostat data available for the period 1998-2007 (Cyprus, Belgium, Spain, Italy and Malta), representing about 19.5% of Europe's population. Based on the 2007 available data Cyprus (64%) and Belgium (32%) have the highest WEI. However, it is necessary to take into account the high water abstraction for non-consumptive uses (cooling water) in Belgium which results in its high WEI. Most of the water abstracted in the remaining three water-stressed countries (Spain, Italy and Malta) is for consumptive uses (especially irrigation) and there is therefore higher pressure on water resources in these three countries.

The WEI decreased in 24 countries over the last 10-17 years, representing a decrease about 12 % in total water abstraction. Most of the decrease occurred in the eastern countries, as a result of the decline in abstraction in most economic sectors. This trend was the result of institutional and economic changes. However, five countries (The Netherlands, Greece, Finland, Slovenia and Turkey) increased their WEI during the period 1990 to 2007 because of the increase in total water abstraction. The WEI has also increased in Cyprus from 1998 to 2007 (lack of data do not allow comparison to the pre-1998 period). It should be noted that since WEI is calculated on a country level basis, spatial variability can not be depicted and a low WEI in one part of a country can leverage a high WEI in another part. For

[46] *Raskin et al. 1997*

example, Pinios RBD in Greece is severely water stressed, nevertheless this is evened out at the country level WEI. Similarly the regional WEI in Portugal is extremely variable per river basin (Sado RB 132%, Leca RB 82%, Minho RB 1%, Lima RB 5%) but at country level is averaged at 15%[47].

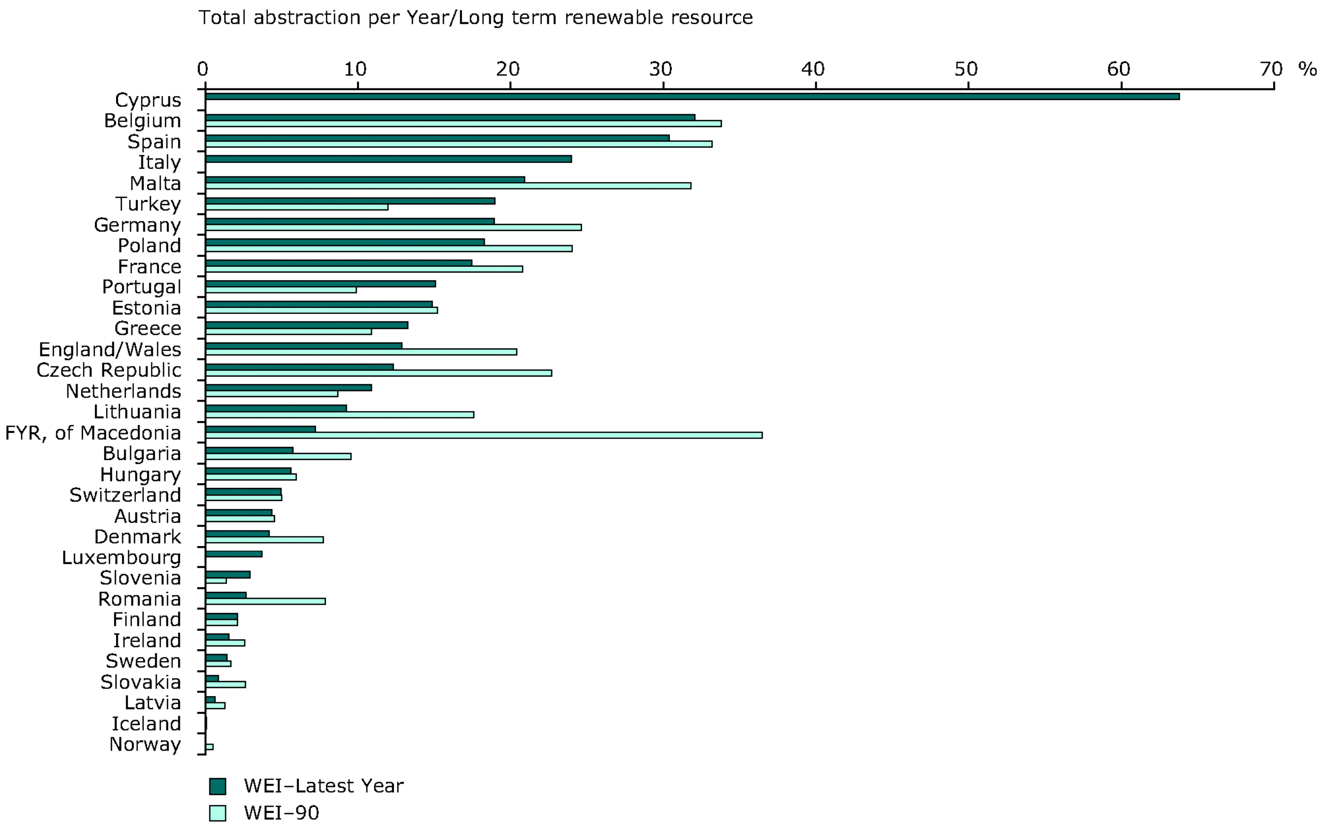



*Figure 61. Water Exploitation Index*

Consequently, and as far as water scarcity is concerned we can infer that although from 1990 the Spanish stress is being reduced, Bullas is situated in a high stressed area.

## 2. Damage caused by a natural disaster

There are no knows important damages caused by a natural disaster in Bullas, apart from fire forest, that's why it is not consider among current impacts.

[47] *European Environment Agency*

Torrential rains can cause land movements and such, but those are too far less infrequent to take in consideration, and fire forest are mostly fueled by arsonists, therefore can't be pinpointed to climate change.

### 3. Soil erosion risk

To evaluate the soil erosion risk in Bullas, firstly, a qualitative approach is being considered using the CORINE soil erosion risk model that involves the computation of four separate indices, which are then combined to give an assessment of erosion risk. This first graph shows a qualitative approach to the soil erosion risk[48] in Spain:

[48] Source : http://139.191.1.96/ESDB_Archive/pesera/pesera_cd/pdf/ereurnew2.pdf

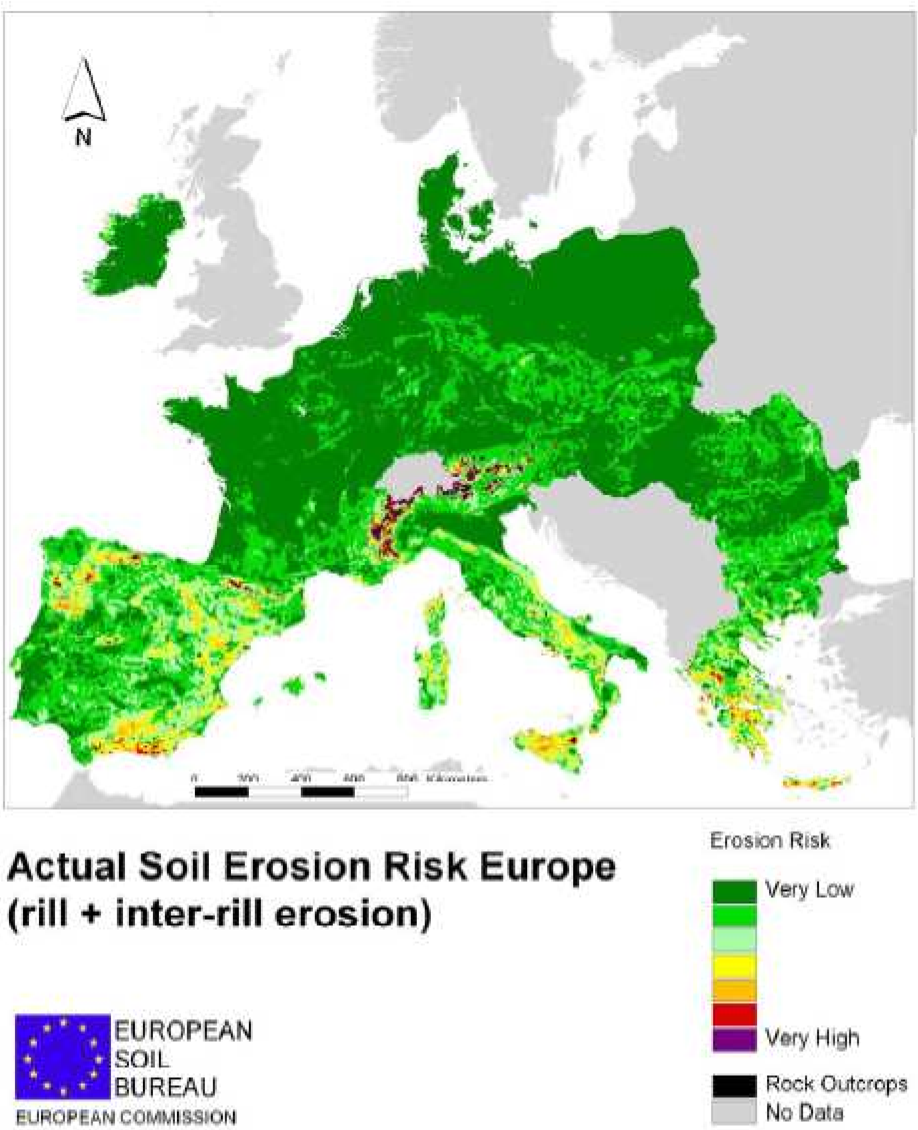



*Figure 62. CORINE Soil Erosion Risk I*

If we focus in greater detail in the Region of Murcia in Spain (red circle) it shows that the soil erosion risk calculated with the CORINE model is medium.

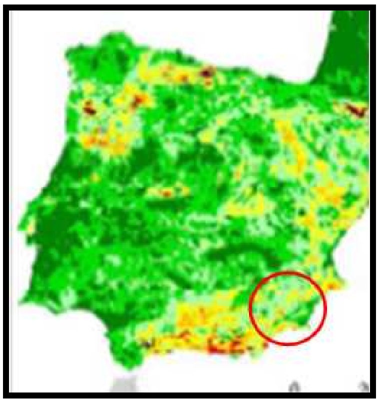


*Figure 63. CORINE Soil Erosion Risk II*

Secondly, a quantitative approach to soil erosion risk in the Region of Murcia is developed.

In the Region of Murcia[49], both natural and anthropogenic factors are favourable to produce important soil loss rates and in some cases, severe loss rates. For more than a century, with increasing population and the processes of land degradation, the problem started acquiring alarming dimensions, accentuated in the last thirty years. Water erosion and desertification are among the most frequent and serious causes of land degradation in Murcia and in many agricultural and forest areas; it is the main agricultural and environmental problem.

Table *27*[50]. Soil erosion by watershed and archipelago in Spain

| Territory | Average loss | Thickness loss | Total loss |
|---|---|---|---|
| | t/ha/year | mm/year | thousands t/year |
| North | 14,14 | 1,11 | 77.346 |
| Duero | 10,61 | 0,82 | 83.174 |
| Tajo | 21,11 | 1,62 | 117.717 |

[49] *Source: Atlas Global de la Región de Murcia*
[50] *Source : Atlas Global de la Región de Murcia*

| | | | |
|---|---|---|---|
| Guadiana | 18,96 | 1,46 | 113.978 |
| Guadalquivir | 44,63 | 3,43 | 255.565 |
| South (C. Guadalquivir) | 32,5 | 2,5 | 17.912 |
| South | 47,76 | 3,67 | 89.591 |
| Segura | 24,53 | 1,89 | 45.949 |
| Júcar | 28,8 | 2,22 | 121.941 |
| Ebro | 28,17 | 2,17 | 238.971 |
| East Pyrenees | 23,44 | 1,8 | 38.147 |
| Baleary Islands | 16,2 | 1,25 | 8.049 |
| Canary Islands | 19,37 | 1,49 | 14.422 |
| TOTAL | 24,26 | 1,87 | 122.276 |

In the Region of Murcia is recognized that soil erosion and loss of tolerance to part of it depends on various factors such as soil thickness and surface organic horizon, its physical properties, the volume and intensity of rainfall, the development of root systems of vegetation, fragility or soil condition after a long history of use and impacts caused by humans.

From the set of processes that can cause soil degradation, water erosion is most noted for his ability to remove and transport of soil, especially in Mediterranean environments. It represents one of the most complete degradation and deterioration which comprises the physical, chemical and biological[51].

The average erosion soil loss in the entire Spanish territory, is estimated at 24.26 t/ha/year, equivalent to 1.87 mm per year what means a removal of soil that can be classified as moderate (values between 12 and 25 t/ha/year). Bullas belongs to Segura basin -inserted in the territory of the Region of Murcia- which registers soil

[51] *Bib-Eron, 2000; Colomer and Sánchez Díaz, 2001; Boix-Fayos, 2005*

erosion that is located on the doorstep of the Spanish average 24.53 t/ha/year, equivalent to a lowering of about 2 mm per year, classified as high moderate.

These average estimates values, hidden fees that go well beyond, especially in those areas most vulnerable to erosion as are the territories constituted basically by soft materials (clay and loam) where gullies has become mainstream. These spaces are identified areas with high values (50-100 t / ha / year), very high (100-200 t / ha / year) and, exceptionally, extreme (more than 200 t / ha / year).

For all the territory of Murcia, erosion rates are highest in the bare land, consisting of soft and devoid of vegetation, scattered basins of Mula, Abanilla-Fortuna, Guadalentín, Quípar and large avenues (Judío, Moro, Cárcavo, Salada, Algeciras, Moreras, etc.). There are also important in rain-fed tree crops (olives and almonds) on hillsides with steep slopes and vineyards in the same situation. In these crops, planting under large, steep slopes, the action of heavy rainfall and tillage system in the direction of the slope, is due to a laminar erosion and major spills.

From this last information we can infer that Bullas is a place with a high erosion rates due to its agriculture being mainly rain-fed, which is according to the following map showing desertification situations in the Region of Murcia.

The risk and main situations of desertification in the region of Murcia, and in particular in Bullas (black line) are the following:

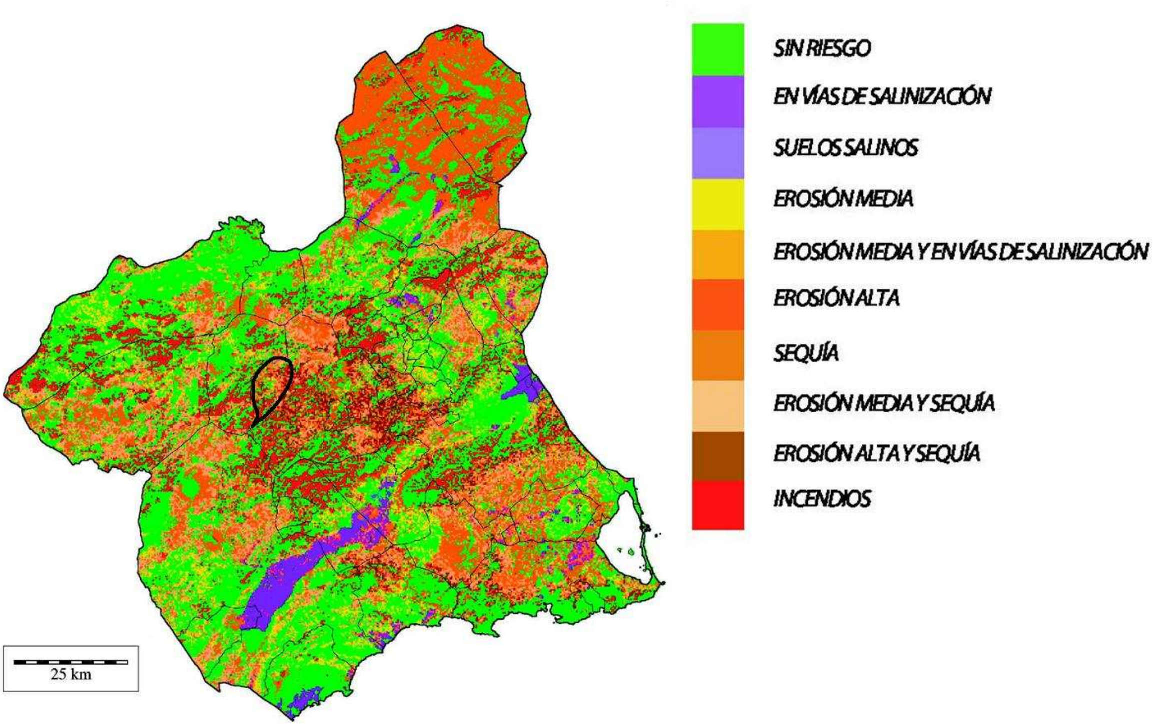



*Figure 64. Region of Murcia's risk and main situations of desertification. Green label: low risk; red label: high risk.*

This figure shows that Bullas is in a medium-high erosion risk area with forecast drought problems.

On the other hand, desertification expresses the result of the combination of geographical, climatic and socio-economic, and human ways of using natural resources, especially for agricultural and rural development. The causes that triggers and control factors are numerous and some of them may change depending on the scale, so it can be different answers depending on the time and space scales are considered[52].

Next figure represents the areas threatened by desertification in the Region of Murcia:

[52] *López Bermúdez, 1996, 2002*

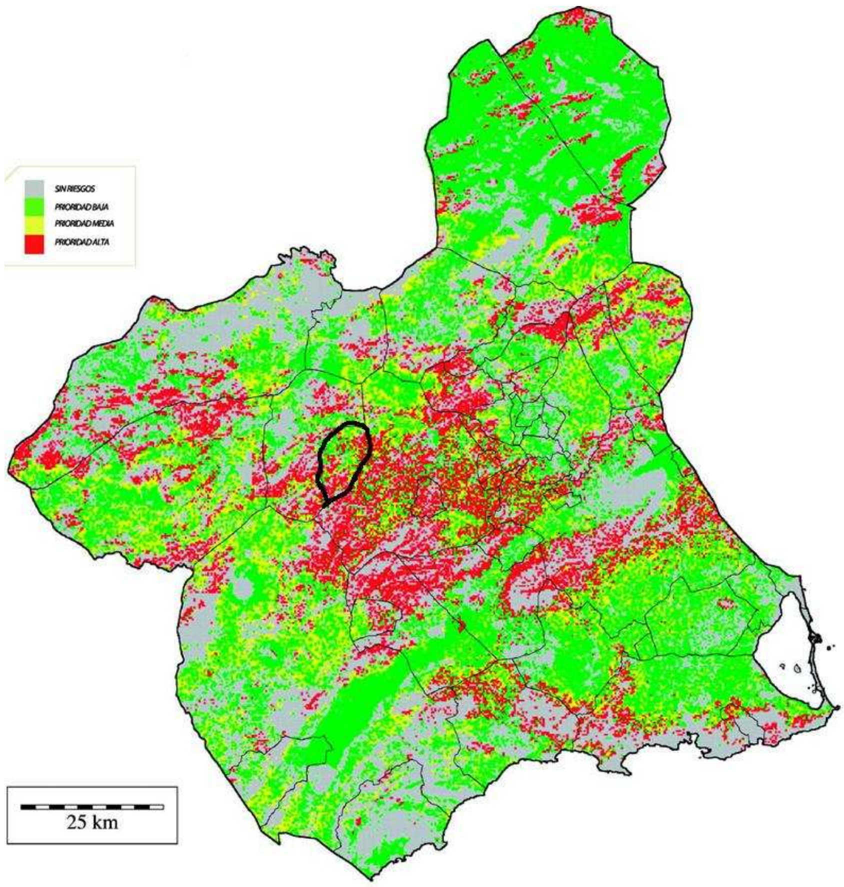



*Figure 65. Region of Murcia's priority desertification land*

In this figure, Bullas appears as a high priority desertification land, in its majority with also some medium priority lands. Regarding to risk of desertification, next table shows the high priority areas in Spain.

*Table 28. Areas at risk of desertification and high priority action*[53]

| Region (%) | Area at risk (has) | (%) | High priority (has) | (%) |
|---|---|---|---|---|
| Northeast | 117.764 | 49,5 | 33.746 | 14,2 |
| Vega media | 60.659 | 56,4 | 16.041 | 14,9 |
| Altiplano | 112.132 | 71,3 | 10.206 | 6,5 |
| Abanilla-Fortuna | 25.716 | 66,8 | 6.238 | 16,2 |
| Suroccidental | 120.290 | 50,4 | 15.258 | 6,4 |
| Mula | 40.863 | 60,2 | 27.075 | 39,9 |
| Bajo Guadalentin | 41.727 | 58,9 | 16.880 | 23,8 |
| Campo de Cartagena-Mar Menor | 69.946 | 60,2 | 10.030 | 8,6 |
| Murcia | 59.039 | 62,5 | 18.911 | 20 |

As it is show in the table above, Bullas municipality that it is included in the Northeast part of the Region of Murcia presents lower percentages of areas at risk of desertification and high priority action, than the average of Murcia region, been more or less in the middle of all parts of the region in risk percentage.

**4. Soil fertility loss**

Soil[54] health is critically important to sustainable agricultural productivity and environmental wellbeing. Healthy Soils provide a range of environmental services including water infiltration, habitat provision and profitable and sustainable agriculture.

Measures of soil organic matter help assess fertility and structure. Soil fertility loss can be evaluated as soil organic matter change over a period of time. Many soil

[53] *Source : INUAMA, 2000.*
[54] *Source: http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil_health_tools_1*

properties impact soil quality, but organic matter deserves special attention because it affects several critical soil functions that can be manipulated by land management practices, and it is important in most agricultural settings. Because organic matter enhances water and nutrient holding capacity and improves soil structure, managing for soil carbon can enhance productivity and environmental quality, and can reduce the severity and costs of natural phenomena, such as drought, flood, and disease. In addition, increasing soil organic matter levels can reduce atmospheric $CO_2$ levels that contribute to climate change.

The following map establishes the clay, slime and organic matter share in soil:

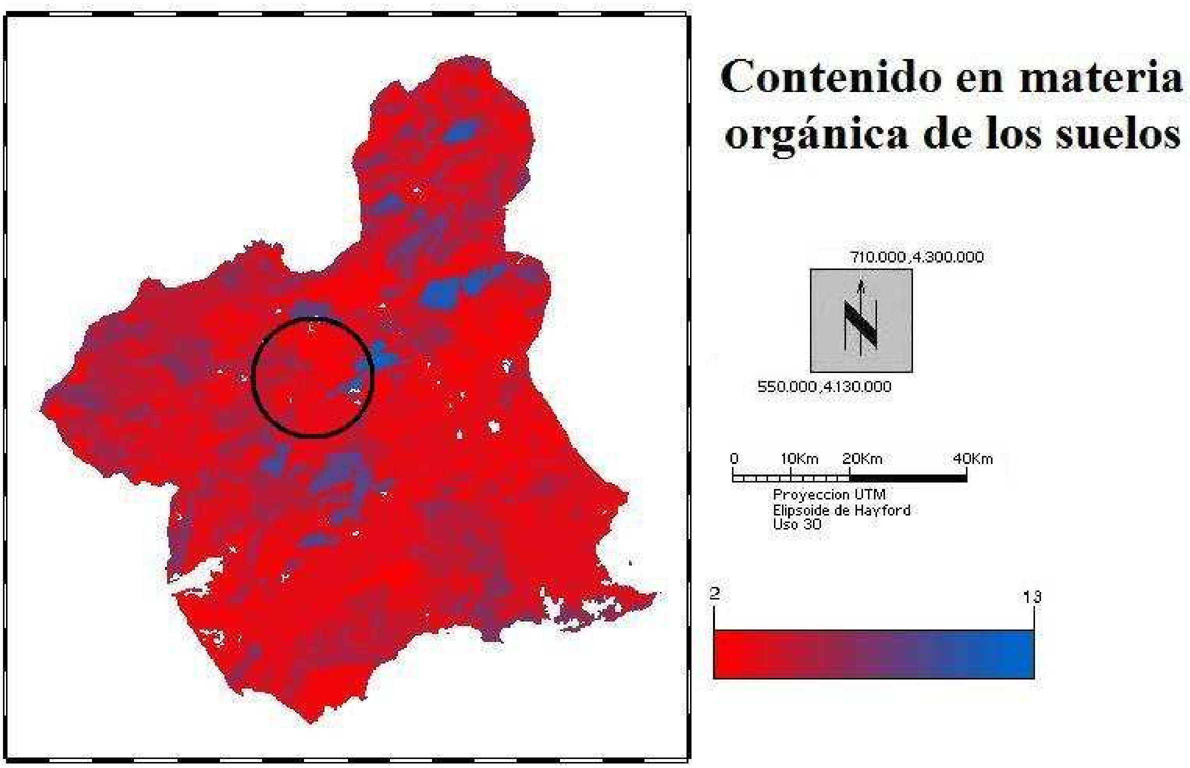



*Figure 66[55]. Organic matter in soil*

The study carried out by Murcia regional government and Murcia University, that produced respectively the Atlas of the Region of Murcia and the Hipatia project,

[55] *Source: Hipatia project. University of Murcia*

concludes that organic matter content in Bullas soil is currently pretty low, which involves high soil fertility loss, since soil fertility has a high dependence of organic matter content.

**5. Increased weed and pest**

On the one hand, Regional Ministry of Agriculture emphasizes the contribution of organic farming to the maintenance of biodiversity and erosion control, with Bullas being a top municipality amongst the region of Murcia in biological agriculture, since Bullas wine farmers reduced 80 % the use of pests in the last few years, and it is one of the appealing of this wine.

On the other hand, is the "Clean Agriculture Program" that has created the Regional Ministry of Agriculture and Water in the Region of Murcia to find alternative phytosanitary low or no impact on the environment and the consumer for major crop pests most significant of agriculture in Murcia. This innovative program is based on the use of biological control methods and biotechnology, with a systematic and progressive reduction of fertilizers and pesticides.

Biological agriculture in Bullas involves the 13 % of total farming. The distribution of organic farming in Bullas is:

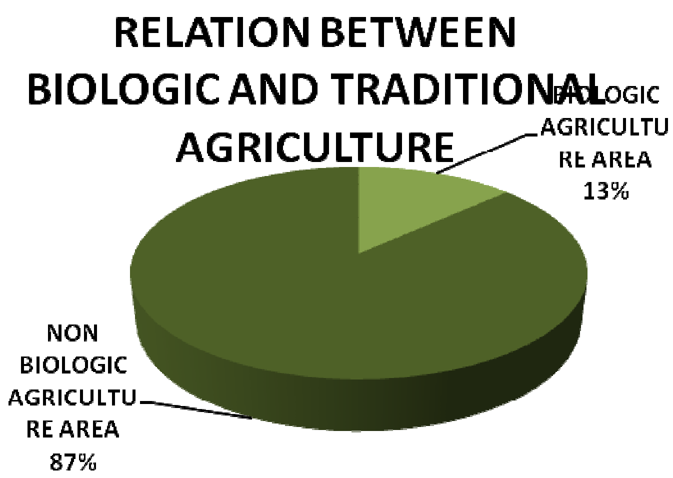



*Figure 67. Relation between organic and traditional agriculture*

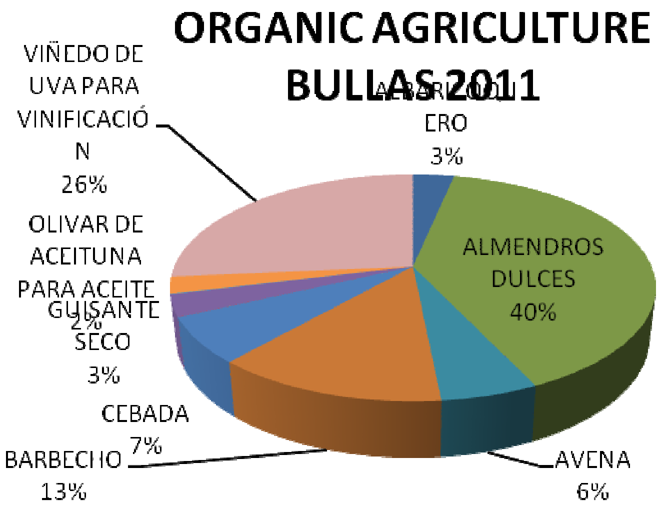



*Figure 68. Organic agriculture in Bullas*

## 6. Wine phenology

Plant phenology is largely temperature dependent; there is an overall trend for earlier occurrence of key phenological events, and consequent shortening of crop growing cycle for winter and summer annual crops, grapevine and olive tree[56]. Higher temperatures tends to an advancing bud-break phase which shift to an earlier post bud break development, but since that occurs in relatively cooler conditions, it can cancel out the increasing temperature trend. If this trend it's cancelled or not depends on grape variety.

Consistent with the increasing temperatures, crop development is expected to be faster, thus phenological stages will be reached early and the length of the growth period of crops with determinate cycle (i.e. cereals, grapevine, etc.) will be shorter[57].

[56] *Moriondo and Bind, 2007*
[57] *Moriondo and Bind, 2007*

We were able to gather information regarding phenological stages with help from the Regulating Council of the 'Bullas' Origin Denomination.

*Table 29. Vineyards' Phenological stages (Bullas D.O)*

| | JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE |
|---|---|---|---|---|---|---|
| 2004 | | | | | | |
| 2005 | | | B1 B2 C | C D | J L | |
| 2006 | | | | | | |
| 2007 | | | B1 | B2 | D E F G J | |
| 2008 | | | | B2 B2 C D E FG | | |
| 2009 | | | B1 B2 | CDEFG | | I J |
| 2010 | | | B1 | B1 B2 C E F | | I1 I2 J |
| | **JULY** | **AUGUST** | **SEPTEMBER** | **OCTOBER** | **NOVEMBER** | **DECEMBER** |
| 2004 | | | | | | O2 |
| 2005 | | M2 | N | N | | |
| 2006 | | | | | | |
| 2007 | | | N | N | | |
| 2008 | M1 | | N | N | O2 | |
| 2009 | M1 M1 | | | N N | | |
| 2010 | M1 | | N | N | | |

| GRAPEVINE | |
|---|---|
| **DOMINANT STATES** | |
| **A** | Sleeping leaf bud |
| **B1** | Bleeding |
| **B2** | Swollen leaf bud |
| **C** | Green tip |
| **D** | Budding leaves |
| **E** | Open leaves |
| **F** | Visible clusters |
| **G** | Separated clusters |
| **H** | Separated flower buds |
| **I1** | Star of flowering (5% open flowers) |
| **I2** | Flowering |
| **J** | Fall of flower caps |
| **K** | Small grain |
| **L** | Closed clusters |
| **M1** | Start of veraison (5%) |
| **M2** | Veraison |
| **N** | Rippening |
| **O1** | Start of fall of leaves (5% falls) |
| **O2** | Full fall of leaves |

Therefore, from these data and from the information provided from the Regulating Council of the 'Bullas' Origin Denomination, the main conclusion inferred is that the grape wine harvest is brought forward, and harvest starts now in earlier months than some decades ago (increase of ripening frequency in September).

Long ago, harvest began after the feast of Bullas (first October weekend). Currently, it usually starts in September due to shortening ripening process of some grape varieties caused by higher temperatures. It must be taken into account that formerly nearly 100% of wine grape was from Monastrell variety, while now there are also white varieties and Tempranillo which are early varieties. But also, changes in harvest months are due to an earlier growing that is caused by an increase in temperature. A higher temperature makes an earlier development.

There are 14 wine grape varieties well adapted to Bullas clime and soil type. Monastrell being the most important one:

**MONASTRELL**

It is the main variety of the Denomination of Origin Bullas. According to its rules, all red and rosé wines must contain at least 60% of this variety.

Synonyms: Alcayata, Garrut, Gayata, Mandó, Mataró, Monastrell, Mourvèdre, Murviedro.

It is considered the native variety of Spanish Mediterranean area. Majority in the wine areas of Murcia, Alicante and south of Albacete. It is grown throughout the Spanish Mediterranean, from Catalonia to Granada and in southeastern France.

Very tough plant that holds up well to drought and frost. In this area, does not usually have disease problems, and its cultivation can be considered almost organic, since no pesticide treatments are usually given only sulfur to prevent fungal diseases. Sensitive to powdery mildew and mildew.

The clusters are large and dense. The grapes are small, round and thick skin.

Its full potential is obtained wine grapes harvested ripe. It gives wines with high alcohol content, not too acidic, tannic, intense color and very aromatic. Suitable for aging.

Regarding Monastrell variety, harvest begins mid-September in the lower altitudes, and it is gradually spread, rising in altitude from 500 to 900-1000 meters.

Not all the grape is gather with the same maturity degree. Formerly, they were wines that could easily reach 15 to 16 degrees of alcohol, while currently; the market demands lower-ranking wines.

Even so, it depends on the temperature and rainfall in the last stages of the wine grape maturity.

Nevertheless, the weather from July the 15th is extremely important –heat waves, storms in august, its intensity and periodicity-, although intensity of rain and dry and windy days among this rainfalls in September, allow the wine grape to get dry and to go on maturating by contrast, with humid days the wine grape can decay.

It is not easy to establish maturity rules, for this reason each vine-grower may choose its priorities between quality or complete maturity.

These days, some wineries has forward the harvest despite the wine grape is not complete mature, because suffering losses higher than the 20% of their production some years before.

## 7. Wine quality

Next table shows the tasting qualification of D.O. Bullas wine from 1995. This is the scale used for assessing the tasting in wines from the Denomination of Origin Bullas. Tasting wines excising 48 points are removed, and can not be bottled as Denomination of Origin Bullas. The rating is based on the vintage wines that have actually made the cut grade and have been bottled as Denomination of Origin Bullas.

To certify this wine quality requires an evaluation of the vintages of the Denomination of Origin Bullas by checking the general data of the wines that have been certified, taking into account the chemical analytical performed on all samples of wines bottled as Denomination of Origin Bullas and from tastings in the Regulatory Board for certification of these wines (organoleptic analysis).

Wine quality strongly depends on climatic conditions, especially those that occur just in the weeks previous to the harvest, because strong rains produces changes in acidity, alcohol amount, pH, etc. Since wine quality depends on such wide compound of variables and unpredicted situations, the very good quality showed in Denomination of Origin Bullas' wines in the last years can be a cause of climatic variability occurred in those years. But those variable conditions can cause a reverse effect in the quality too, as it is shows in 2003, when there was a heat wave that surprised farmers which were not able to recollect all grapes in time to avoid higher sugar levels.

*Table 30. Vintage rating of the Denomination of Origin Bullas Council.*

| YEAR | QUALIFICATION |
|---|---|
| 1995 | VERY GOOD |
| 1996 | GOOD |
| 1997 | VERY GOOD |
| 1998 | EXCELLENT |
| 1999 | VERY GOOD |
| 2000 | VERY GOOD |
| 2001 | GOOD |
| 2002 | GOOD |
| 2003 | GOOD |
| 2004 | VERY GOOD |
| 2005 | VERY GOOD |
| 2006 | VERY GOOD |
| 2007 | VERY GOOD |
| 2008 | VERY GOOD |
| 2009 | VERY GOOD |

**Score:**

Excellent: 0-7 points

Very good: 8-23 points

Good: 24-44 points

Correct: 45-62 points

Fair: 63-78 points

Defective: 79-90 points

Evaluation of the vintages of the Denomination of Origin Bullas by checking the general data of the wines that have been certified, taking into account the chemical analytical performed on all samples of wines bottled as Denomination of Origin Bullas and from tastings in the Regulatory Board for certification of these wines (organoleptic analysis).

WINES OF THE VINTAGE 1998:

Of the few samples you have, is considered the best vintage wines of the D.O. Bullas. It was a warm and a dry year, but the wines obtained, kept fresh aromas of grape varieties. Excellent wines.

WINES OF THE VINTAGE 1999, 2000 and 2001

These years were also generally good, although the wine samples obtained were very small. Perhaps the year 2000 was the best of the three.

WINES OF THE VINTAGE 2002:

Alcohol high. Low total acidity. Correct pH. Tasting of the wines was good. Pleasant. Compensated. Good vintage.

WINES OF THE VINTAGE 2003:

Alcohol appropriate. Correct total acidity. Good pH. Tasting of wines, very good. Pleasant. Compensated. Wines were very healthy, with very low volatile acidity. Great features in terms of aromas and flavors. Quite high color intensity. Very good vintage.

WINES OF THE VINTAGE 2004:

Alcohol content of wines produced at the beginning of the harvest (white, early areas), low in general. High total acidity, low pH. Wine cooler.

As the harvest progresses, the grapes harvested are increasing grade, and finally, the wines made (pink and red wines in general) have a fairly high alcohol level, higher than the average of other years, total acidity is low, and pH is high. Tasting of the wines was good. Year of warm wine.

After aging, the wines are quality wines obtained.

WINES OF THE VINTAGE 2005:

The white and pink wines, with regular features, not overly fruity. Matures. Not very cool in general.

Regarding the red wine, alcoholic high acidity and pH normal. With great extract color. Bodied wines. Warm. Ripe fruit, soft tannins (well matured grapes). Grapes late, great quality. Retain some acidity. A vintage with very good fitness for long aging. Year of cool wines.

Tasting wines of this vintage once aged in wood, high quality wines.

It provides great durability over time of these wines.

WINES OF THE VINTAGE 2006:

The white and rose wines, whose grapes are harvested first, with few flavors are generally warm wine, present lack of freshness and the color pink are uploaded. More alcohol than in other years.

The red wines have an alcoholic high (not excessively), and a low total acidity and high pH in general. A layer of very high color, ripe, fleshy black fruit aromas, stewed fruit, prunes, also vegetables, wine, spicy, burning, astringent, harsh, even to the nuances present liqueur. Something in drying aftertaste. Low aromatic intensity. Very warm wines.

WINES OF THE VINTAGE 2007:

In whites, alcohol normal. Wines fresh, fruity. Very low volatile acidity. Wines very healthy.

In red wines, alcohol content of normal to low. High total acidity in the early harvest. High overall total acidity. Volatile acidity higher than other years.

Little color coat. IPT low. Fruit aromas. Soft wines. Wines with vegetal undertones. Somewhat astringent. Spicy. Trend of reduced wine. On the palate, full bodied, broad.

Good scores in tasting.

WINES OF THE VINTAGE 2008:

The white and rosé wines, with grapes harvested early in the campaign are very correct wine with high alcohol level, ripe grapes, total acidity and pH suitable generally low. High color intensity. Quality wines. As harvest progresses, the rains begin, leading to delay the harvest of red varieties, time after time. The acidity of the grapes is dropping, the sugar is diluted and the alcohol does not rise, maturing not ending well. Eventually, a small percentage of the harvest, collected at baseline, before the start of the rains are good quality wines. The rest, wines with low alcohol content, low color intensity, low acidity, dilution. You lose more than 20% of the grape harvest expected due to rotting, and the rest, a lot should be allocated to table wine, the low quality of wine produced. High volatile acidity.

It is a campaign of pure formality. Several lines of wines, the highest quality, usually made of plots cultivated at higher altitudes, and therefore later, can not be processed because the harvest is lost.

There are few wines designated to wood aging. Only wines harvested initially with an alcoholic high.

WINES OF THE VINTAGE 2009:

Grapes from high alcohol content have a harvest start of 10 days ahead of the original date. The total acidity of white and pink is not very high, is rather low, however, the pH is fine, is not very high. The alcohol content of white and pink is higher than normal (white exceeding 12 º A, and even 13). Pink with major graduations at 13 ° A. Wine healthy, low volatile acidity, but have low intensity and low aromatic freshness. Something green. The grape has been as high alcohol content, but not fully mature (seeds), which makes the wines somewhat hard in the mouth.

In red, low acidity, high pH. Some drying in the mouth. Alcoholic high in general. High color intensity, high IPT. Wines something green, hard. Drying tannins.

Once started the harvest, the rains appear and with them the fear of losing part of the harvest in the previous year. Some wineries expect the grapes ripen, and the rain spoil the grapes. Other wineries, with the lesson learned last year, trying to pick grapes with low-grade but not to lose the crop.

There is a 20% lose of the expected harvest due to rot caused by rains at harvest time.

WINES OF THE VINTAGE 2010:

With the impending rain forecast in the harvest begins, wineries try to advance the grape harvest. Some wineries have made some changes in the culture, to try to avoid loss of quality in the grape if it rains during harvest. For example, leave grass between the streets of the vineyard, to absorb the rainfall during the harvest, and is not taken by the vines and thin components (acids, sugars ...) and not be delayed ripening by these storms are becoming more frequent and abundant.

Other wineries do not wait for the grapes to reach maturity and collect the grape phenolic although the seeds are not totally ripped.

Throughout the harvest weather forecasts point to storms, but in the end, the skies remained overcast much of the time, but the rains are very scarce. In the end, the grapes are collected earlier than in other years, ending in general before the harvest.

The resulting wines are lighter in general, less alcoholic, but healthy.

The white and rose wines have an alcoholic high, however, the total acidity is high and low pH. These wines are compensated nice. The volatile acidity is low. Wines very polite and pleasant to drink, aromatic, fresh, fruity.

Red wines are quality ones, wines with good alcohol content, but not excessive, maintaining a good total acidity, a proper pH and low volatile acidity. Wine, usually with a good aptitude for aging and preserving aromas of the grape (fruit and flowers as well). It is a very good year, but time will tell.

## 4.2.1 Exposure

### 4.2.1.1 BIOPHYSICAL INDICATORS

1. **Soil and climate (agrometeorology indicators)**

**Air temperature**

In general, the next graphs show that temperature in Bullas is likely to increase, not only the mean annual temperature, but also the coldest and hottest months (Graphics done using climatic data from Bullas Meteorological stations).

- Mean annual air temperature (ºC):

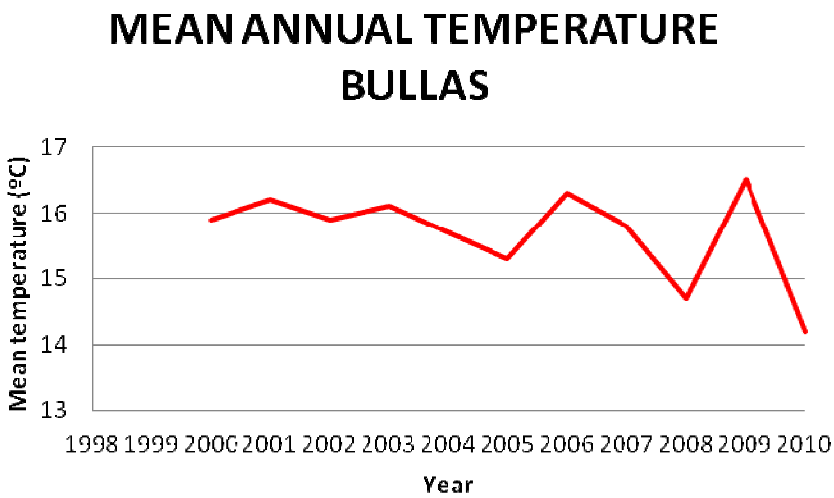



*Figure 69. Mean annual temperature in Bullas*

- Projections from Regional Climate Models (RCM) and Global Climate Models (GCM)[58]:

The three RCMs estimate a rise of the mean air temperature at the end of the century between 3.7 °C (SMHIRCA) and 4.0 °C (RM5.1 and RACM02). The most intense warming is in summer (between 4.9 °C and 5.6 °C), the least intense in spring (between 2.0 °C and 3.3 °C). For the A1B scenario, the INGV estimate a

[58] Source: Spanish Agency of Metheorology (Aemet) and "Climate trends and projections" ISPRA 2010.

warming at the end of the century equal to 2.8 °C, while the CNRM estimate is 3.8 °C. The warming predicted by GCMs in the A1B scenario is lower than that predicted by RCMs. In the A2 scenario, the GCMs predict a warming between 3.8 °C and 4.8 °C, while in the B1l scenario the CNRM estimate is 2.5 °C. This means that the uncertainty due to the two opposite scenarios (i.e. A2 and B1) is something around 2.0 °C. This uncertainty is likely to be wider when more GCMs are considered.

With regards to the GCMs projections, the maximum increase for the mean temperature (6.5 °C) is predicted by the CNRM model in the A2 scenario, while the minimum increase (1.6 °C) is predicted by the INGV model in the A1B scenario.

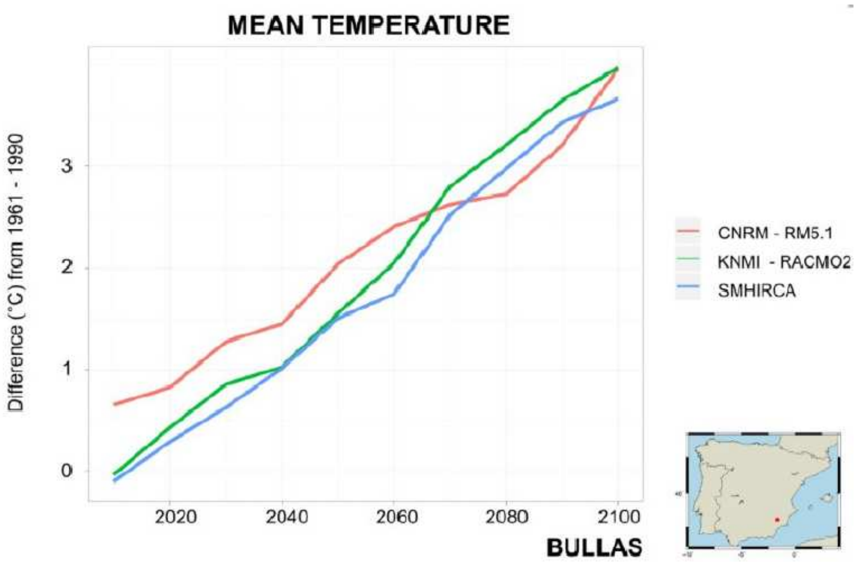



*Figure 70. Annual mean temperature variation predicted by RCMs (ºC)*

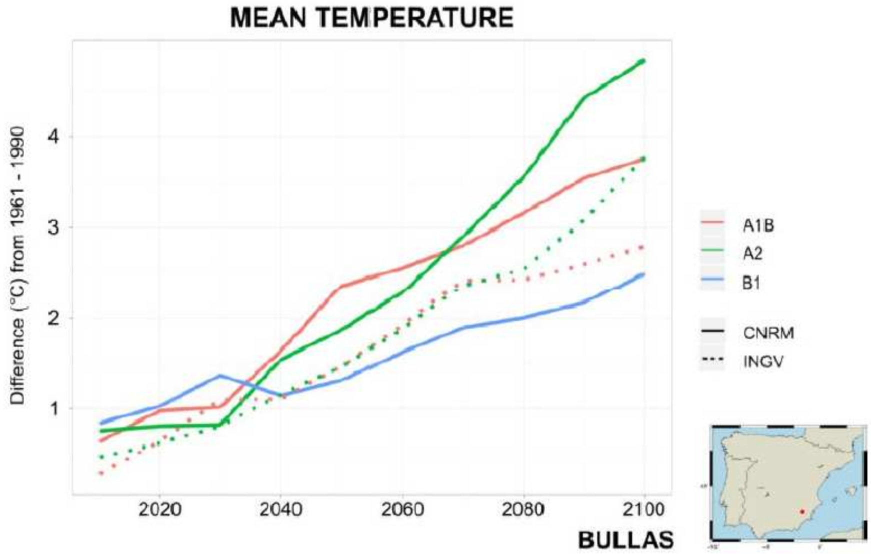



*Figure 71. Annual mean temperature variation predicted by GCMs (ºC)*

- Annual mean of maximum air temperatures (ºC):

*Table 31. Annual mean of maximum air temperatures (ºC). Year 2010*

| Year | 2010 |
|---|---|
| Annual mean of maximum air temperatures (ºC) | 21,02 |

- Projections from Regional Climate Models (RCM)[59] :

[59] Source: Spanish Agency of Metheorology (Aemet) and "Climate trends and projections" ISPRA 2010.

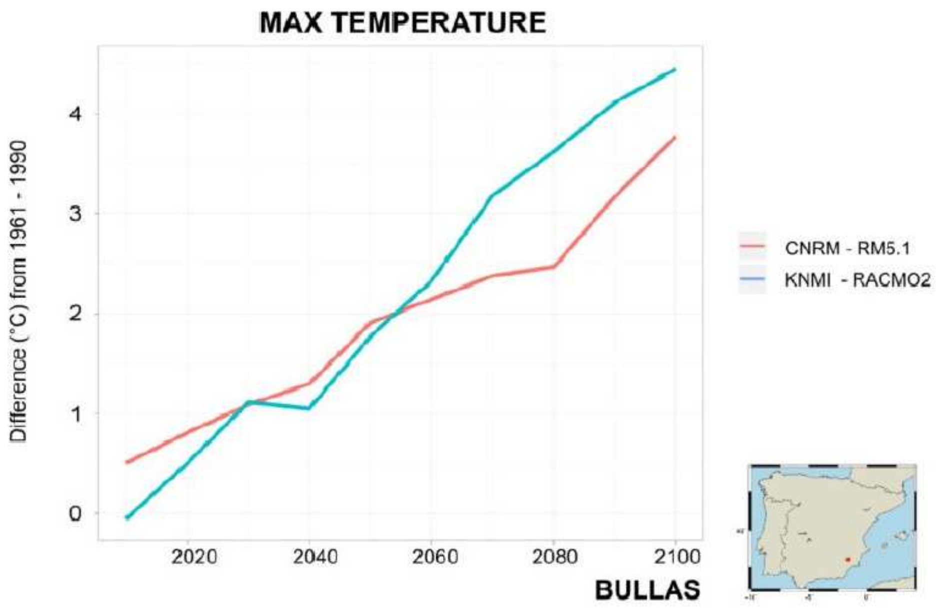



*Figure 72. Annual maximum temperature variation predicted by RCMs (ºC)*

- Mean air temperature of the coldest month (ºC):

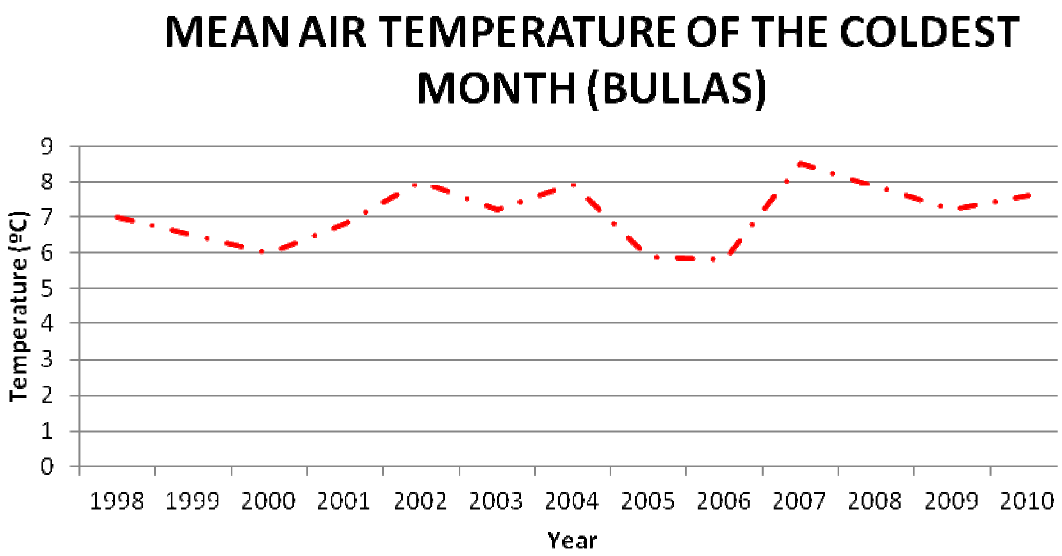



*Figure 73. Mean air temperature of the coldes month*

◈ Mean air temperature of the hottest month (ºC):

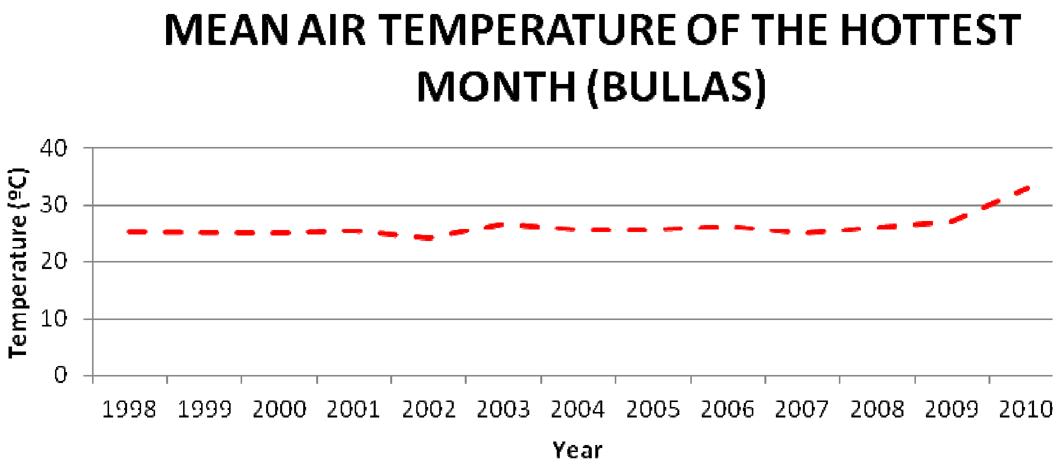



*Figure 74. Mean air temperature of the coldes month*

**Precipitation**

In the last fifteen years, annual precipitation has slightly increased, with the exception of 2005 drought. By contrast, the distribution of the precipitation has not remained constant, with a higher difference gap between the most and the less rainy month.

◆ Annual precipitation (mm):

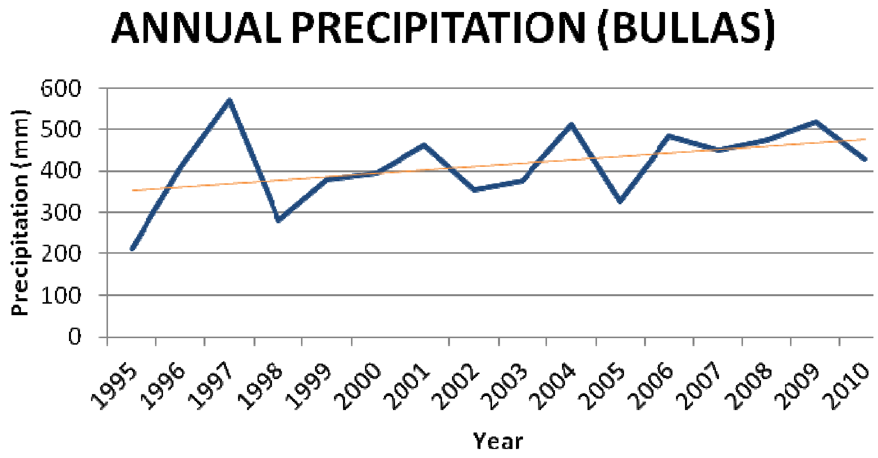



*Figure 75. Annual precipitation*

◆ Precipitation of the most rainy month (mm)

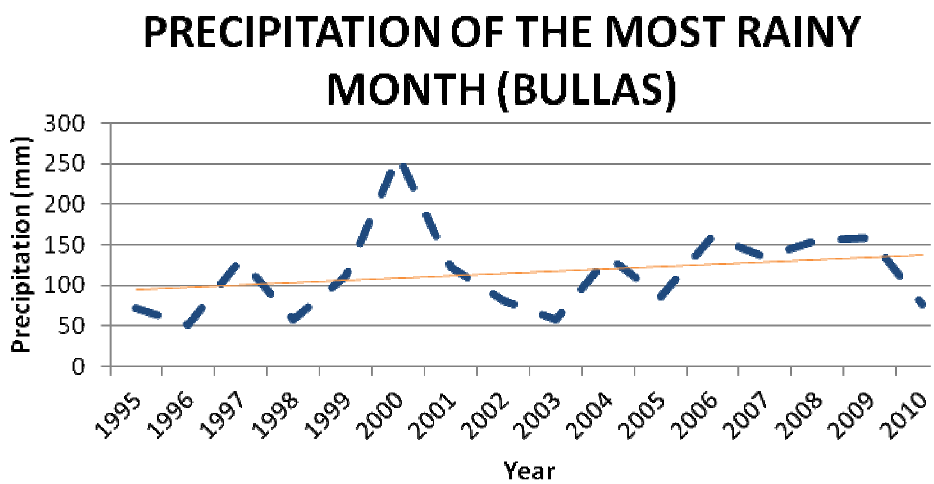
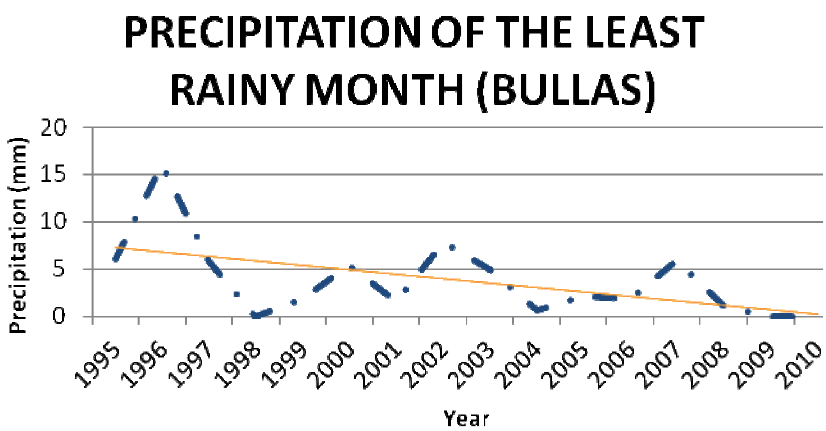



*Figure 76. Precipitation of the most rainy month*

- Precipitation of the least rainy month




(mm):

*Figure 77. Precipitation of the least rainy month*

**Incoming solar radiation**

Annual solar radiation in Bullas is around 4000 kJ m$^{-2}$ year$^{-1}$, being nearly 2000 kJ m$^{-2}$ year$^{-1}$ the least irradiated month and nearly 7000 kJ m$^{-2}$ year$^{-1}$ the most irradiated one.

- Accumulated annual solar radiation (kJ m$^{-2}$ year$^{-1}$)

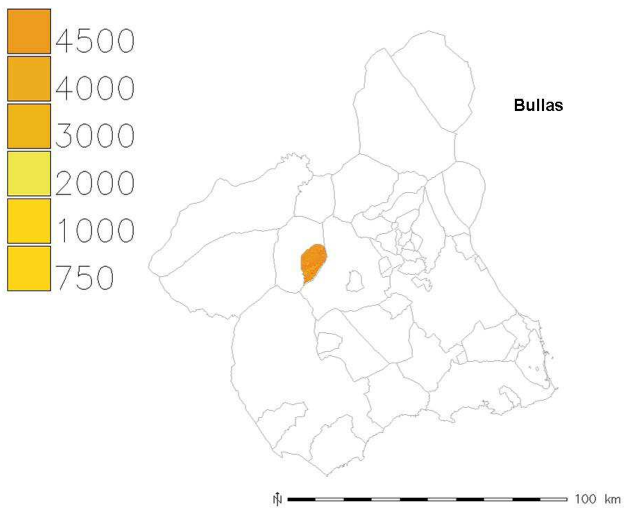


*Figure 78[60]. Accumulated annual solar radiation*

- Accumulated solar radiation of the most irradiated month (MJ $m^{-2}$ $month^{-1}$):

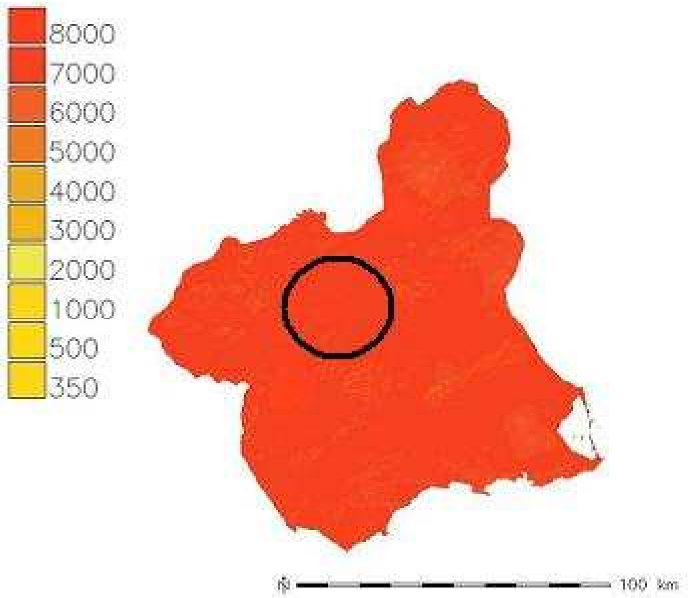
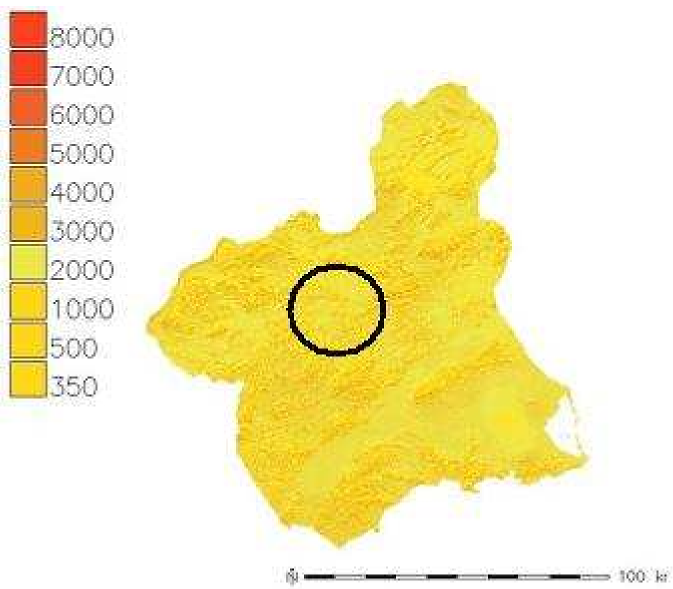



*Figure 79[61]. Accumulated solar radiation of the most irradiated month*

- Accumulated solar radiation of the least irradiated month (MJ $m^{-2}$ $month^{-1}$):




[60] *Source: "Atlas de radiación solar de la Región de Murcia"*
[61] *Source: "Atlas de radiación solar de la Región de Murcia"*

*Figure 80[62]. Accumulated solar radiation of the least irradiated month*

**Global radiation**

Next figure shows the monthly distribution of global radiation in Bullas.

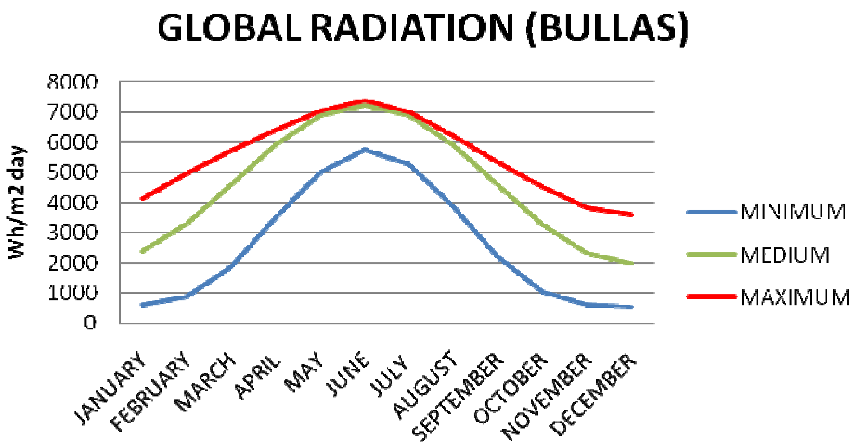



*Figure 81[63]. Global radiation*

**Reference evapotranspiration**

- Accumulated annual reference evapotranspiration (mm year$^{-1}$):

Next figure shows the monthly Thornthwate water balance for Bullas. Only in the months from November to March rainfall exceed potential evapotranspiration (the amount of water that would be evaporated if we had infinite reserves), which causes it to generate a stock about 71 liters, which is used in April, May and June.

The total annual potential evapotranspiration is 809 mm.

[62] *Source: "Atlas de radiación solar de la Región de Murcia"*
[63] *Source: "Atlas de radiación solar de la Región de Murcia"*

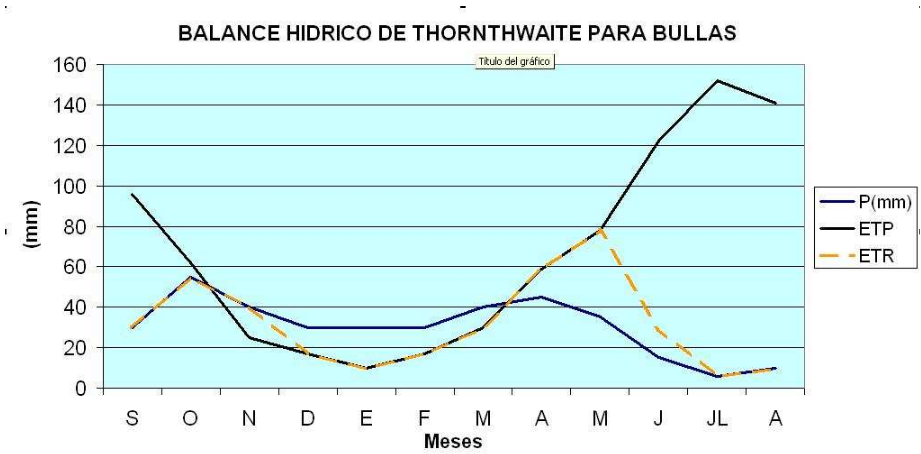



*Figure 82. Evapotranspiration (Thornthwaite) for Bullas*

- Water balance:

Next figure shows that in Bullas there are half of the aquifers in equilibrium (green) and half with risk of overexploitation (yellow). Data for this indicator is available only for the Murcia Region, however, we have indicated in the next figure Bullas (black circled). We can infer from this figure that Bullas have zones in equilibrium (aquifers in that zone are not overexploitated) and in overexploitation

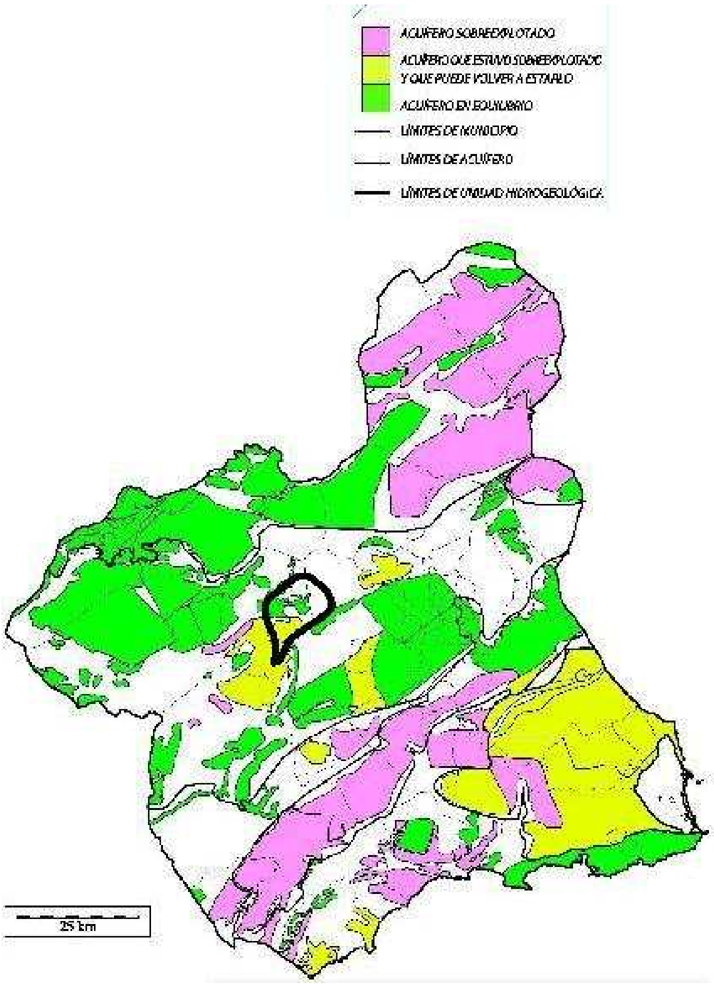



*Figure 83. Water balance in the Region of Murcia*

- Potential evapotranspiration (ETP)[64]:

Evapotranspiration is the loss of moisture in the ground surface that occurs through direct water evaporation and transpiration from living organisms, especially plants. Of total rainfall water, only one part feeds surface and ground waters, while the other feeds the evapotranspiration.

The ETP is the evapotranspiration that would occur with soil moisture and vegetation cover in top condition and depends primarily on temperature. Since optimal conditions of soil moisture that would allow real evapotranspiration (ET)

[64] Source : http://servicios2.marm.es/sia/indicadores/

to reach the ETP are not always presents, the ET is usually less than the ETP, with a greater difference between them in the drier areas.

The indicator shows the average value of the ETP in mm, calculated from monthly values obtained by the simulation model Precipitation-Contribution (SIMPA). SIMPA is a distributed hydrological model used for assessment of water resources in the natural system that has been developed by the Center for Studies and Experimentation of Public Works (CEDEX).

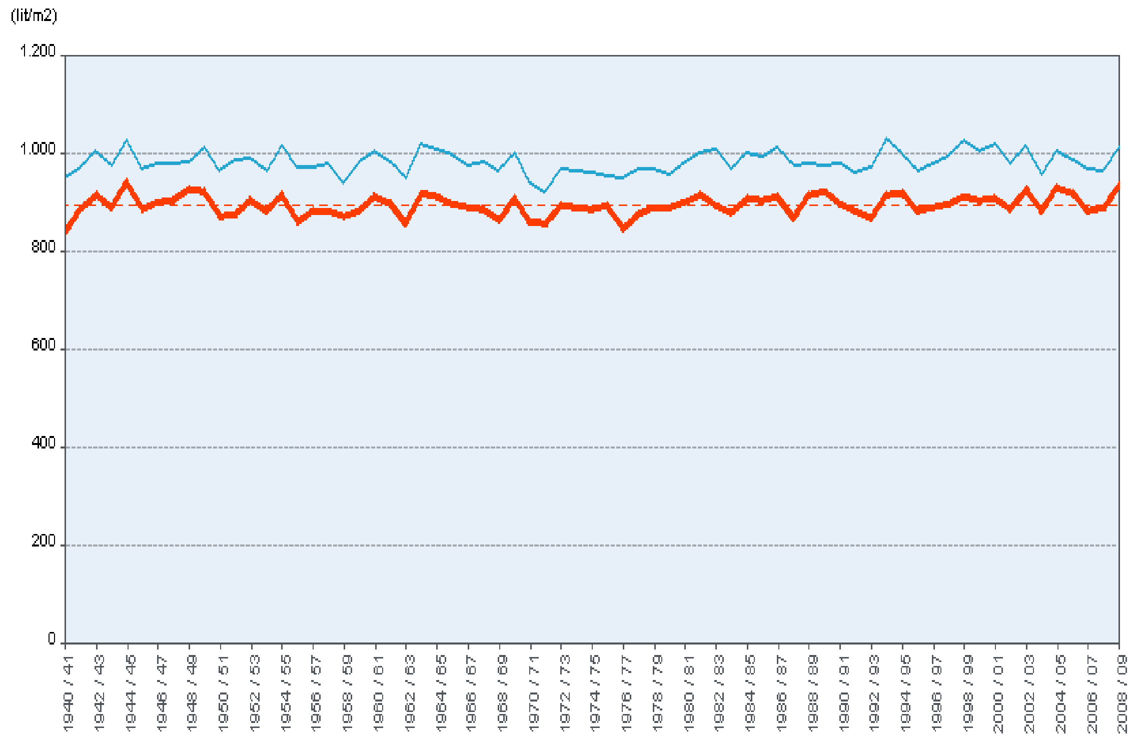



*Figure 84. Potential evapotranspiration in Spain and Segura basin*

*Red dotted line: Spanish basins mean levels*

*Red line: Spanish basins levels*

*Blue line: Segura basin level*

The ETP varies depending on temperature, so their spatial and temporal variation follows the behavior of this variable. The average in Spain ETP has ranged from 803mm, which was recorded the water year 1940-41, and the 925 mm of the hydrological year 2002-2003. The average in the period 1940-2006 has been 867 mm, and since the second half of the period provided there is a trend to increased ETP due to increased temperature.

The ETP depends on temperature, with higher temperatures increase evaporation rates and the transpiration of plants. This is a key environmental factor in influencing the hydrological cycle, as ETP decreases with increasing runoff. Not only affects the generation of water resources but also determines the volume of water that requires different uses of water, having a decisive influence on the water needs of crops.

The indicator is calculated as the sum of the monthly values obtained by the model SIMPA. The model calculates the monthly value of the ETP over the entire territory 1km$^2$ cells using a combination of the methods of Thornthwaite and Penman-Monteith, and introduces a reduction factor which takes into account the effect of vegetation.


*Figure 85. Potential evapotranspiration in Spain*

- Anomaly evapotranspiration (ETP)[65]:

The indicator shows the annual deviation from potential evapotranspiration (ETP) in a given year compared to the average ETP reference period. The evapotranspiration is the moisture loss from a surface that occurs through direct water evaporation and transpiration from living organisms, especially plants. Of total precipitable water, only one part feeds surface and ground waters, while the other feeds the evapotranspiration. The ETP is the one that would occur with soil moisture and vegetation cover in top condition and depends primarily on temperature.

Next figure shows the annual deviation of the indicator (measured for Spain and Segura basin as a percentage) since 1940-41 to 2009. An increase of the deviation has occurred due to the dependence of the indicator with the temperature.

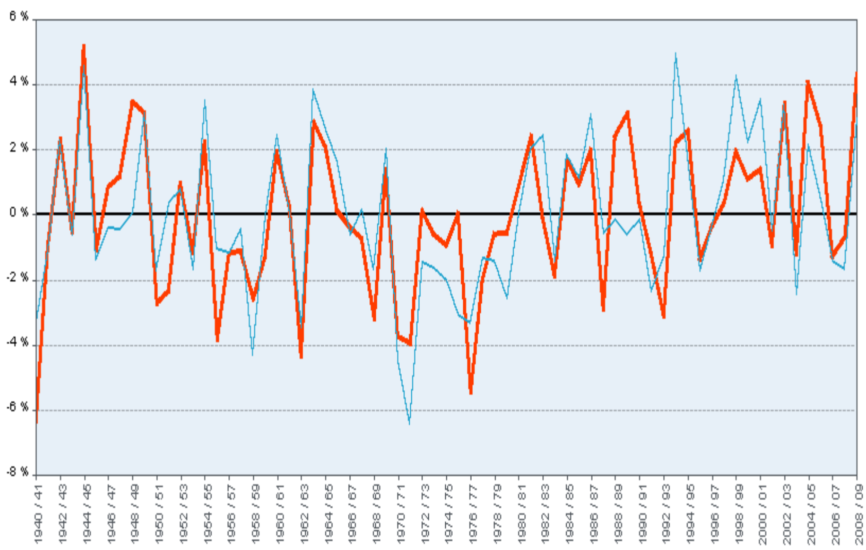



*Figure 86. Anomaly evapotranspiration of Spain and Segura basin*

*Red dotted line: Spanish basins mean levels*

*Red line: Spanish basins levels*

*Blue line: Segura basin level*

[65] Source : http://servicios2.marm.es/sia/indicadores/

◈ Mean anomaly evapotranspiration[66]:

Next table and figure show the mean anomaly evapotranspiration in Segura hydrographic land demarcation, where Bullas is situated.

As explained in the previous point, anomaly evapotranspiration shows the annual deviation from potential evapotranspiration (ETP) in a given year compared to the average ETP reference period.

*Table 32. Mean anomaly evapotranspiration*

| Hydrographic Land Demarcation | Mean anomaly ETP 1999/00-2008/09 (%) | Mean anomaly ETP 2004/05-2008/09 (%) | Mean anomaly ETP 2007/08 (%) | Mean anomaly ETP 2008/09 (%) |
|---|---|---|---|---|
| Segura | 0,88 | 0,51 | -1,67 | 2,97 |

[66] Source: http://servicios2.marm.es/sia/indicadores/


*Figure 87. Mean Anomaly Evapotranspiration in spanish basins*

## 2. Soil and climate (frosts)

In the case of autumn frost, if the temperature drops to - 2 or - 3 ° C leaves partially dry but clusters remain intact.

When the temperature decreases over - 6 ° C not only produces the drying of the leaves but ripen grapes suffer from loss of water by alteration of the membranes, increasing sugar levels leaving those grapes only for liqueur wines.

On the contrary, if the grape ripe is incomplete at the time of frost, a colour change to a reddish tint occurs altering the taste of the produced wines.

Light damage such as necrosis of the spinal cord and the diaphragm are considered when frost happening. Very serious damage would be the death of the buds of a year. These calamities are worse in young vineyards than in older ones.

As means against frost we have artificial mists and irrigation by aspersion. The second is really effective but costly, even though the installation serves against the ice, as summer irrigation and means for parasite fighting.

Bullas has approximately 9 days of frost per year. Strong winds and frosts occur sporadically between October and April[67], during the growing season.

In the case of hailstones, most common damage is breakage of leaves and falling flowers or small berries. In some cases wounds shoots can occur mainly when the stones are relatively large.

## 3. Soil and climate (temperature)

The temperature is a physical property of matter that quantitatively expresses the common notions of hot and cold.

Too high temperatures (30 - 34 ° C) especially if they are accompanied by dryness, hot and dry wind, burn leaves and clusters. The optimum temperatures for the cultivation of vines in their different stages of development would be as follows:

- Opening of buds: 9-10 ° C
- Flowering: 18-22 ° C
- From flowering to colour change: 22 - 26 ° C
- From change colour to maturity: 20 - 24 ° C
- Harvest: 18 - 22 ° c

Following graphics shows monthly average temperature for the growing season which is the most risky period in wine agriculture since climate conditions while that period largely affect grapes chemical and organoleptic qualities, such as pH, acidity, sugar levels, alcohol amount, etc.

[67] Source : Bullas Meteo and Bullas Wine Marketing Board

◆ Monthly average temperature (ºC):

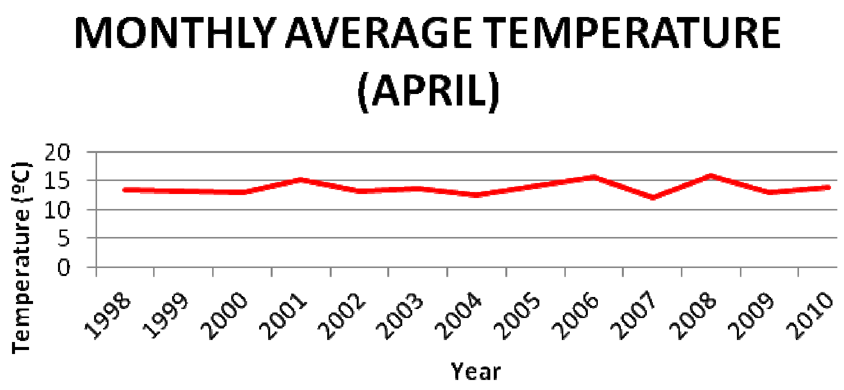



*Figure 88. Monthly average temperature (April)*

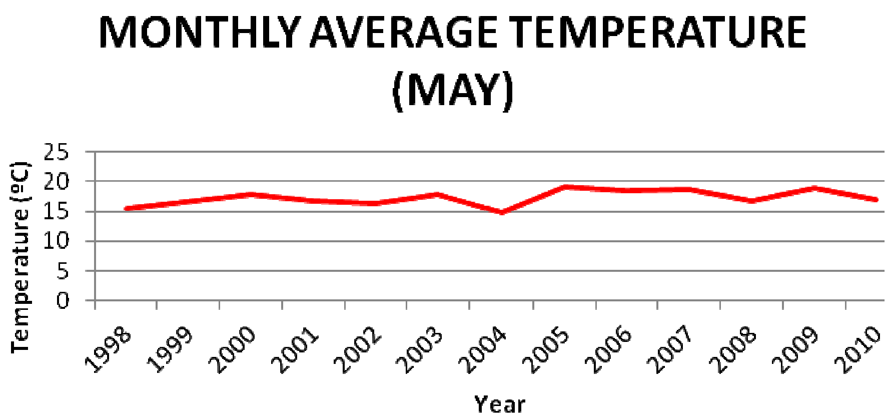



*Figure 89. Monthly average temperature (May)*

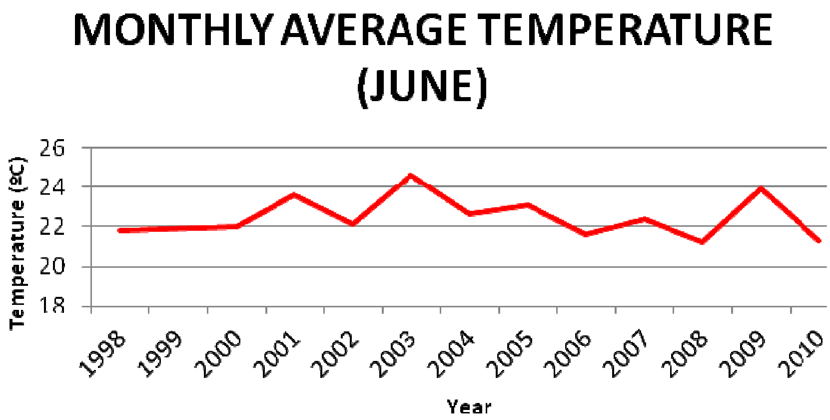



*Figure 90. Monthly average temperature (June)*

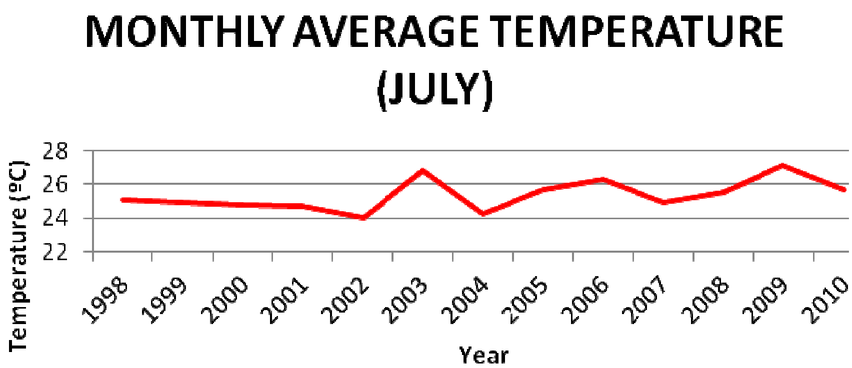



*Figure 91. Monthly average temperature (July)*

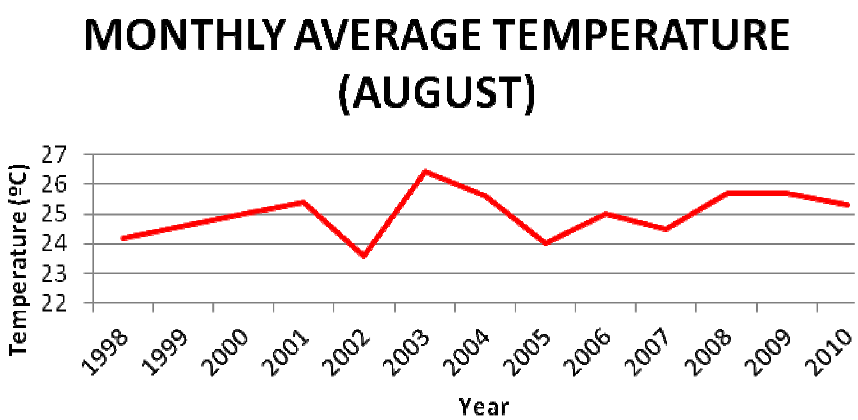


*Figure 92. Monthly average temperature (August)*

## 4. Soil and climate (precipitation)

The main forms of precipitation include drizzle, rain, sleet, snow, graupel and hail. Increasing temperatures tend to increase evaporation which leads to more precipitation.

Regarding rainfall distribution in cultivation would be approximately as shown:

- Sprouting: 14-15 mm. There is an intense root activity, which is promoted by the rain.
- Flowering: 10 mm. The rains are usually harmful.
- From bloom to fruit set: 40-115 mm. An intense photosynthesis is necessary.
- Between fruit set and maturation: 80-100 mm. An intense photosynthesis is necessary.
- Harvest: 0-40 mm. The rains tend to be harmful.

The Annual precipitation in Bullas since 1995 it is show on Figure 75.

- Projections from Regional Climate Models (RCM) and Global Climate Models (GCM):[68]

  The three RCMs predict a reduction of the annual cumulated precipitation at the end of the century, ranging between - 29.7% (SMHIRCA) and - 39.0% (RACM02). The relatively wide range of the variation reflects the high uncertainty which characterizes the precipitation projections. All the RCMs show a quite stable decrease over the whole century for the seasonal and annual precipitations, with two models out of three predicting a relative maximum in the middle of the century. Summer is the season when the

[68] Source: Spanish Agency of Metheorology (Aemet) and "Climate trends and projections" ISPRA 2010.

stronger reduction of the precipitation at the end of the 21 century occurs; such a reduction ranges between - 34.6% and - 50.0%. Finally, the RCMs do not predict an increase in seasonal precipitations.

With regards to the GCMs, in the A1B scenario the CNRM model estimates a drop of the precipitation of - 32.7%, while the INGV estimate is of -30.7% for the last ten years of the period. In the A2 scenario, the GCMs predict a drop of the annual precipitation between - 37.1% and - 37.8%, while in the B1 scenario the global CNRM model predicts a - 26.3% reduction.

The results from 2010 to 2100, as percentage variation with respect to the period 1961-90, are shown in details in the following figures.

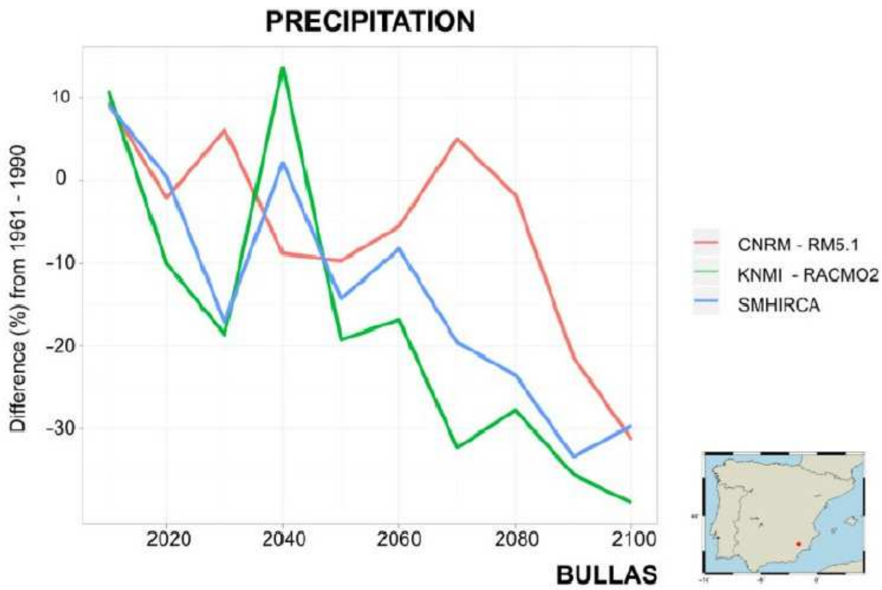



*Figure 93. Annual cumulated precipitation variation predicted by RCMs (%)*

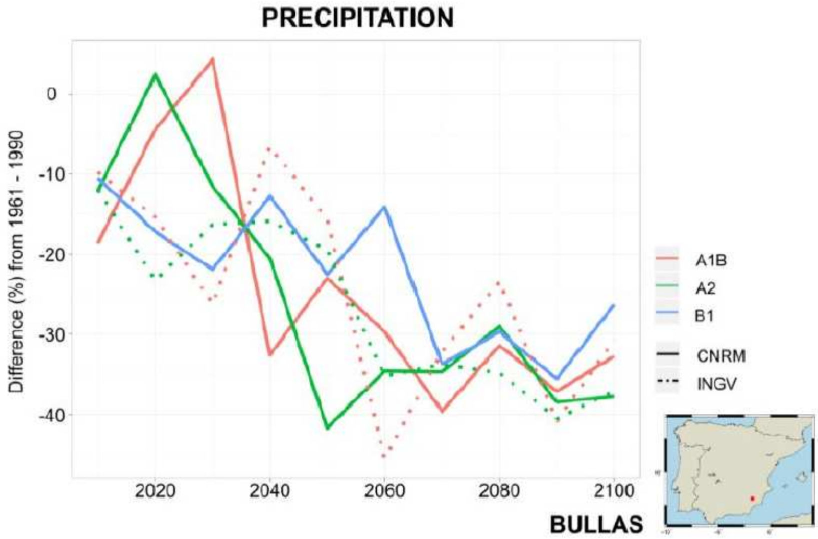



*Figure 94. Annual cumulated precipitation variation predicted by GCMs (%)*

- Frequency of rainstorm events

Periodically there are torrential rains and thunderstorms, mainly in September and October[69].

## 5. Soil and climate (Water availability and storage)

This means the degree to which a system is exposed to available long-term average water quantity. The exposure will affect long-term water availability and thus long-term water supply. Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations, naturally replenished by surface water from precipitation, streams, and rivers[70]. An aridity index (AI) is a numerical indicator of the degree of dryness of the climate at a given location. It serves to identify, locate or delimit regions that suffer from a deficit of available water, a condition that can severely affect the effective use of the land for such activities as agriculture or stock-farming [71].

[69] *Source: Regulation Council of Denomination of Origin "Bullas"*
[70] *Source: http://en.wikipedia.org/wiki/Groundwater*
[71] *Source: http://en.wikipedia.org/wiki/Aridity_index*

Water availability is considered as top one concern for farmers.

- Hydrological status[72]:

The status shows the incidence of hydrological drought in the use of water resources in river basins through an index developed by the Spanish Ministry of Environment and Rural and Marine Affairs to monitor the drought.

This is a dimensionless indicator for which sets out four possible scenarios: normal, pre-alert, alert and emergency.

In the period between February 2006 and December 2008 the indicator values are among the state and pre-alert warning, the minimum values of the series was produced in February 2006, the summer of this year and the winter of 2007-08, and the indicator shows higher values in the spring of 2007. Those indicators returned to normal in 2010 due to the rain occurred.

The situation in the various river basin evolves very differently, for example, in Segura river basin, there're nearly no oscillations, remaining in a state of emergency for almost the entire period.

Drought is a phenomenon characteristic of climate in Spain, with Murcia Region being one of the most affected ones, so it is important to develop strategies for early identification in order to anticipate their impact and mitigation in the environmental, social and economic. By indicating the status of water resources, which include volumes stored in reservoirs, groundwater levels in aquifers, circulating flows in rivers and rainfall data, establish different levels of risk of drought conditions. Each level of risk is associated with an alert or drought scenario and for each scenario set the appropriate measures to address drought and mitigate its potential consequences.

The indicator is constructed from the indicator values for monitoring drought in each operating system. The values of the river basin are obtained by weighting

[72] *Source:http://servicios2.marm.es/sia/indicadores/ind/ficha.jsp?cod_indicador=30&factor=estado*

according to the volume of demand for water in each system to the total volume demanded in the demarcation. In a similar way ponders the weight of each river basin to calculate the national average.

The index is classified into four ranges that define different stages of drought:

- 1 to 0.5: Normality, drought risk is considered low or very low. Green colour.
- 0.30 to 0.49: Pre-alert, the risk of drought is defined as a medium. Yellow colour.
- 0.15 to 0.29: Alert, drought risk is considered high. Orange colour.
- 0 to 0.14: Emergency drought risk is high. Red colour.

Red line is referred to Spain mean values, while blue line is referred to Segura basin.

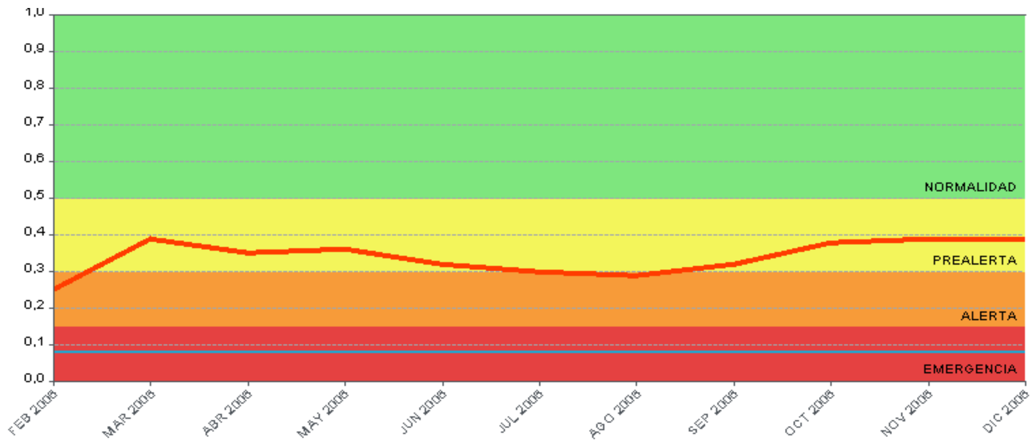



*Figure 95. Water availability and storage in Spain and Segura basin (2006)*

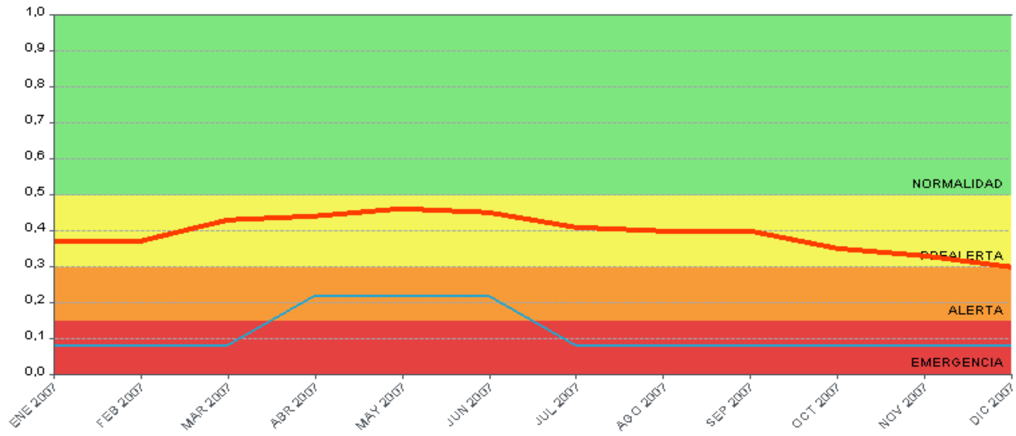



*Figure 96. Water availability and storage in Spain and Segura basin (2007)*

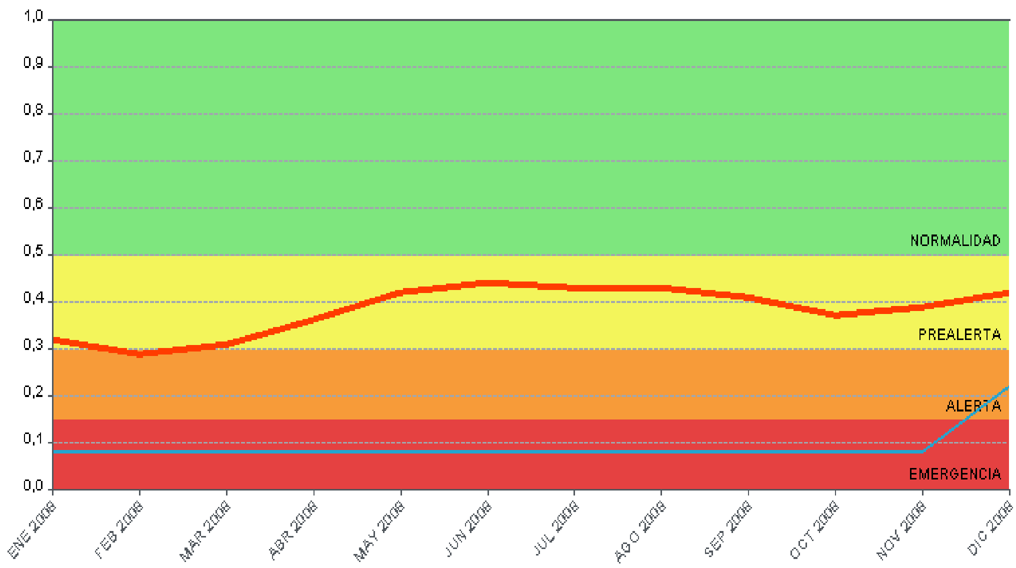



*Figure 97. Water availability and storage in Spain and Segura basin (2008)*

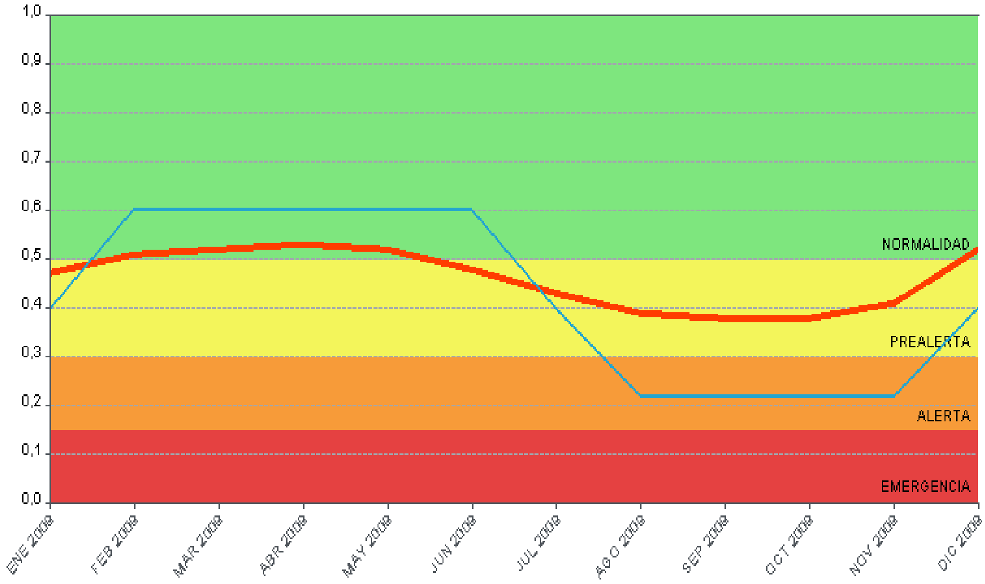



*Figure 98. Water availability and storage in Spain and Segura basin (2009)*

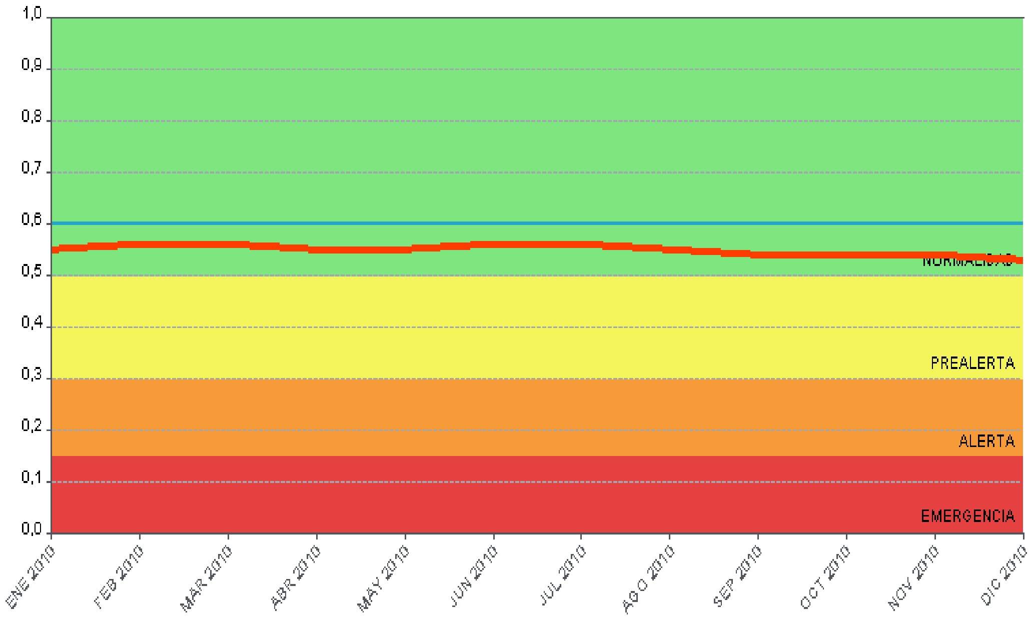



*Figure 99. Water availability and storage in Spain and Segura basin (2010)*

- Groundwater level (m): The Northwest Region has more than 252 springs, being 20 of them located in Bullas.

Following figures[73] show their disposition in the Region of Murcia, with Bullas zone black circled.

- Aquifers:

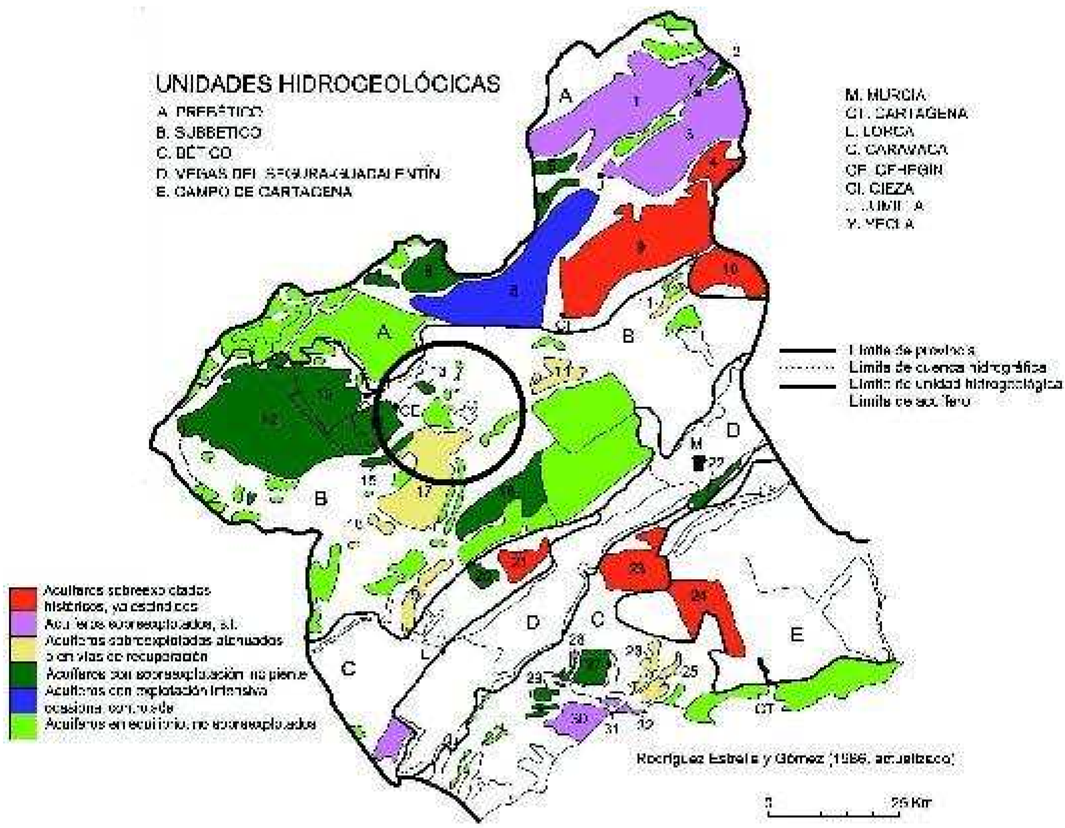



*Figure 100. Disposition of groundwater level in the Region of Murcia*

[73] Source: Atlas de la Región de Murcia

◈ Underground water:

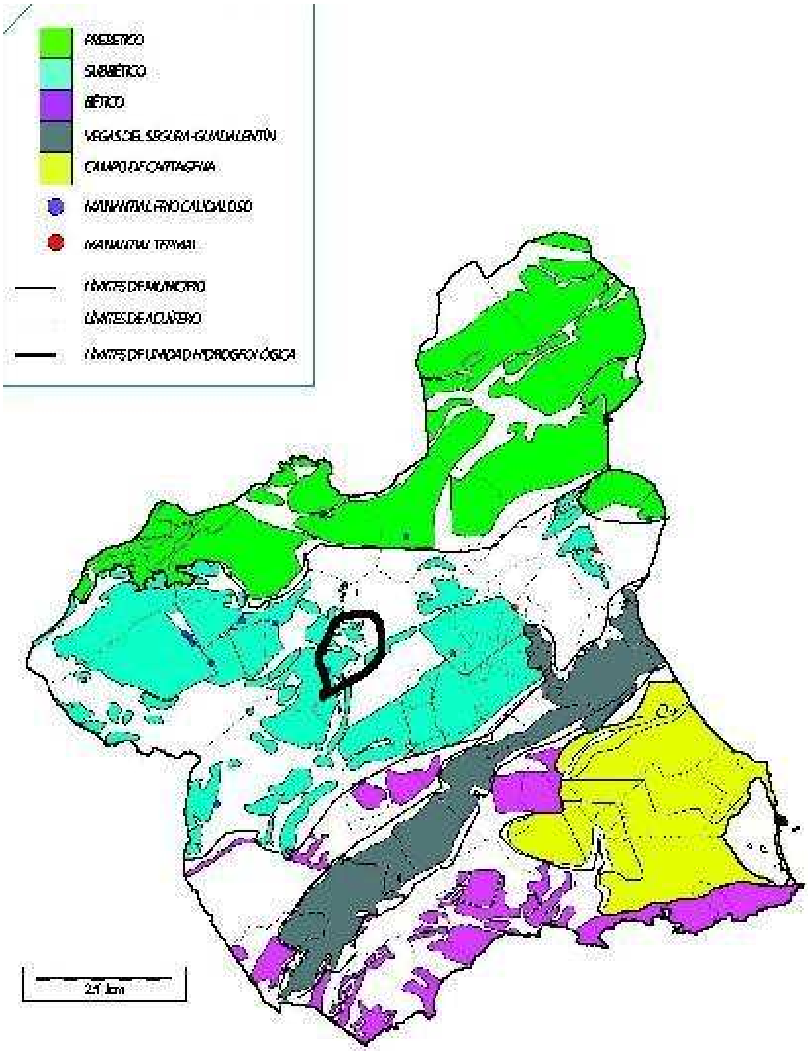



*Figure 101. Main hydrogeological units and aquifers in the Region of Murcia*

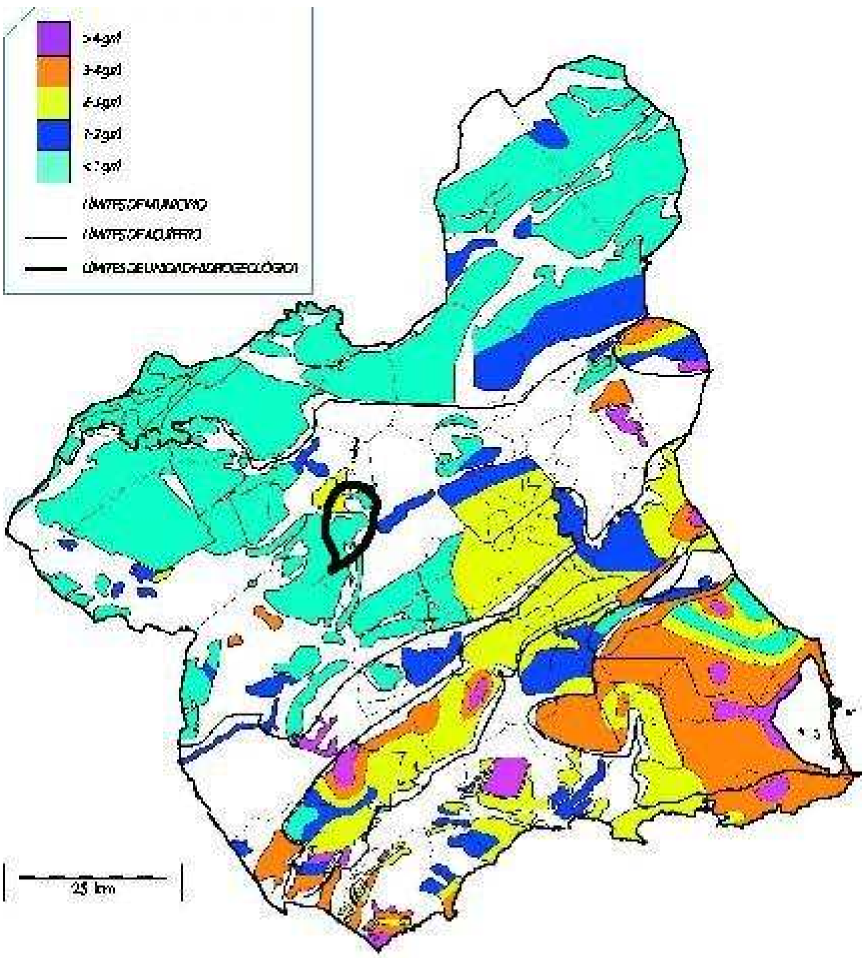



*Figure 102. Chemical quality of  ground water in the Region of Murcia*

◆ <u>Aquifer state:</u>

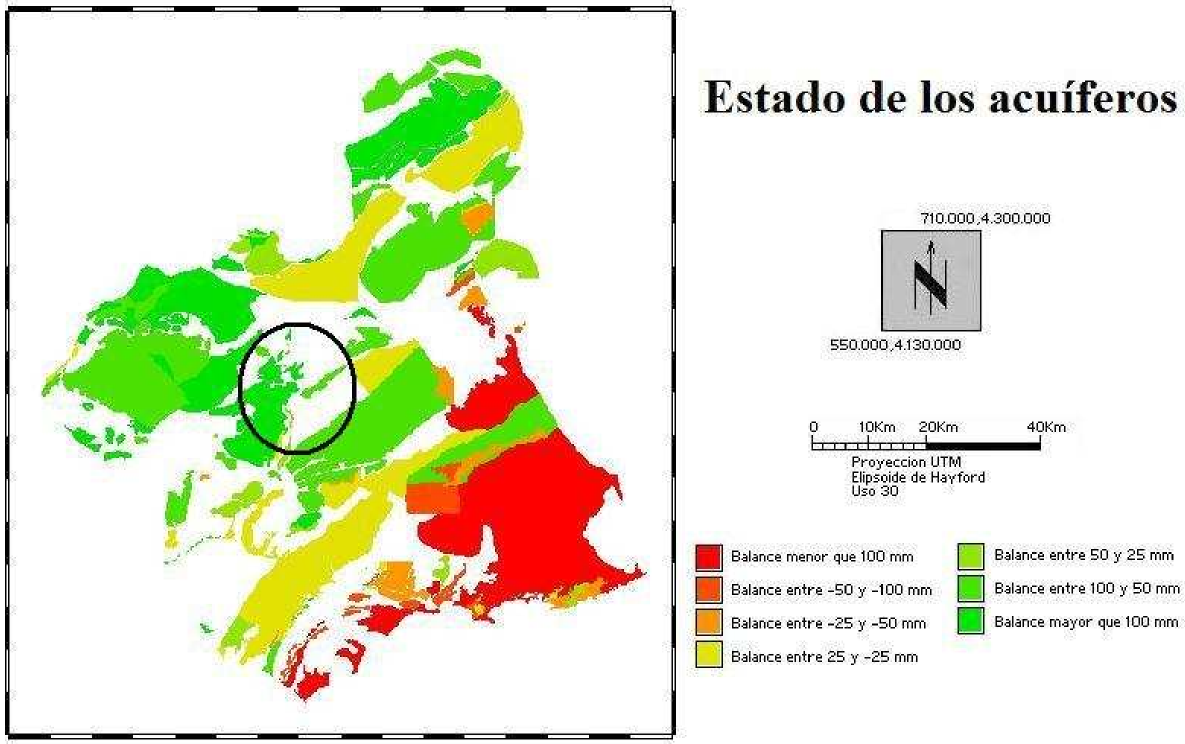



*Figure 103. Water balance of aquifers in the Region of Murcia*

## 6. Biomass/Yield (Phenology)

Phenology is the study of periodic plant life cycle events and how these are influenced by seasonal and interannual variations in climate. Observations of phenological events have provided indications of the progress of the natural calendar since ancient agricultural times.

The physiological and morphological differences between varieties (genotypes) enable wine grape production over a relatively large range of climates. Each grape variety grows in a range of temperature and for some the range is large (Kym Anderson et. All., 2008), as is shown in the following picture:

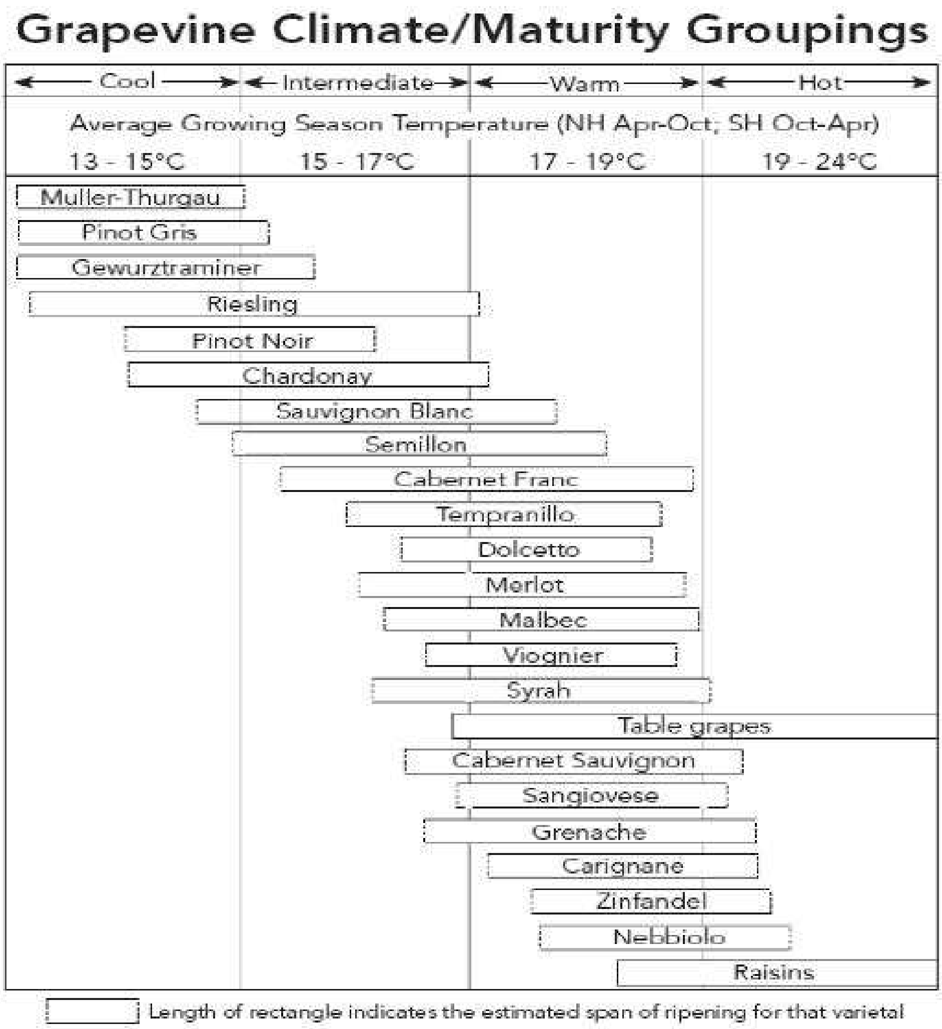



*Figure 104. Groupings of climate-maturity based on phonological requirements for berry development to produce high to premium quality wine.*

*This is based on examination of production in benchmark regions for each variety (Jones 2008).*

Next figure shows how wine quality might vary with changes in climate and illustrate the “inverted U” and optimum frequency of observed in more detailed analysis (Webb, 2006; Jones et all, 2005). Warming may increase or decrease quality depending on the variety and the region. Plasticity depends on variety and production techniques.

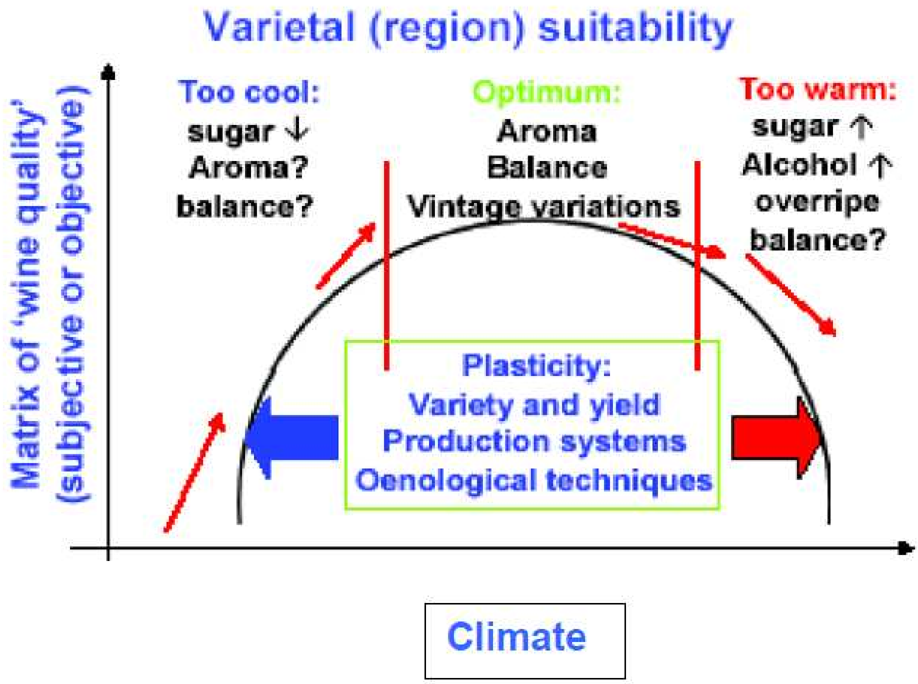



*Figure 105. Boundaries of suitable climates for wine production illustrating the "inverse U" curve that defines optimum temperatures for production of quality wine.*

*Note that present climates may be above or below the optimum so that warming may increase quality in some regions and decrease quality in others. There is also plasticity dependent on variety and on variation in production techniques. (Schultz 2008)*

Viticulture regions tend to lie in the 12-22ºC isotherm (Jones 2007). Grapes can be grown outside this range, at some cost in terms of other valuable characteristics foregone. (Kym Anderson et. All., 2008).

## 7. Biomass/Yield (Growing season)

Growing season, period in which plants can be growth. In much of Europe, the growing season is defined as the average number of days a year with a 24-hour average temperature of at least 5 C (6 C is sometimes used). This is typically from

April until October or November, although this varies considerably with latitude and altitude, see above example in point 6.

Wine grapes in Bullas:

*Table 32. Wine grapes growing season.*

| APRIL | | | | AUGUST | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

Other crops:

*Table 33. Bullas other crops growing season.*

| PRODUCTION CALENDAR | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apricot tree | | | | | Weeks 18-22 | | | | | | | |
| Peach tree (Yellow) | | | | | | | | Weeks 25-43 | | | | |
| Peach tree (White) | | | | | | | Weeks 22-25, 27-31 and 33-37 | | | | | |
| Peach tree (Red) | | | | | | | Weeks 20-38 | | | | | |
| Vineyard (dessert grape) (White without) | | | | | | | | Weeks 28-32 and 36-39 | | | | |
| Vineyard (dessert grape) (Black without) | | | | | | | | | Weeks 33 to 48 | | | |
| Vineyard (dessert grape) (Red whith) | | | | | | | | | Weeks 33 to 48 | | | |
| Vineyard (dessert grape) (Red without) | | | | | | | | | Weeks 31 to 48 | | | |
| Plum tree (Yellow) | | | | | | | Weeks 25-39 and 32-40 | | | | | |
| Plum tree (Black) | | | | | | | | Weeks 29-33 and 35-40 | | | | |
| Plum tree (Red) | | | | | | Weeks 22-36 | | | | | | |

## 4.2.1.2 EXPOSURE EVALUATION

All in all, taking into account the characteristics of climate and agriculture in Bullas previous defined in this document, and the different studies about future impacts in Mediterranean agriculture from climate change, we can identify the impacts that Bullas' agriculture is likely to be exposed to:

*Table 34. Exposure evaluation*

| EXPOSURE | | | |
|---|---|---|---|
| **Impact** | **Factors influencing the exposure of the sector** | **Exposed groups** | **Level of exposure** |
| Crop area changes<br><br>(including impacts in native plants and crops) | Changes in optimal farming conditions (increase in air temperature, heat stress, reduction of rainfall, extreme events, increasing atmospheric $CO_2$ levels and tropospheric $O_3$ levels) and decreases in productivity cause changes in crop distribution or even agricultural use land abandonment.<br><br>Loss of native plant and animal species (extinction or migration) and/or increase in invasive species due to more favorable climate can lead in loss of diversity in Mediterranean species.<br><br>Decrease on "natural" land due to an increase on industrialization and social infrastructures. | Farmers<br><br>Wine industry<br><br>Tourism industry | Medium-high |
| Crop quality and productivity changes. | The growing season of most of the crops (and in particular vineyards and Olive trees, which are two of the mail agricultural crops in Bullas) is carried out mostly during the spring-summer, where the major climatic anomalies are found influencing the crop quality and the productivity of the crops.<br><br>General decreases in yields (usually caused by shortening of the growing period), but (expected) increase in grapevine yields which can be detrimental to wine quality.<br><br>For wine grapes there are also links between higher temperature and lower quality and is expected a compression of harvest dates among varieties (earlier budburst, the earlier harvest and the shorter season).<br><br>Climatic variability make agriculture increasing unstable and make it more difficult for farmers to plan what crops to plant and when. | Farmers<br><br>Wine industry<br><br>Tourism industry | Medium-high |

| | | | |
|---|---|---|---|
| Agricultural pests, diseases, and weeds | Increased risk of agricultural pest, diseases and weeds due to changes in climate conditions.<br><br>For wine grapes there is an increased risk of phylloxera spread based on the increased rate of emergence of the insect from the soil with warming, and making the spread of the insect more probable (Dr Kevin Powell, DPI Victoria, Pers. Com.) | Farmers<br><br>Wine industry<br><br>Tourism industry | Medium-high |
| Soil erosion, salinity, and desertificatio n | Reduction or loss of the biological or economic productivity of soil due to warmer temperatures, reduction of precipitations, water resources deficit, increase of extreme events (heat waves, droughts, heavy storms).<br><br>General problems derived from aquifer over-exploitation, salinity of soil and desertification. With increased aridity often comes decline in soil structure and increased salinity (Clarke et al. 2002; Richards et al., 2008).<br><br>The water and nutrients derived from the soil by the vine, combined with the climate, can strongly influence the ratio of vegetative to reproductive growth (vine balance), and it is this that the viticulturist is largely trying to manage to achieve the optimum for fruit quality and yield (Dry et al. 2005).<br><br>Increase in urbanization. | Farmers<br><br>Wine industry<br><br>Tourism industry | Medium-High |
| Irrigation requirements (Water availability) | All studies converge in the definite and significant impact of climate change on the further deterioration of water resources in the Mediterranean (A. Iglesias et all, 2011).<br><br>The demand for water increases in all areas due to increases in crop evapotranspiration in response to increased temperatures. (A. Iglesias et all, 2011).<br><br>Decrease in water availability and increase in water demand.<br><br>Increase in irrigation requirements. | Farmers<br><br>Wine industry<br><br>Tourism industry | High |
| Increased | Increase of extreme events may cause emergency | Farmers | Medium |

| | | | |
|---|---|---|---|
| expenditure in emergency and remediation actions (including fires) | and/or remediation actions and significant losses in yields.<br>Hotter and drier season may cause increases in frequency and intensity of fires. | Wine industry<br>Tourism industry | |
| | **WINERY LEVEL**[74] | | |
| **Impact** | **Factors influencing the exposure of the sector** | **Exposed groups** | **Level of exposure** |
| Wine quality | The major impact to wine quality with change in climate will be largely the result of impacts on the grapevine.<br>The water and nutrients derived from the soil by the vine, combined with the climate, can strongly influence the ratio of vegetative to reproductive growth (vine balance), and it is this that the viticulturist is largely trying to manage to achieve the optimum for fruit quality and yield (Dry et al. 2005). | Farmers<br>Wine-wide<br>Tourism-wide | High |
| Wine production | The major impact to wine production with change in climate will be largely the result of impacts on the grapevine.<br>The water and nutrients derived from the soil by the vine, combined with the climate, can strongly influence the ratio of vegetative to reproductive growth (vine balance), and it is this that the viticulturist is largely trying to manage to achieve the optimum for fruit quality and yield (Dry et al. 2005). | Farmers<br>Wine-wide<br>Tourism-wide | High |

[74] Source: Considerations considered from Bullas Denomination of Origin Council

## 4.2.2 SENSITIVITY

### 4.2.2.1 SENSITIVITY INDICATORS: AGRICULTURAL SYSTEM CHARACTERISTICS

1. **Inputs and technology (surface and production)**

Climate change could influence in the crop production or in the food industry which is directly linked to crop production. Production and surface statistics are available with a consistent time series according to national institutions of statistics, which implement agricultural survey with a disaggregated level (regional, province, municipalities, etc). For example, for the wine production sector, according to the IPCC, quality wine in good years is not guaranteed, and the demand for wine in poor years is not met, implying a higher economic risk[75].

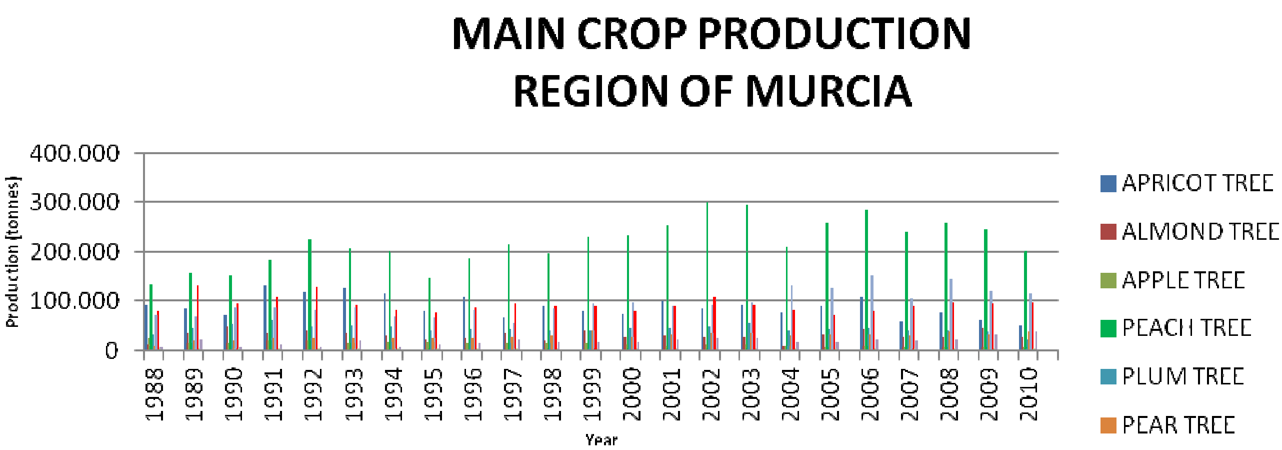



*Figure* 106. *Main crop production in the Region of Murcia*

Changes in main production crops during last 30 years appears to be only in production values, (while the percentage of each crop type is maintained) with a high increase of them, due to land overexploitation and the use of more developed production techniques.

[75] *IPCC, 2007; Chapter 13*

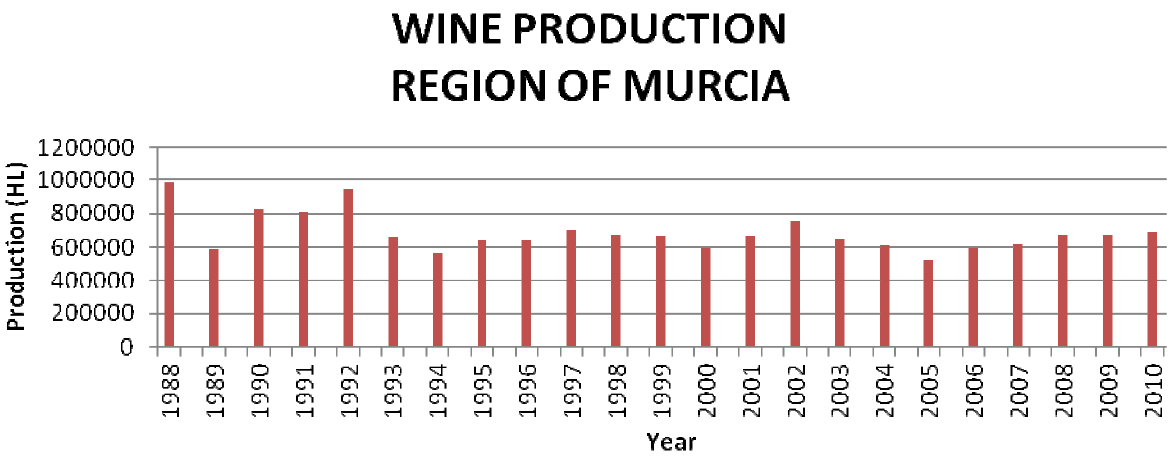



*Figure* 107. *Wine production in the Region of Murcia*

The Region of Murcia has several different wine production zones, with Bullas been one of the most important ones, and wine production has been more or less steady in its levels, been an important, but not the most important economical value of the region.

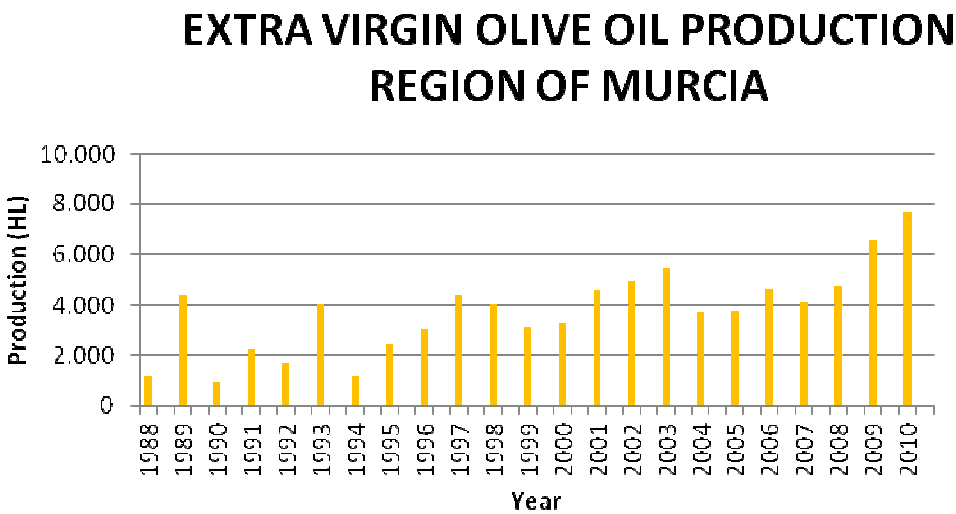



*Figure* 108. *Extra virgin olive oil production in the Region of Murcia*

Oil production has slightly increase in last decade, due to the fact that olive tree need a really long growing period before been having an economic value for its production, and the fact that they need less water that other types of crops.

## 2. Crop yields

Crop yield (also known as "agricultural output") is not only a measure of the yield of cereal per unit area of land under cultivation, yield is also the seed generation of the plant itself. According to the IPCC; perennial crops are more vulnerable than annual crops. Perennial crops (e.g. grapevine, olive and energy crops) have been relatively less studied in the context of climate change impacts. Yet predictions in main EU viticultural areas have shown an increase in yield variability (e.g. fruits production and quality)[76].

In general, perennial crops such as vineyards and olive trees are more exposed to climate changes variations, as their growing season is carried out mostly during the spring summer, in which major climatic anomalies are found. Durum wheat, whose life cycle takes place mainly in autumn and spring, is affected to a lesser extent. The significant reduction of yield of crops will have a major impact on the local economy such as to determine possible changes in land use. Through a spatial analysis of the impact of climate change, it is possible to highlight in detail the areas most vulnerable in different timing. Maps can be used for a careful economic evaluation in terms of determining the effects of climate change on income from farming, forestry and animal husbandry at the regional level[77].

Yield information for the main agricultural products different than wine grapes, expressed in tonnes per hectare (t/ha) with a time series it is show in the following figures:

[76] *IPCC, 2007- Chapter 13*
[77] *Moriondo et al 2009*

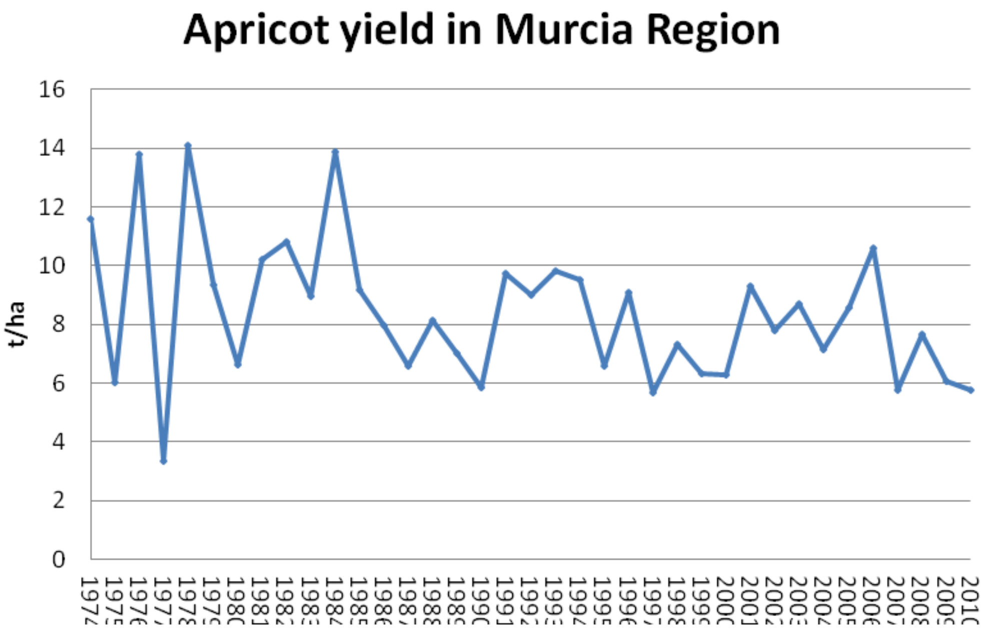



*Figure 109. Apricot yield in Murcia Region*

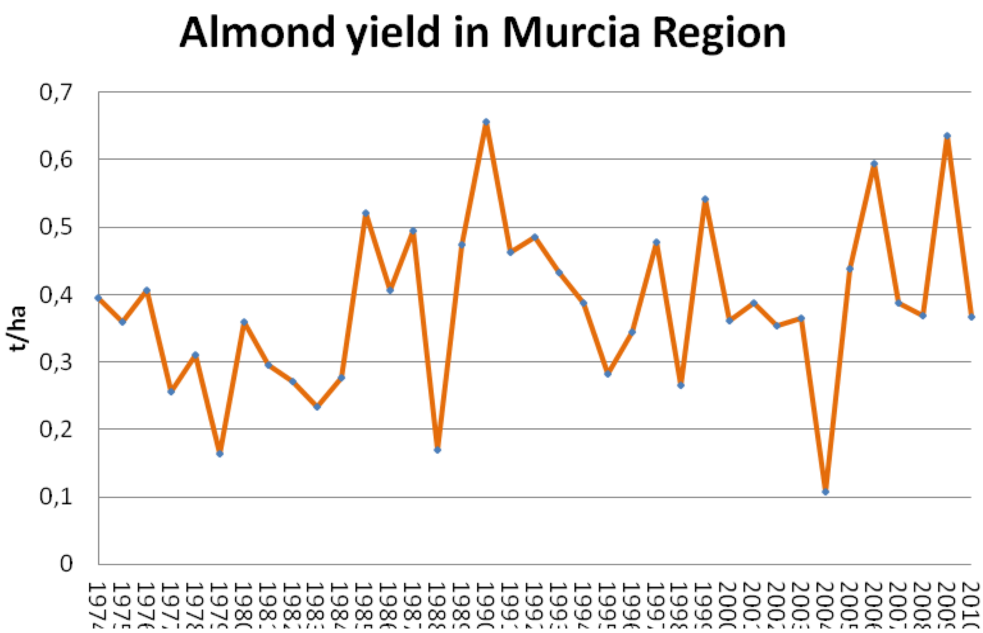



*Figure 110. Almond yield in Murcia Region*

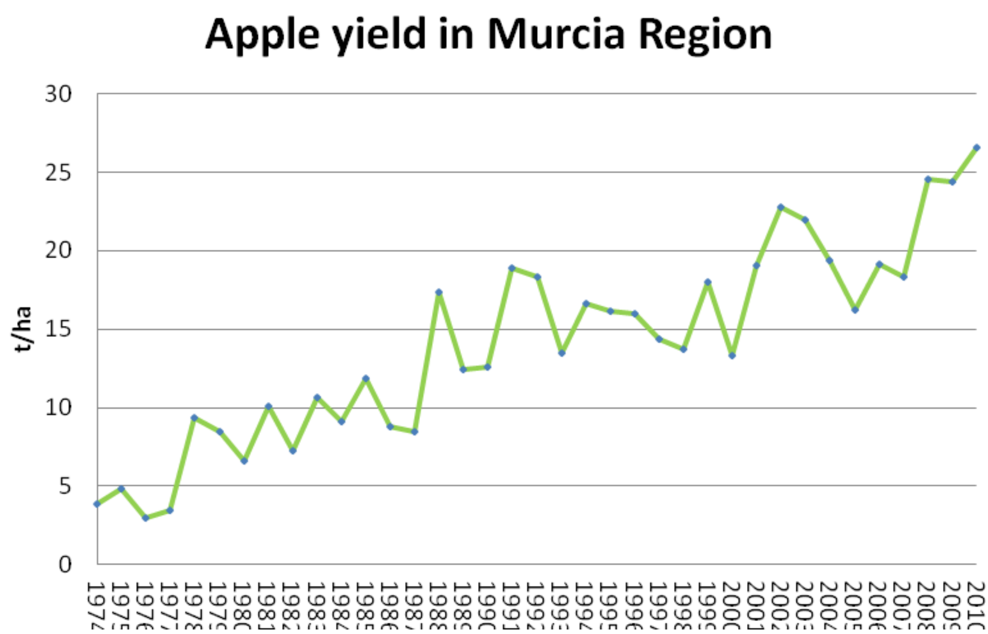



*Figure 111. Apple yield in Murcia Region*

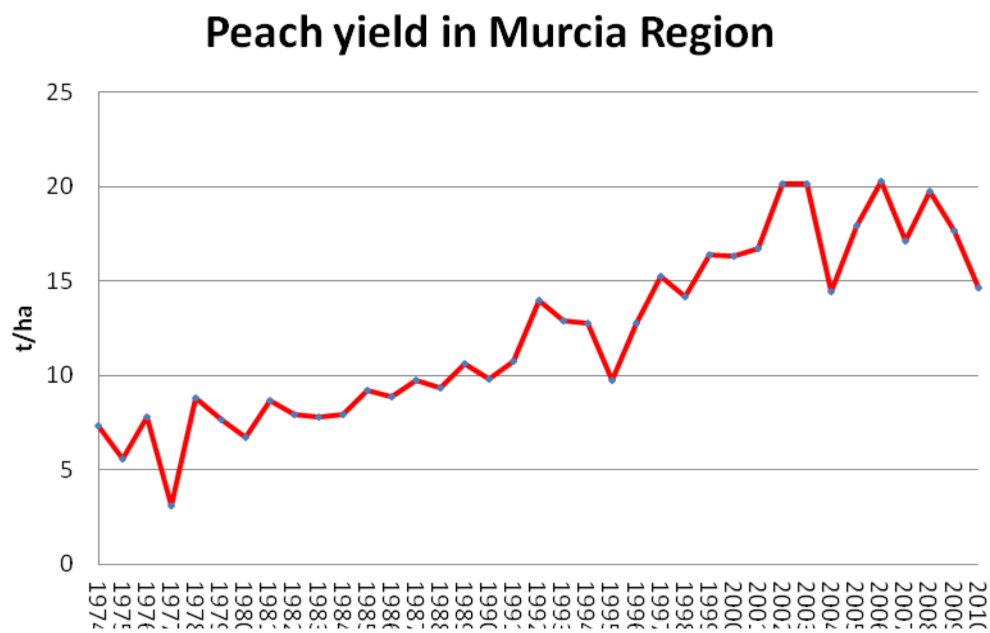



*Figure 112. Peach yield in Murcia Region*

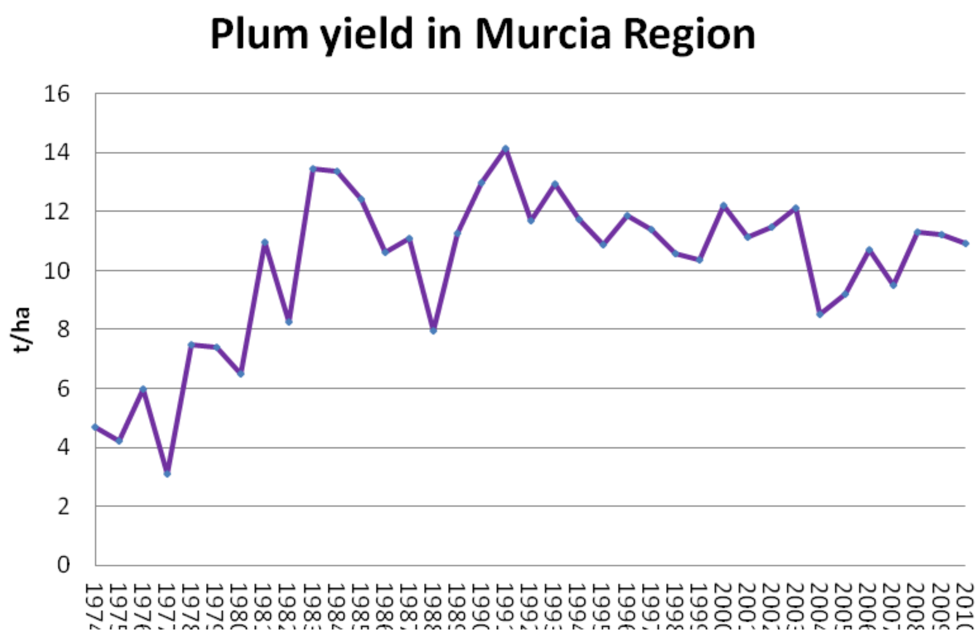



*Figure 113. Plum yield in Murcia Region*

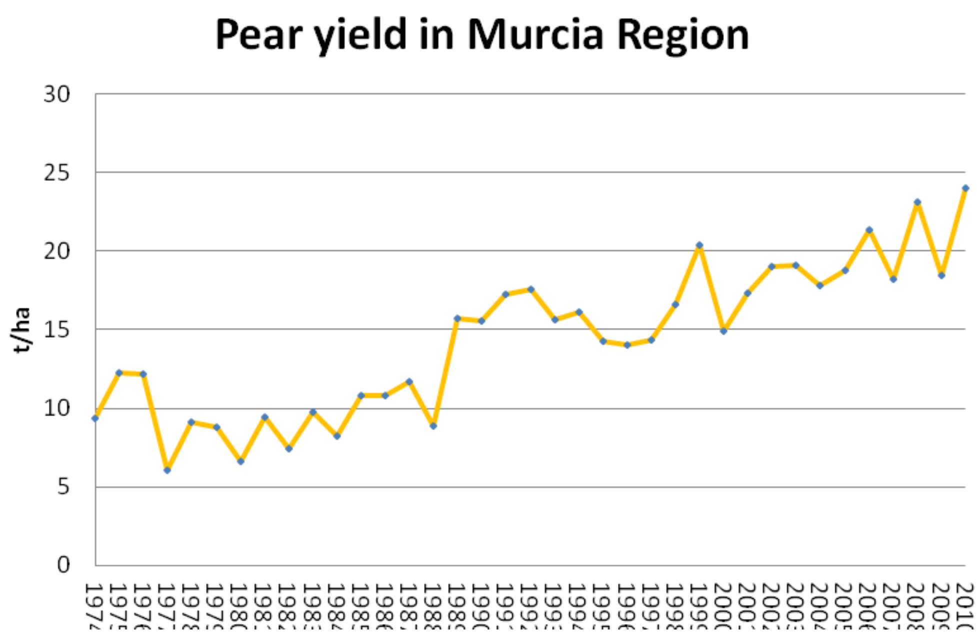



*Figure 114. Pear yield in Murcia Region*

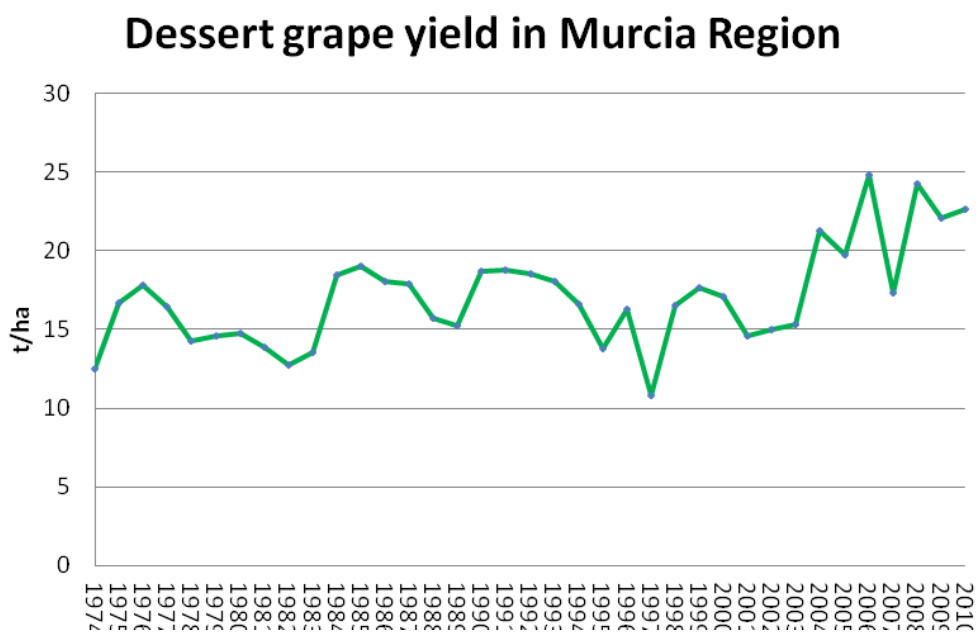



*Figure 115. Dessert grape yield in Murcia Region*

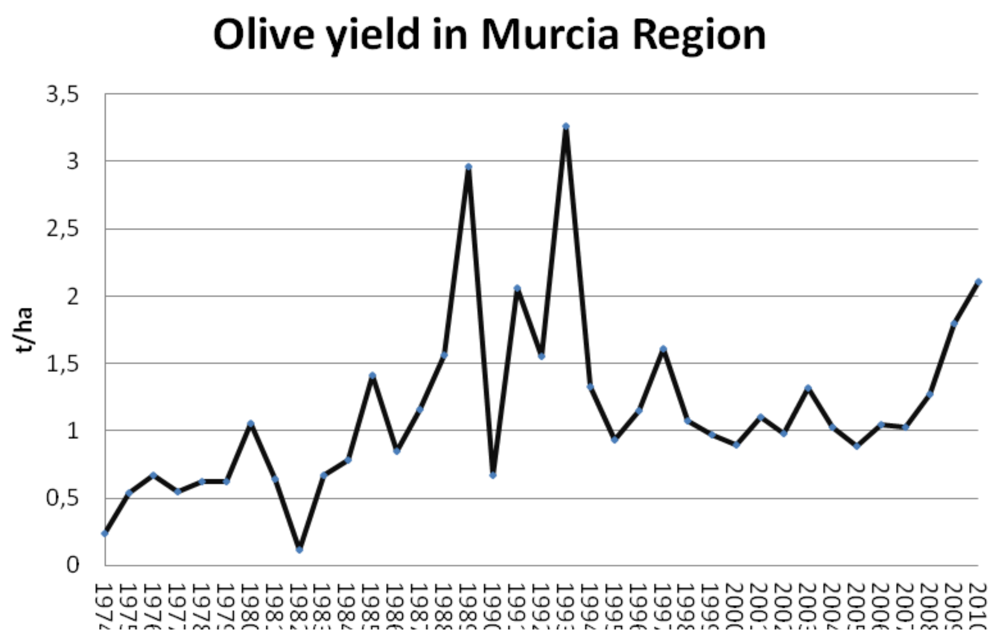



*Figure 116. Olive yield in Murcia Region*

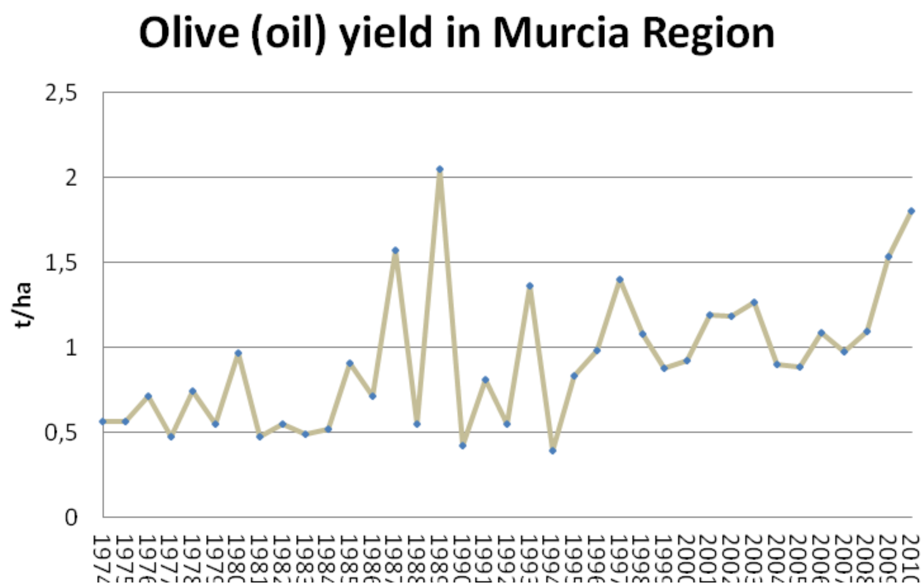



*Figure 117. Olive (oil) yield in Murcia Region*

### 3. Irrigation share (water scarcity)

Irrigation share and thus water scarcity is determined by the influence of the stress factor (e.g. climate change or changes in hydrological regime) on the functioning of the system. Each basin reacts different to an equal rainfall reduction. Logically, high water demand systems are more sensitive to water scarcity than low demand ones.

- Water uses[78]: Water delivered to cultivation lands for each irrigation techniques in 2007.

[78] Source: Spanish National Statistics Institute (INE).

*Table 35.* Water delivered to cultivation lands for each irrigation techniques in 2007.

| AUTONOMOUS COMMUNITIES | IRRIGATION TECHNIQUE (THOUSANDS OF CUBIC METERS) | | | | |
|---|---|---|---|---|---|
| | **Spray irrigation** | **Drip irrigation** | **Gravity irrigation** | **Others** | **Total** |
| Navarra | 51.344 | 50.912 | 351.752 | 843 | 454.851 |
| La Rioja | 96.673 | 23.224 | 103.108 | 1.327 | 224.332 |
| Aragón | 614.149 | 113.085 | 1.574.904 | 197 | 2.302.335 |
| Cataluña | 154.167 | 256.980 | 1.031.475 | 2.662 | 1.445.284 |
| Castilla y León | 1.083.660 | 75.694 | 1.044.766 | 25 | 2.204.145 |
| Castilla-La Mancha | 937.045 | 736.669 | 77.868 | 5.183 | 1.756.765 |
| C. Valenciana | 15.269 | 808.349 | 688.634 | 2.744 | 1.514.996 |
| R. de Murcia | 12.211 | 455.193 | 83.167 | 1.232 | 551.803 |
| Extremadura | 406.757 | 313.289 | 861.188 | --- | 1.581.234 |
| Andalucía | 334.854 | 2.513.658 | 861.455 | 2.409 | 3.712.376 |
| Rest of Autonomous Communities | 271.056 | 119.625 | 65.395 | 6.682 | 462.758 |
| **SPAIN** | **3.977.185** | **5.466.678** | **6.743.712** | **23.304** | **16.210.879** |

Reservoir storage[79]: The indicator shows the volume of water stored in a series of selected reservoirs at the beginning of the hydrological year, 1st October each year (in thousands of $hm^3$). The reservoirs selected are those with a capacity exceeding 5 $hm^3$, and include those intended for consumptive uses and hydropower generation.

[79] Source: http://servicios2.marm.es/sia/indicadores/ind/ficha.jsp?cod_indicador=30&factor=estado

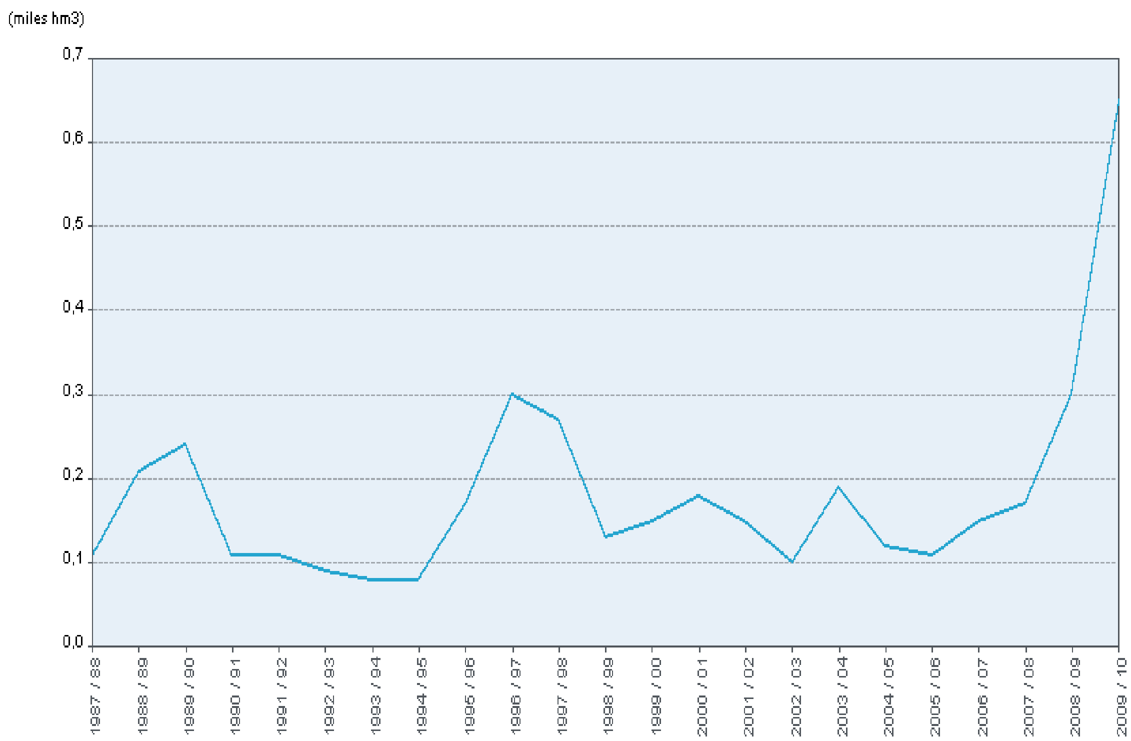



*Figure 118. Reservoir storage in Segura basin.*

Evolution of the indicator: In the period between the hydrological years 1987-88 and 2006-07 the indicator was highly variable, ranging from 13.350hm3 stored in the year 1994-95 to the 30.640hm3 stored in the year 1997-98. During the first five years are recorded lower volumes stored coinciding with the drought, from 1995-96 and to 2003-04 values are higher, except for a decline in the years 1998-1999 and 1999-2000 and in the last three years the values are close to the average of the period (22.830hm3).

Environmental relevance: The indicator permits monitoring the evolution of the reserve of water stored in major reservoirs, and is a key variable for managing water resources and to assess whether it has sufficient volume to meet water demands of each territory. The volumes of water reserves in reservoirs used in monitoring drought conditions and status indicator variable hydrological systems of exploitation of water resources within each river basin.

The state of indicator depends on the contributions of water to occur, which is a function of the climatology of the period of the drawdowns have been made to meet the demands of various uses and the outlets of the reservoirs to maintain a flow Rivers Environmental.

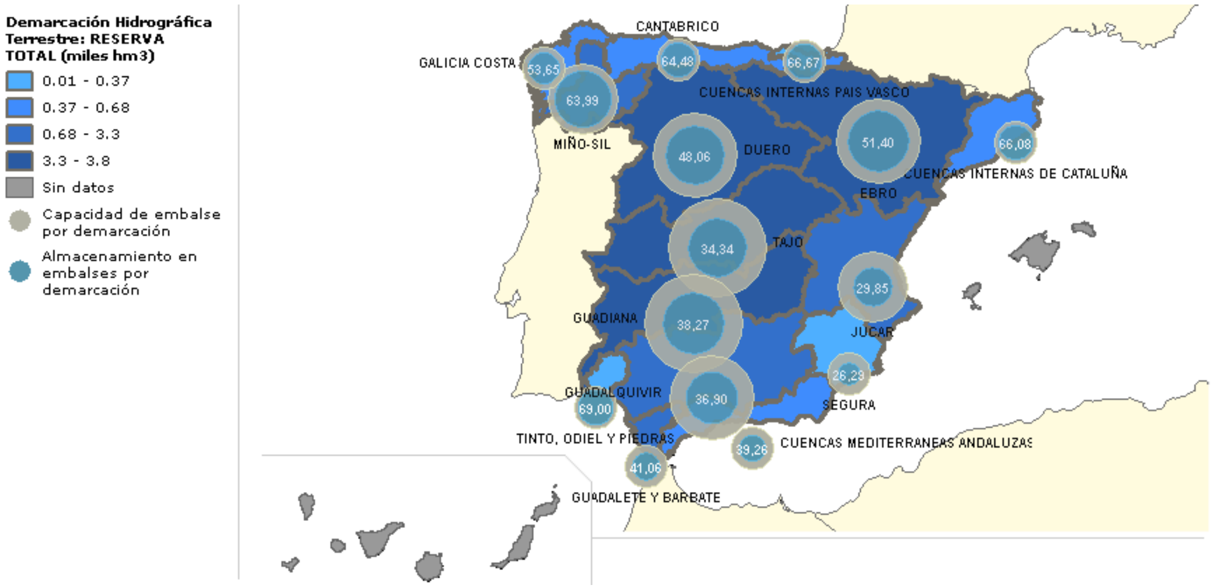



*Figure 119. Reservoir storage in Spanish basins.*

<u>Precipitation[80]:</u> Precipitation is the water that reaches the Earth's surface from the atmosphere in liquid form (rain) or solid (snow). The indicator shows the average annual precipitation in l/m2 (or mm) calculated from the monthly average values obtained by the simulation model Precipitation-Contribution (SIMPA). SIMPA is a mathematical model to simulate the natural input of water resources has been developed by the Center for Studies and Experimentation of Public Works (CEDEX).

Red doted line is referred to Spanish basins mean levels, red bold line and blue line are referred to Spain and Segura basin levels respectively.

[80] Source: http://servicios2.marm.es/sia/indicadores/ind/ficha.jsp?cod_indicador=30&factor=estado

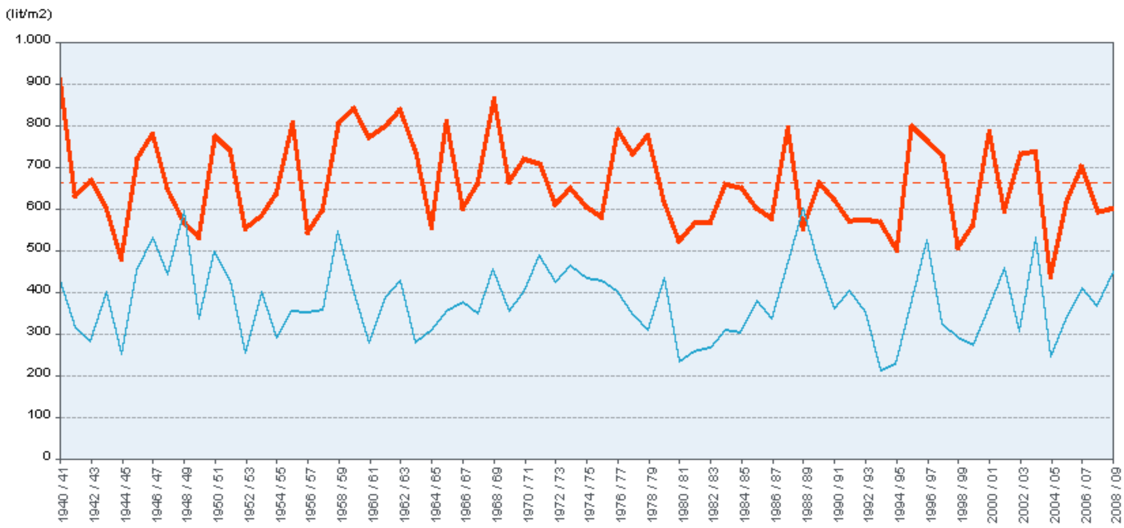



*Figure 120. Mean annual precipitation in Spain and Segura basin.*

Evolution of the indicator: From the hydrological years 1940-41 and 2005-06 there have been periods of dry and wet years, highlighting the period of drought in the early 90's. The average for Spain in this period is 655 mm / year, with a maximum value of 900 mm in the year 1940-41, while the minimum values have only been less than 500 mm in two hydrological years, 1944-45 2004-05. Throughout the year recorded the highest rainfall in winter and lowest in summer, being on average the wettest month of December with 87 mm of precipitation, and July is 15 mm less rainfall. Given the climatic differences in the various Spanish regions, the precipitation media in inter-river basin are very different from the maximum recorded in the Cantabrian river basin of 1,403 mm per annum until the minimum of 377 mm produced in Segura river basin.

Environmental relevance: Rainfall is a key environmental variable because it is the source of natural water resources and can say that triggers other processes of the hydrological cycle. Ecosystems and economic systems depend on water for their development and, therefore, to follow it is essential for proper management. The study and monitoring of precipitation is one of the basic aspects of the analysis of water resources, being in Spain is especially relevant for the spatial and temporal irregularity with which this phenomenon occurs.

Calculation: The indicator is calculated as the sum of the monthly values obtained by the model SIMPA. The model estimates the monthly precipitation during the simulation period in each of the cells in a km2 in which it has divided Spanish territory. Different maps are obtained by precipitation from the interpolation of the data recorded in the gauges by the method of inverse distance squared. The interpolation procedure followed uses the data collected since 1940 by over 5,000 weather stations of the Meteorological Agency.

Taking into account Hydrological status mentioned on Exposure section, Water uses, Reservoir storage and Precipitation, Segura river basin is one of the most sensitivity river basins in Spain due to the lack of rainfall and high temperatures, that causes reservoir storage in Segura basin to be one of the lowest ones in Spain.

#### 4.2.2.2 SENSITIVITY ASSESSMENT

*Table 36. Bullas' sensitivity assessment.*

| SENSITIVITY | | | | |
|---|---|---|---|---|
| **Impact** | **Existing stress unrelated to climate** | **Sensitive groups** | **Factors influencing the sensitivity of the sector** | **Sensitivity** |
| Crop area changes (including impacts in native plants and crops) | The municipality's economy is based on agriculture, in particular depending on wine quality and production of other key sectors for economic development of the municipality. | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br><br>Ecosystems | Bullas main crops are perennial which are more vulnerable to changes in climate than irrigated crops, because their growing season is carried out mostly during the spring summer, in which major climatic anomalies are found.<br><br>On the other hand, changes in crop phenology are apparent in perennial crops, such as fruit trees and wine-making varieties of grapes, which are less dependent on yearly management decisions.<br><br>Loss of indigenous crop varieties are expected due to changes in crop growth conditions.<br><br>Ignorance if the new weather conditions are suitable to the grapes used to produce wine in Bullas. | S3: Yes - Functionality is likely to get worse |

| | | | | |
|---|---|---|---|---|
| Crop quality and productivity changes. | The municipality's economy is based on agriculture, in particular depending on wine quality and production of other key sectors for economic development of the municipality. | Socio-economic groups (Farmers, Wine industry, Tourism industry) | Bullas main crops are perennial which are more vulnerable to changes in climate than irrigated crops, because their growing season is carried out mostly during the spring summer, in which major climatic anomalies are found.<br>On the other hand, changes in crop phenology are apparent in perennial crops, such as fruit trees and wine-making varieties of grapes, which are less dependent on yearly management decisions.<br>Loss of indigenous crop varieties are expected due to changes in crop growth conditions.<br>Ignorance if the new weather conditions are suitable to the grapes used to produce wine in Bullas. | S4: Yes - Functionality will get worse |
| Agricultural pests, diseases, and weeds | Gradual increase in the number of organic farming in the municipality, due to the low level of pests, diseases and weeds, that makes possible the non use of chemical products to combat them.<br>For grape wine there is an | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br>Ecosystems | Quality and organoleptic characteristics of wine depends on the chemical used as pesticides in fields. | S3: Yes - Functionality is likely to get worse |

| | | | | |
|---|---|---|---|---|
| | increased risk of phylloxera spread based on the increased rate of emergence of the insect from the soil with warming, and making the spread of the insect more probable but it didn't happen so far in Bullas. | | | |
| Soil erosion, salinity, and desertification | The actual soil erosion risk in Bullas is quite high. Mean annual soil loss in Bullas is around 50-200 t/ha.year.<br>Bullas is considered as a desertification (and erosion) risk area.<br>In general, Mediterranean soils are currently experiencing a range of conservation problems, including high erosion rates (and erosion-derived agro-chemical pollution of waterways), declines in soil organic matter, and | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br>Ecosystems | Many Bullas rainfed crops (vineyards) are on steep slopes making them more vulnerable to desertification.<br>Change in suitability of soil for wine production. | S4: Yes - Functionality will get worse |

| | | | | |
|---|---|---|---|---|
| | vulnerability of soil organic carbon pools. These are linked to site factors and changing land management practices and are being exacerbated by climate change and the increasing incidence of extreme weather events. Increased intensity of precipitation is likely to change patterns of erosion and accretion, increase the occurrence of storm flooding and storm damage and lead to greater incidences of waterlogging. (A. Iglesias et all, 2011) | | | |
| Irrigation requirements (Water availability) | Bullas has water shortage same as the rest of the region, which leads to an increase of water prices for irrigation as well as availability<br>Aquifer over-exploitation.<br>Urbanization. | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br>Ecosystems | Bullas main crops are rainfed.<br>Public intervention plays a key role.<br>Even so, the demand for, and the supply of, water for irrigation will be influenced not only by changing hydrological regimes (through changes in precipitation, potential and actual evaporation, and runoff at the watershed and river basin scales), but by concomitant | S4: Yes - Functionality will get worse |

| | | | | |
|---|---|---|---|---|
| | | | increases in future competition for water with non-agricultural users due to population and economic growth.<br>Water quality and/or quantity might in future not be able to satisfy farmers' demand. | |
| Increased expenditure in emergency and remediation actions (including fires) | At present, there are no knows important damages caused by a natural disaster in Bullas. | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br>Ecosystems | Number and frequency of extreme events can cause important losses in crops and in agricole infraestructures due to floods, fires, etc. | S3: Yes - Functionality is likely to get worse |
| **WINERY LEVEL[81]** | | | | |
| **Impact** | **Existing stress unrelated to climate** | **Sensitive groups** | **Factors influencing the sensitivity of the sector** | **Sensitivity** |
| Wine Quality | Wine quality depends on farming conditions. | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br>Ecosystems | The vine is extremely sensitive to the various shifts associated with climate change. | S4: Yes - Functionality will get worse |

[81] Source: Considerations from the Denomination of Origin Council.

| | | | | |
|---|---|---|---|---|
| Wine Production | Wine production depends on farming conditions. | Socio-economic groups (Farmers, Wine industry, Tourism industry)<br>Ecosystems | The vine is extremely sensitive to the various shifts associated with climate change (Rainstorms, droughts, high temperatures, frosts, etc.) | S4: Yes - Functionality will get worse |

## 4.2.3 ADAPTIVE CAPACITY

Bullas most important crop are the vineyards, with wine production been the base of its economy, that is why the adaptative capacity of the municipally strongly depends on the success or not of wine production adaptation to climate change.

#### 4.2.3.1 ADAPTATIVE CAPACITY INDICATORS: SOCIO-ECONOMIC DATA

**1. Rural welfare (farm income)**

A farm income statement (sometimes called a farm profit and loss statement) is a summary of income and expenses that occurred during a specified accounting period.

Agriculture in the Region of Murcia is a strategic sector in the regional economy. Its importance is reflected in the value of production of the agricultural industry, with 1,440 million euros of Final Production Plant (fruits and vegetables), a percentage of workers close to 10% of the regional population and agricultural income per employee of 25,799 euros according to the Labour Force Survey 2007.

Of the total area of the region, 50% (566,623 ha) is for agricultural land, of which 67% are operated as dry and remaining 33% as irrigation.

The Region of Murcia, and its rich gardens, are considered one of the most fertile and prosperous in Spain, giving rise to an agricultural industry based on quality, environmental balance, with a high percentage of drip irrigation, and investment in research and development to ensure the viability of new crops planted and profitability of the traditional.

The result of this agricultural industry is a wide range of horticultural products that enjoy a strong position and prestige in domestic and international markets, some of which shine with light itself by its unique characteristics and their undoubted quality. Jumilla pears, peaches early Cieza, White table grapes, melon of

Torre Pacheco, Santomera lemons, wine Denominations of Origin Yecla, Bullas and Jumilla, tomatoes of Mazarrón and paprika from Murcia are a clear example of it.

Regional agricultural production is concentrated in vegetables with 46%, 23% citrus fruit, sweet fruits by 16% and 7% for vineyards. The remaining 8% is distributed among other products.

A key aspect of the economy of the Region of Murcia is the food production for export, as compared to the regional market represents a percentage above 50%.[82]

In Bullas, and specifically for wine production, the economic value of the Denomination of Origin production can be seen in following pages.

*Table 37. Production and plantation areas in the totally of the region of Murcia.*

| Region of Murcia Crop | Regular plantation Area (ha) | | | | | Spread trees (number) | Yield | | | Production (tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | | In production | | | Production area (kg/ha) | | Spread trees | |
| | Unirrigated | Irrigated | Total | Unirrigated | Irrigated | | Unirrigated | Irrigated | | |
| **Apple tree** | - | 273 | 273 | - | 268 | - | - | 25000 | - | 6700 |
| **Pear tree** | - | 1651 | 1651 | - | 1557 | - | - | 24567 | - | 38251 |
| **Apricot tree** | 347 | 9680 | 10027 | 285 | 9071 | - | 1500 | 8422 | - | 76823 |
| **Peach tree** | 7 | 10910 | 10917 | 7 | 10476 | - | 6500 | 20828 | - | 218240 |

[82] *Source:http://www.regmurcia.com/servlet/s.Sl?sit=c,24,m,3111&r=ReP-23210-DETALLE_REPORTAJESPADRE*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Plum tree** | - | 3558 | 3558 | - | 3212 | - | - | 12500 | - | 40150 |
| **Almond tree** | 66021 | 6393 | 72414 | 61318 | 5474 | - | 301 | 1503 | - | 26684 |
| **Vineyard (dessert grapes)** | - | 5927 | 5927 | - | 5532 | | - | 26000 | | 143832 |
| **Olive** | 468 | 730 | 1198 | 423 | 693 | - | 650 | 1800 | - | 1522 |

*Table 38. Wine production (Region of Murcia)*

| **Region of Murcia**<br>**Crop** | **Production area yield (kg/ha)** | | | | **Grape production (tonnes)** |
|---|---|---|---|---|---|
| | **One crop** | | **Asociated crop** | | |
| | **Unirrigated** | **Irrigated** | **Unirrigated** | **Irrigated** | |
| **Vineyard (for wine)** | 1800 | 5800 | - | - | 96519 |

*Table 39. Wine production (Region of Murcia)*

| Region of Murcia | **Total new wine** | | | **Table wine** | | |
|---|---|---|---|---|---|---|
| **Production (hectolitres)** | **White** | **Red and rosé** | **Total** | **White** | **Red and rosé** | **Total** |
| **Wine** | 27025 | 648609 | 675634 | 15085 | 362036 | 377120 |

*Table 40. Olive oil production (Region of Murcia)*

| **Region of Murcia**<br>**Olive** | **Dress olive (tones)** | **Virgen extra oil (tonnes)** | **Olive-pomace oil (tones)** | **Degreased olive pomace oil (tones)** | **Cloudy (hectoliters)** |
|---|---|---|---|---|---|
| | 1641 | 4728 | 473 | 7430 | 225 |

## 2. Protection and trade

Influence of regional, national and international agricultural market. With and important factor being price of agricultural products, since they are staples foods, but those process depend on seasonal demands, production quantity, etc. Thus, the importance of those products in economy it is also visible in the number of workers in the agricultural sector, that even if its number is the lowest in the following table and graphical representation, that is due to the fact that the Region of Murcia Region has suffer in the last decade a construction "boom", and many farmers sold their lands for new constructions, and more and more people went to work in that sector each passing year.

| Workers per activity sector | | |
|---|---|---|
| Agriculture | 288 | 6,32 % |
| Industry | 959 | 21,00 % |
| Construction | 1.966 | 43,15 % |
| Services | 1.343 | 29,48 % |
| No data | 0 | 0,00 % |
| **Total** | **4.556** | **100 %** |
| Self-employed | 778 | |
| Employed | 3.778 | |

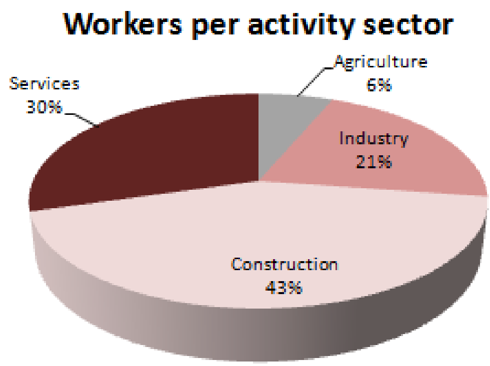



*Figure 121. Workers per activity sector in Bullas*

**Wine market:**

With the construction "boom" that the Region of Murcia suffered in the last decade, many farmer sold their lands and changes activities to go work in that construction sector, which led to and 7,94 % enterprises in Bullas' agriculture sector in 2009.

| Enterprises per activity sector | | |
|---|---|---|
| Agriculture | 42 | 7,94 % |
| Industry | 59 | 11,15% |
| Construction | 167 | 31,57 % |
| Services | 261 | 49,34 % |
| No data | 0 | 0,00 % |
| **Total** | **529** | **100 %** |

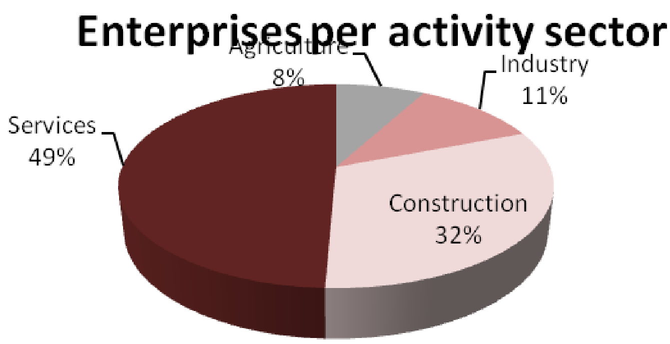


*Figure 122. Enterprises per activity sector in Bullas*

The majority of Bullas Denomination of Origin wine production, it is produced to be consumed within the territory of Spain, with its prices been determined by country economy, as it is show in the following table, noticing the influence of current national recession period (red circle).

Table 41. Market economic value of Bullas D.O. Wine

| SEASON (D.O. BULLAS WINE) | 2002/2003 | 2003/2004 | 2004/2005 | 2005/2006 | 2006/2007 | 2007/2008 | 2008/2009 | 2009/2010 |
|---|---|---|---|---|---|---|---|---|
| INTERNAL MARKET ECONOMIC VALUE (€) | 1267912 | 1290660 | 1086940 | 996003 | | 1490000 | 1532779 | **1394794** |
| EXTERNAL MARKET ECONOMIC VALUE (€) | 585946 | 561955 | 496388 | 229061 | | 1047200 | 550434 | **388306** |
| TOTAL ECONOMIC VALUE (€) | **1853858** | **1852615** | **1583328** | **1225064** | | **2537200** | **2083213** | **1783100** |

## 3. Crop insurance:

Crop insurance is purchased by agricultural producers, including farmers, ranchers, and others to protect themselves against either the loss of their crops due to natural disasters, such as hail, drought, and floods, or the loss of revenue due to declines in the prices of agricultural commodities[83]. IPCC describes insurance for heat wave, droughts, frost, summer droughts and hailstorm.

In the Region of Murcia there are some agricultural organizations such as Fecoam, Apoexpa, Proexport, etc., that advise farmers in cultivar development, and help them to adapt to new situations, such as climate change. Those organizations are also present in Bullas, but over there, and specificall for wine production, the organization in charge of this is the Regulating Council of the 'Bullas' Origin Denomination.

Evolution of the sum insured in Spain[84]:

[83] *http://en.wikipedia.org/wiki/Crop_insurance*
[84] *Source: http://dialnet.unirioja.es/servlet/articulo?codigo=2945306*

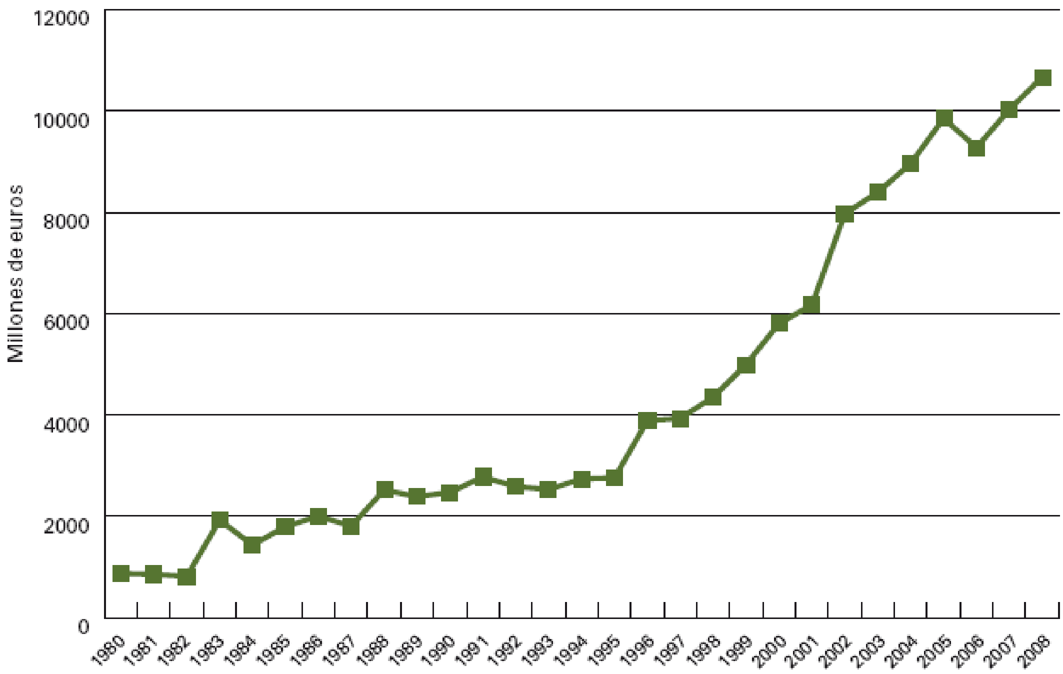



*Figure 123. Evolution of the sum insured in Spain*

Current situation of insured crops in the Region of Murcia[85]:

- Peach tree: 95 % of total production insured.
- Apricot tree: 85 % of total production insured.
- Vineyard (dessert grapes): 46 % of total production insured.
- Vineyard (wine): 53 % of total production insured.
- Plum tree: 37 % of total production insured.

Most of the crops are insured which leads on a higher adaptive capacity.

## 4. Production:

Main adaptation for vineyards and other cultivations in Bullas is represented by the increase of localized unirrigated cultivations, as a part of an adaptation process due to water shortage and climate change. This adaptation process follows no plan at the moment, and it is basically an "auto-adaptation" from farmers using their

[85] *Source: http://dialnet.unirioja.es/servlet/articulo?codigo=2945306*

own knowledge in farming, specifically for vineyards. This adaptation it is also slowly introducing specific technology to fight against climate change.

*Table 42. Economical and production data of Bullas Denomination of Origin (2002/2010)*

| SEASON (D.O. BULLAS WINE) | 2002/2003 | 2003/2004 | 2004/2005 | 2005/2006 | 2006/2007 | 2007/2008 | 2008/2009 | 2009/2010 |
|---|---|---|---|---|---|---|---|---|
| AREA (Ha) | 2550 | 2500 | 2500 | 2254 | 2258 | 2500 | 2563 | **2545,29** |
| Vine growers | 800 | 800 | 800 | 670 | 675 | 650 | 608 | **674** |
| kg of grapevine manufactured by Bullas D.O. wineries | | | | 7514589 | 7793522 | 7636750 | 6021878 | **5899614,55** |
| Production (HL) | **25416,92** | 15500 | 15185 | 12994 | 14425 | 16387 | 13008 | **14712,72** |
| Spanish marketing (HL) | 5133,25 | 5162,64 | 4348 | 6124 | 3461 | 4709 | 5043 | **4665** |
| Export (HL) | 3279,66 | 3243,79 | 2751,75 | 1433 | 2521 | 2693 | 2163 | **1431** |
| Stock on July 31th (HL) | 16155,76 | 17238,59 | 14343 | 14495 | 14495 | 16946 | 17747 | **17666** |

*Red data are waiting for approval[86].

## 5. Cultivar and crop change (cultivar development)

Broad-adapted, widely adapted, stress-tolerant cultivars coupled with sustainable crop and natural resource management, will provide means for farmers to cope with climate change and benefit consumer worldwide. Multi environment trials are very important for breeding cultivars with general or specific adaptation and yield stability[87].

Premium wine production, adaptation options may include the shift of varieties from their original cultivation areas to match their climatic requirements and to escape extreme events. Precocity may be a key word also for grapevine to escape both drought and heat stress during fruit ripening phase and the choice of the plant material is the first key for a warmer climate adaptation[88].

In the Region of Murcia there are some agricultural organizations such as Fecoam, Apoexpa, Proexport, etc., that advise farmers in cultivar development, for future adaptations and help them to adapt to new situations, such as climate change,

[86] Source: Council of Bullas Denomination of Origin
[87] Source: Reynolds, 2010
[88] Source: Moriondo and Bindi, 2007

while in Bullas the organization in charge of this is the Regulating Council of Bullas Denomination of Origin.

### 6. Agricultural modeling:

Crop modelling is used for main agricultural products, and specifically for wine the organization in charge of this is the Regulating Council of Bullas Denomination of Origin, to facilitate planning and adaptation to climate change. Those models are useful even if Bullas is not a critical microclimate for grape growing, since they help to improve phenological developments and wine management for the different varieties.

### 7. Weather forecast

Some indicators concerning weather forecast that may help to adapt to climate change are, in an autonomous approach, improved weather forecast to prevent impact on agriculture, as well as providing farmers with updated weather bulletins, also on the internet, and specifically for wine production, to implement a monitoring system for the maturation period of the grapevine.

Weather forecast can be used by farmers for prevention, and as an early warning system. Weather forecast is available in the municipality of Bullas from many sources, such as:

- National Agency of Meteorology (AEMET)
- Agro-climatic stations: The Ministry of Environment and Rural and Marine Affairs, since 1998 promotes the installation, operation and maintenance of Agro-climatic Information System for Irrigation (SIAR), which basically involves creating an infrastructure that captures, records and transmits the data necessary for calculating water demand of irrigated areas.

  The parameters obtained are temperature and humidity, wind speed and direction, solar radiation and precipitation, so that they can draw conclusions about irrigation needs based on actual data from their own areas.

In the Region of Murcia, there are agro-climatic stations in the following areas[89]:

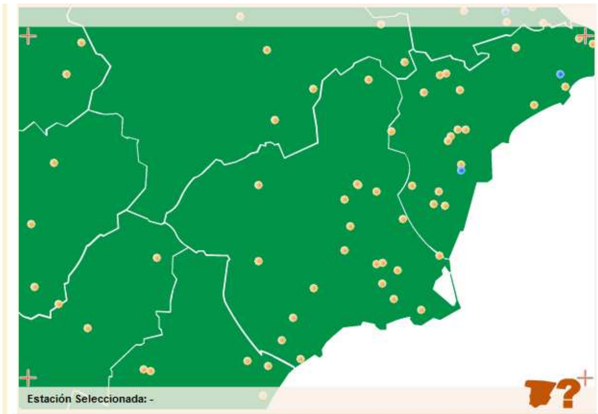



Figure *124*. Agroclimatic stations in the Region of Murcia

- Other local sources:

http://previsionmeteorologicabullas.blogspot.com/ (BULLAS METEO)

There is enough information available about weather forecast because of the importance of the agricultural sector in Murcia, which helps the sector to avoid, when possible, crop losses, and Bullas' farmers tend to use them.

## 8. Water management (efficient water use)

Water has become in a good very controversial, a bad distributed resource and it worries who has its control in these last years. The modernization of irrigation is interested because it has a space, social, economical, water distribution importance. The Region of Murcia, in recent years has become a laboratory of experience of modernization of irrigation. In the European Union, the improvement and modernization of irrigation participate of the Common Agrarian Politic (PAC) and the Rural Development, and they also participate of the Environmental Politic (2000/60/CE Directive) and the Sustainable Development. The new Sustainable Irrigation Plan «Horizon 2013» must collect the Lisboan

[89] *Source: Ministry of Environment and Rural and Marine*

Strategy proposals about job and competitively and the Gotemburg Declaration proposals about historical and environmental value[90].

The Region of Murcia is one of the leading regions in Spain in water management, due to the lack of available water in the region. Bullas, as well as all the other municipalities in Murcia use the most efficient irrigation techniques for its cultivations, and there was also a slightly change in the direction of production with an increase of unirrigated cultivations, such as some varieties of vineyards for wine production.

[90] *Source: E. Gil Meseguer, 2010.*

#### 4.2.3.2 ADAPTIVE CAPACITY EVALUATION

**Adaptive capacity:**

Adaptive capacity relays strongly on a place socio-economic situation, and the awareness of the population about the arising problems, and what changes do they carry with. So far that those are determinant factors in the evaluation of the adaptive capacity evaluation of a specific place. There are some common barriers to the agricultural system's ability to accommodate changes in climate, which are listed above:

*Table 43. Factors influencing adaptive capacity in Bullas.*

| **Determinants of adaptive capacity** | **Barriers to incorporating adaptive practices** |
|---|---|
| Socio-economic conditions | - Bullas economy is mainly agricultural.<br>- The rural area occupied more than 96% of the total (82.1 km$^2$). |
| Awareness | - Farmers are unaware/ unconcerned about climate change.<br>- Farmers have more immediate concerns.<br>- Farmers are confident with their own adaptive abilities.<br>- Farmers are generally accepting of their own limitations in the face of extreme weather conditions.<br>- Farmers are confident in the local conditions. |

| | |
|---|---|
| Technology | - Informed decisions require extensive research.<br>- New cropping and livestock machinery is often complicated, means a steep learning curve once it is acquired.<br>- High cost of new technology.<br>- Other factors to consider in the adoption of biotechnology.<br>- Sometimes technological response is not available to address climate conditions. |
| Resources | - Bullas net farm income declining due to the current global economic situation (wine is not a staple/basic food).<br>- Farmers retiring soon not likely to invest in changes.<br>- There are many small farms which have less access to capital for new technology.<br>- Volatile commodity prices increase financial risk, cause producers to cut costs (e.g. input costs). |
| Human capital | - Some farmers are late innovators, and wait until technology is proven before incorporating it.<br>- Inexperience dealing with new risks limits response.<br>- Knowledge, experience, and ability to learn influences the use of technologies.<br>- If farmer’s children do not join farm business growth is often restricted, which can restrict incorporating new practices.<br>- Some farmers choose to stay small, restricts incorporating new technologies. |

| | |
|---|---|
| Social capital | - Young people are not becoming farmers.<br>- Some farms are increasing in size: competition from large farms threatens smaller operations |
| Information management | - Limited extension services to communicate climate change impacts and adaptation.<br>- New weather-related problems catch farmers without a response (i.e. pest) |

*Table 44. Bullas' adaptive capacity*

| **ADAPTIVE CAPACITY** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Impact** | **Adaptation baseline (Underway and planned adaptation actions, etc)** | **Factors determining the adaptive capacity of the sector** | **Is the system already able to accommodate changes in climate with minimal costs and disruption?** | **Can the sector adjust to the projected impact with minimal cost and disruption?** | **Barriers to the system's ability to accommodate changes in climate** | **Existing stress unrelated to climate that limit the system's ability to accommodate changes in climate** | **Rate of projected climate change compared to the adaptability of the system** | **Adaptive capacity** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Crop area changes (including impacts in native plants and crops) | Common Agricultural Policy (CAP).<br><br>The (CAP) has a role to play in facilitating helping farmers to adapt their production to the climate change. | In the Region of Murcia there are some agricultural organizations such as Fecoam, Apoexpa, Proexport, etc., that advise farmers in cultivar development, and help them to adapt to new situations, such as climate change, while in Bullas, and specifically for wine the organization in charge of this is the Regulating Council of Bullas Denomination of Origin.<br><br>Technology and innovation can contribute to improve the competitiveness of farming systems.<br><br>Most of the crops are | No, it requires high level of investments, and political implication. | Maybe, but it will require significant cost and staff intervention. | Biological Geographical Physical Economic Social Political | Ecosystem fragmentation<br><br>Presence of invasive species | Faster than the adaptability of the sector/system | AC3. Maybe - Will require some costs ($$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | insured. | | | | | | |
| Crop quality and productivity changes. | Common Agricultural Policy (CAP). The (CAP) has a role to play in facilitating helping farmers to adapt their production to the climate change. | In the Region of Murcia there are some agricultural organizations such as Fecoam, Apoexpa, Proexport, etc., that advise farmers in cultivar development, and help them to adapt to new situations, such as climate change, while in Bullas the organization in charge of this is the Regulating Council of the 'Bullas' Origin Denomination. Technology and innovation can contribute to improve the competitiveness of farming systems. | No, it requires high level of investments, and political implication. It requires investments in Research & Development. | Maybe, but it will require significant cost and staff intervention. | Biological Geographical Physical Economic Social Political | Ecosystem fragmentation Presence of invasive species | Faster than the adaptability of the sector/system | AC3. Maybe - Will require some costs ($$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Most of the crops are insured. | | | | | | |
| Agricultural pests, diseases, and weeds | Clean agriculture program. | In the Region of Murcia there are some agricultural organizations such as Fecoam, Apoexpa, Proexport, etc., that advise farmers in cultivar development, and help them to adapt to new situations, such as climate change, while in Bullas the organization in charge of this is the Regulating Council of the 'Bullas' Origin Denomination.<br>Most of the crops are insured.<br>Technology and innovation can contribute to improve the competitiveness of farming systems. | No, it requires high level of investments, and political implication.<br>It requires investments in Research & Development. | Maybe, but it will require significant cost and staff intervention. | Biological Physical Economic Social Political | Pollution<br>Presence of invasive species | Faster than the adaptability of the sector/system | AC4: Yes - But will require some slight costs ($$) and staff interventions |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Clean agriculture program. | | | | | | |
| Soil erosion, salinization, and desertification | | Water availability.<br>Population involvement.<br>Rational use of water. | No, it will require significant cost and staff intervention | No, it will require significant cost and staff intervention | Biological Geographical Physical Economic Social Political | Urbanization Resources overexploitation | Faster than the adaptability of the sector/system | AC3. Maybe - Will require some costs ($$$) and staff intervention |
| Irrigation requirements (water availability) | | New technology and innovation.<br>Public intervention plays a key role. | No, it will require significant cost and staff intervention.<br>It requires investments in Research & Development. | No, it will require significant cost and staff intervention | Biological Geographical Physical Economic Social Political | Urbanization Population growth<br>Resources overexploitation | Faster than the adaptability of the sector/system | AC3. Maybe - Will require some costs ($$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Increased expenditure in emergency and remediation actions (including fires) | National and Regional Plans. | Most of the crops in Bullas are insured. | No, it will require significant cost and staff intervention | No, it will require significant cost and staff intervention | Biological Geographical Physical Economic Political | | Faster than the adaptability of the sector/system | AC3. Maybe - Will require some costs ($$$) and staff intervention |
| **WINERY LEVEL** | | | | | | | | |
| **Impact** | **Adaptation baseline (Under way and planned adaptation actions, yet)** | **Factors determining the adaptive capacity of the sector** | **Is the system already able to accommodate changes in climate with minimal costs and disruption?** | **Can the sector adjust to the projected impact with minimal cost and disruption?** | **Barriers to the system's ability to accommodate changes in climate** | **Existing stress unrelated to climate that limit the system's ability to accommodate changes in climate** | **Rate of projected climate change compared to the adaptability of the system** | **Adaptive capacity** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Wine quality | - | There is a Regulating Council of the 'Bullas' Origin Denomination.<br><br>Access and ability to process information.<br><br>Availability of technical tools.<br><br>Resources to invest in adaptation.<br><br>Willingness of the sector to change and adapt.<br><br>Potential impacts in wine grapes | No | Maybe.<br><br>The system is already able to offset the problems derived from higher temperatures, using chemical techniques in wineries, while hazards from extreme events | Limited financial resources.<br><br>Technological advances are needed. | Biological<br>Geographical<br>Physical<br>Economic<br>Social<br>Political | Faster than the adaptability of the sector. | AC3. Maybe - Will require some costs ($$$) and staff intervention |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | quality due to higher temperatures can be thwarted in wineries while potential impacts due to extreme events or changes in precipitation patterns can cause irreversible damages. | | and precipitation patterns are more difficult to counteract. | | | | | |
| Wine production | - | Access and ability to process information.<br>Availability of technical tools.<br>Resources to | No | Maybe.<br>The system is already able to offset the | Limited financial resources.<br>Technological advances are needed. | Biological<br>Geographical<br>Physical<br>Economic<br>Social<br>Political | Faster than the adaptability of the sector. | AC3. Maybe - Will require some costs ($$$) and staff intervention | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | invest in adaptation.<br>Willingness of the sector to change and adapt.<br>Potential impacts in wine grapes quality due to higher temperatures can be thwarted in wineries while potential impacts due to extreme events or changes in precipitation patterns can cause irreversible | | problems derived from higher temperatures, using chemical techniques in wineries, while hazards from extreme events and precipitation patterns are more difficult to counter | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | damages. | | act. | | | | |

## 4.2.4 VULNERABILITY

### 4.2.4.1 VULNERABILITY INDICATORS

1. **Water scarcity:** Vulnerability to water scarcity is determined by the gap between water supply and demand and is expressed as a % change of current and expected future water sufficiency in comparison with a baseline.

   *Water Stress*[91]; *Water Exploitation Index* (WEI)[92] ; Falkenmark index[93].

2. **Droughts:** Vulnerability to droughts and water scarcity is determined by the gap between water supply and demand and is expressed as a % change of current and expected future water insufficiency in comparison with a baseline.

   Palmer Drought Severity Index (PDSI)[94], Crop moisture index[95].

3. **Socio-economic developments:** Assessment of the vulnerability of agriculture to climate change is strongly dependent on concurrent changes in socio-economic development pathways. An integrated approach to the construction of socio-economic scenarios required for the analysis of climate change impacts on European agricultural land use is presented by Adildtrup et al (2006). Antle et al (2004) concluded that the relationship between relative vulnerability and resource endowments varies with assumptions about climate change, adaptation, and economic conditions.

### 4.2.4.2 VULNERABILITY ASSESSMENT

***VULNERABILITY = function [exposition (+); sensitivity (+); adaptive capacity (-)]***

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[91] Measured as the ratio of total water availability to total water withdrawals

[92] Water Exploitation Index (WEI) for a country is calculated as the mean annual total demand for freshwater divided by the long-term average freshwater resources

[93] Measures renewable water recourses per capita

[94] Measures meteorological droughts. PDSI is based on the cumulative difference between normal precipitation and precipitation needed for evapotranspiration (Palmer, 1965). Alley (1985) adjusted it to measure the hydrological drought as well.

[95] Measured as the difference between the actual and expected weekly evapotranspiration (Palmer, 1968)

*Table 45. Sensitivity and adaptive capacity matrix*

| SENSITIVITY AND ADAPTIVE CAPACITY MATRIX | | | | | |
|---|---|---|---|---|---|
| | **S1** | **S2** | **S3** | **S4** | **S5** |
| **AC1** | V2 | V2 | V4 | V5 | V5 |
| **AC2** | V2 | V2 | V3 | V4 | V5 |
| **AC3** | V2 | V2 | V3 | V4 | V4 |
| **AC4** | V1 | V2 | V2 | V3 | V3 |
| **AC5** | V1 | V1 | V2 | V3 | V3 |

**VULNERABILITY SCALE:**
**V1: Low vulnerability**
**V2: Medium-Low Vulnerability**
**V3: Medium Vulnerability**
**V4: Medium-High vulnerability**
**V5: High vulnerability**

*Table 46. Vulnerability ratings*

| VULNERABILITY RATINGS | | | | |
|---|---|---|---|---|
| **High vulnerability (S5-AC1)=V5** | **Medium-High Vulnerability (S4-AC2)=V4** | **Medium Vulnerability (S3-AC2 or S3-AC3)=V3** | **Medium-Low Vulnerability (S2-AC3 or S2-AC2)=V2** | **Low Vulnerability (S1-AC5)=V1** |
| **Impact** | **Impact** | **Impact** | **Impact** | **Impact** |
| | Crop quality and productivity changes. | Crop area changes (including impacts in native plants and crops) | Agricultural pests, diseases, and weeds | |
| | Soil erosion, salinization, and desertification | | Increased expenditure in emergency and remediation actions (including fires) | |

| | | | | |
|---|---|---|---|---|
| | Irrigation requirements (water availability) | | | |
| | Wine quality and production | | | |

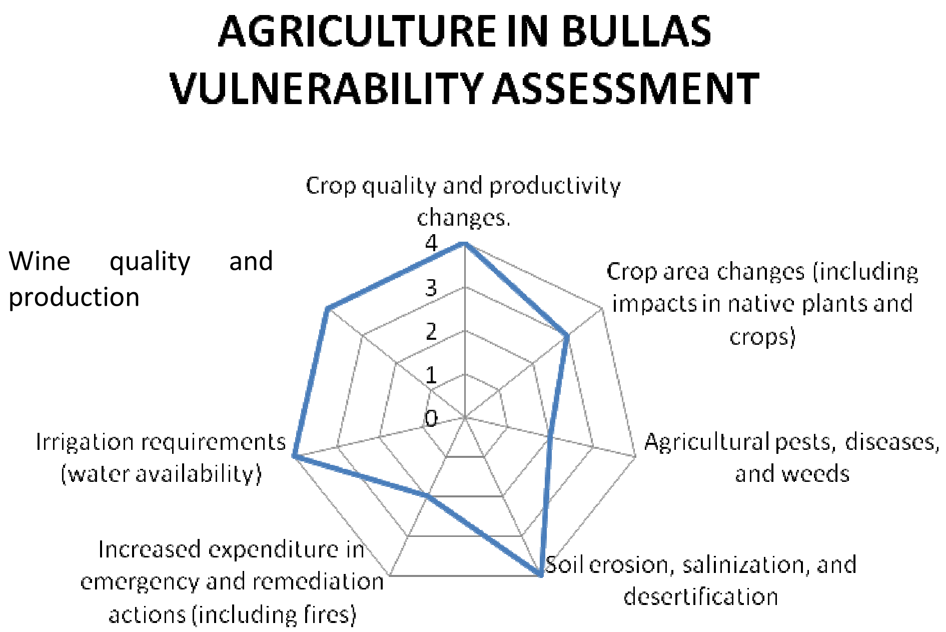



*Figure 125. Agriculture in Bullas vulnerability assessment*

## 4.3 Soil

Land is hilly with altitude typography upward from south to north. This typography does not result in broad valleys, but small ones with its own microclimate. Hillsides soils are brown and so tough that they need to be open mechanically before planting the vines. They consist of land-brown limestone and limestone crust, low in organic matter, good drainage and high levels of limestone, as well as alluvial soils of highly variable soil characteristics.

Bullas is characterized as a zone of limestone in the Subbetica litosoils area and shallow soils over them. From the standpoint of growing importance soils are noted for their brown-limestone soils (moderately high water capacity and permeability is not very high, high percentage of 35-65% calcium carbonate, pH close to 8, living organic matter 1-2%) and limestone crust (extreme aridity, vegetation and difficult to accommodate easily eroded) and alluvial (water-holding capacity average around 30%, permeability is not very high percentages of calcium carbonate 40-60% active, pH 7-8, organic matter between 0.5-1%).

The low organic content of these soils, good soil drainage and the high level of limestone are favorable characteristics for growing quality vines. In the case of land reclamation crust is required prior to it. The alluvial soils, soil characteristics are highly variable and in some cases when they have good depth, good drainage, proper proportion of lime and a low proportion of organic matter can form excellent soil for growing vines.

Soil includes:

- Soil
- Vegetation
- Management

Before studying the vulnerability of this sector, it's necessary to take into account the degree of erosion that Bullas' soil is suffering currently, there are different approaches to assess the soil loss risk. Data from "Geographic Atlas of the Region of Murcia", calculated with ULSE model, point out than the sediment loss in soil by rill and inter-rill erosion, caused by water in Murcia is between 50 and 200 t/Ha.year.

## 4.3.1 Exposure

Soil functions must be protected because of both their socio-economic and environmental importance. Socio-economic analysis to identify the fragility of an area on the basis of the human pressure to which it is subjected.

### 4.3.1.1 EXPOSURE INDICATORS

The following indicators allow to identify the fragility of Bullas on the basis of the human pressure to which it is subjected.

- **Population density**: 150,59 inh/km$^2$
- **Population growth rate** (1993-2008): 0-25%

Regarding to <u>grape wine production</u>:

- **Tillage**: There are farms that have ceased to plow and now they make a crop based on the work of the grass which springs from the plot, but in general:
    - **Tillage depth:** Arable land should never be more than 20 cm. Although sometimes there are farmers who make a "Vina" that is when you only move 3 to 5 cm. terrain, in order to cool it because the thermal oscillation. In addition, with this work to stir up dust and keep this on the leaves, it is needed to protect the cluster from moisture, since dust that takes most of the moisture from condensation.

- **Tillage direction:** Perpendicular to the slope, and never on behalf of the slope.
- **Tillage operations:** The type of plow used is the typical step-shaped grating or swallow or dove shape.
- **Timing of first tillage operation:** is usually done in October / November, that way compaction from harvest work it is removed, and the ground is prepared for the first precipitation. Always before the ground freezes.

- **Principal type of fertilizer:** Fertilizers are not used in Bullas. When a quality-oriented farming is done, there should not fertilize each year. When fertilization is required, it is done while in biological rest of the plant and, usually, it is done one year in one lane and the next in the other. Although in recent years and due to the lack of benefits, fertilization was not mainly used.

Anyway, it is only used in plots where grape wines are cultivated in trellis with located irrigation.

- **Use of Phytosanitary products:** Phytosanitaries are not used in Bullas, and now even less, wines in the Denomination of origin has turn to ecological cultivation. Sulfur, and cupric sulfur are used in general as a preventive.

If any pest attack, the approach is to try to deal with it, and if there is mold (mildew, powdery mildew ...), too, but minimally. About Lobesia attacks in the last phenological stages of grapevine (in almost vintage), is not usually treated, and if you do not have pheromone mating disruption, use of which has fallen more than three-quarters in the past two seasons due to decreased grant from the Regional Administration, the attacks tend to be quite harmful. The grapes will rot and must be used for purposes other than wine VCPRD.

- **Total number of mechanical interventions:** Between 5 and 6 times a year, based on precipitations. It looks excessive, but that how is it works in Bullas.

#### 4.3.1.2 EXPOSURE ASSESSMENT

*Table 47. Exposure*

| EXPOSURE | | | |
|---|---|---|---|
| **Impact** | **Factors influencing the exposure of the sector** | **Exposed elements/groups** | **Level of exposure** |
| Soil fertility loss | Fires frequency.<br>Over exploitation.<br>Grazing intensity. | Farmers (net farm income)<br>Wine industry<br>Tourism industry<br>Water supply<br>Rural housing | Medium |
| Soil Salinization | Changes in precipitation patterns. | Farmers (net farm income)<br>Wine industry<br>Tourism industry<br>Water supply<br>Rural housing | Medium |

| | | | |
|---|---|---|---|
| Soil compactation | Grazing intensity.<br>Fires frequency | Farmers (net farm income)<br>Wine industry<br>Tourism industry<br>Water supply<br>Rural housing | Medium |
| Soil erosion | Fires frequency.<br>Grazing intensity | | Medium |
| Soil sealing | Aquifer over exploitation | | Medium |
| Aquifer<br>over-exploitation | Changes in precipitation, evaporation and factors that affect water consumption.<br>Drying climate in some regions might lead to water supply problems for farmers.<br>Water quality and/or quantity might in future not be able to satisfy farmers' demand.<br>Urbanization<br>Population grown | Wine-wide<br>Farmers (net farm income)<br>Tourism<br>Rural housing | Medium |
| Land abandonment | Soil fertility loss | Wine-wide | Medium |

| | | | |
|---|---|---|---|
| | Organic matter decline<br>Salinization<br>Soil compactation<br>Soil erosion<br>Soil sealing | Farmers (net farm income)<br>Tourism<br>Rural housing | |
| Organic matter decline | Land over exploitation.<br>Soil compactation (heavy rains tend to wash organic matter in lose soils). | Wine-wide<br>Farmers (net farm income)<br>Tourism<br>Rural housing | Medium |
| WINERY LEVEL | | | |
| **Impact** | **Factors influencing the exposure of the sector** | **Exposed groups** | **Level of exposure** |
| Change in suitability of soil for wine production | Soil fertility loss<br>Organic matter decline<br>Salinization<br>Soil compactation<br>Soil erosion | Wine-wide<br>Farmers (net farm income)<br>Tourism<br>Rural housing | Medium |

| | | | |
|---|---|---|---|
| | Soil sealing | | |

## 4.3.2 Sensitivity

### 4.3.2.1 SENSITIVITY INDICATORS

- Topography or slope gradient: Topographic maps from http://www.cartomur.com/visorcartoteca/ (north and south of Bullas Municipality).

  Figure 126. Bullas' topographic map I


C-415
bullas

Figure 127. Bullas' topographic map II

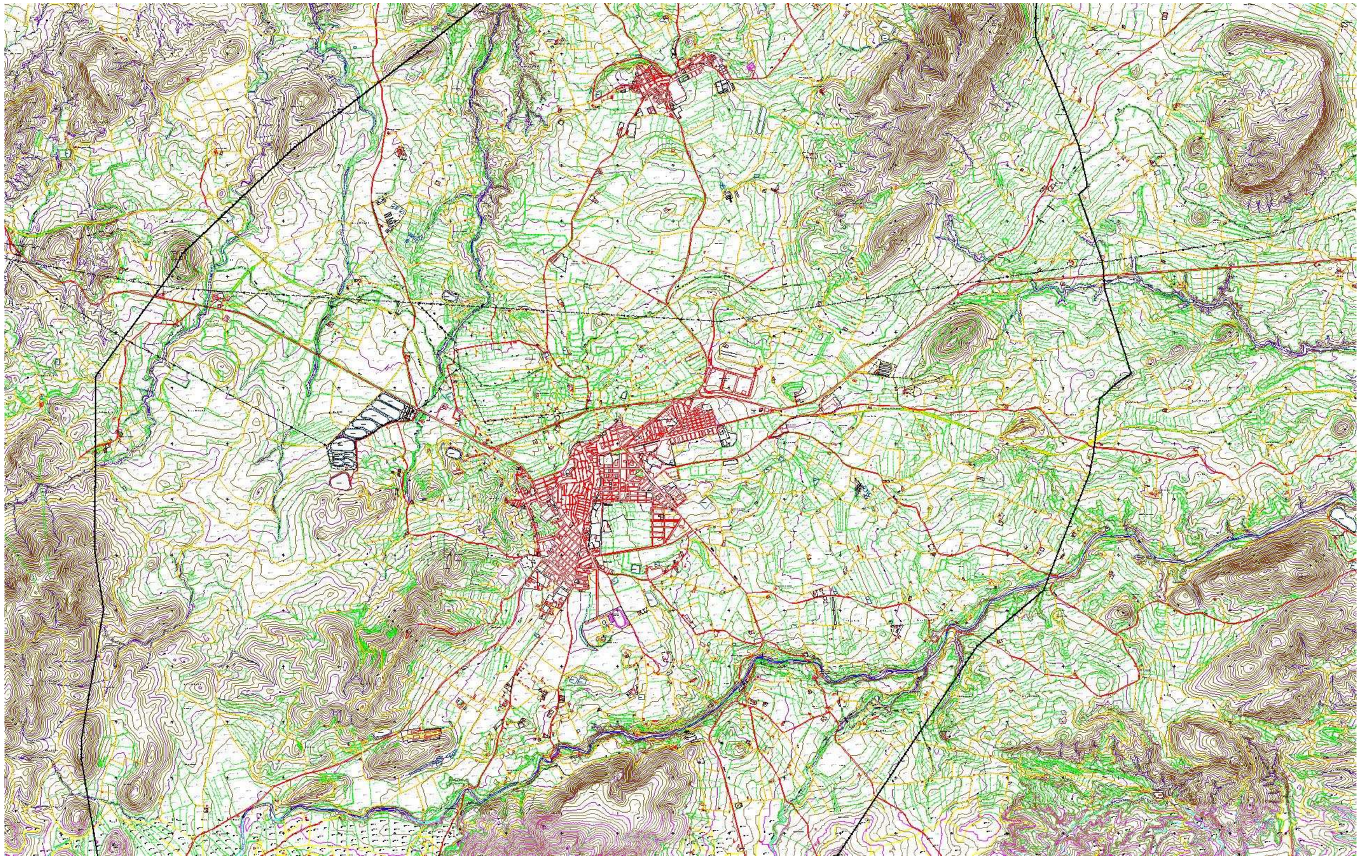
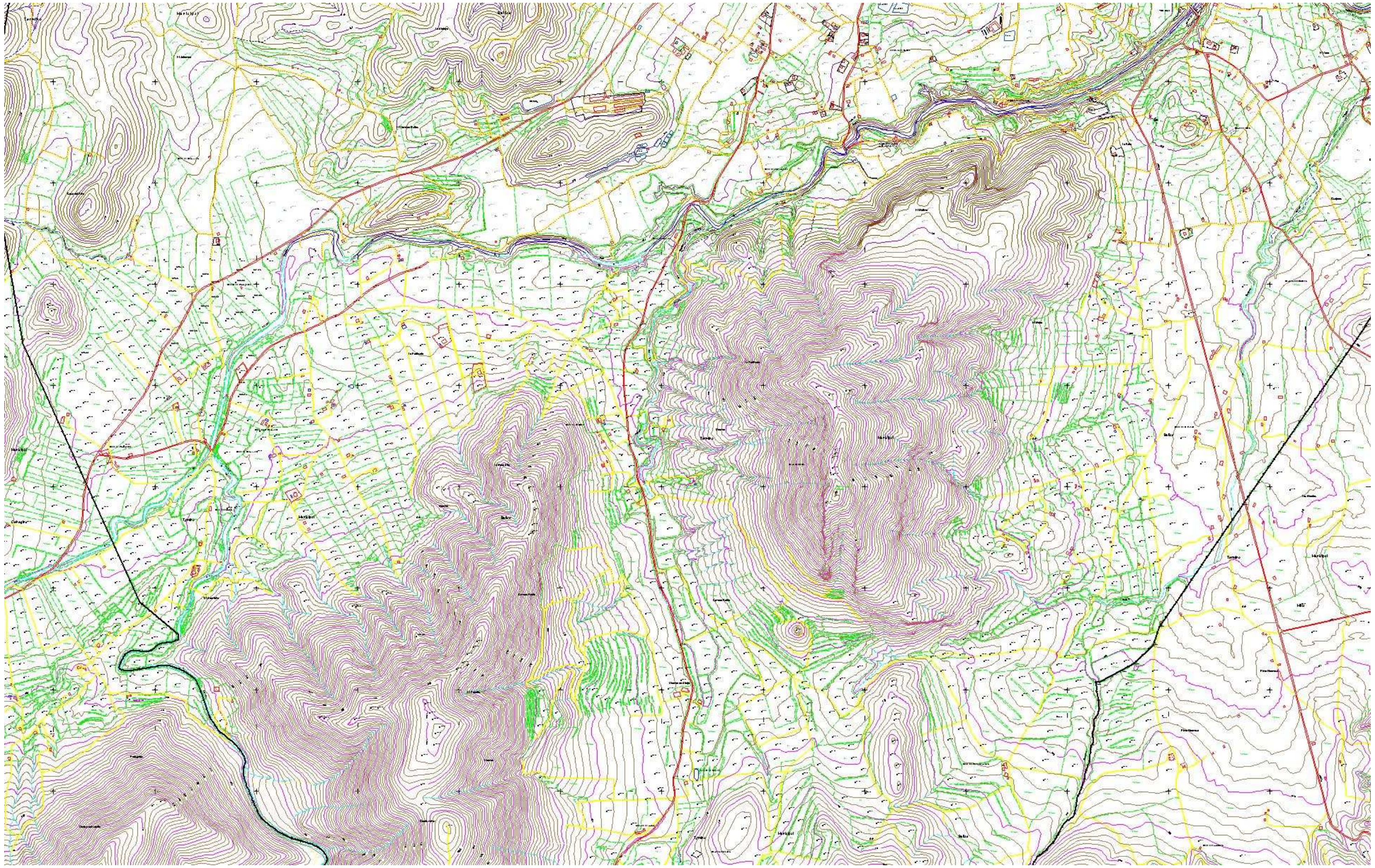


Figure 128. Bullas' topographic map III



- Local vegetation status: NDVI INDEX from Cuenca del Segura:

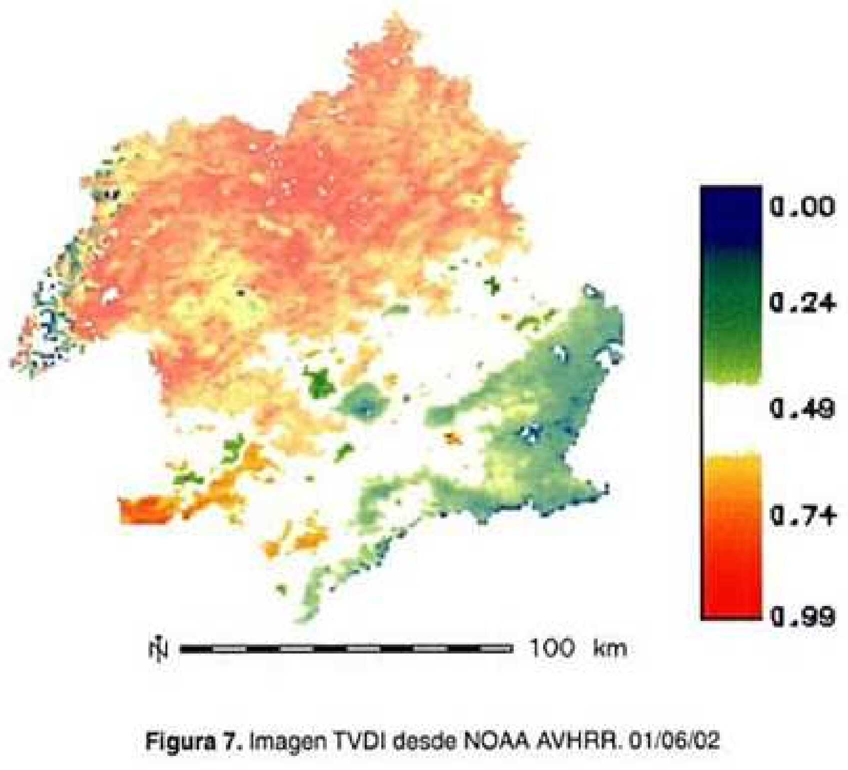
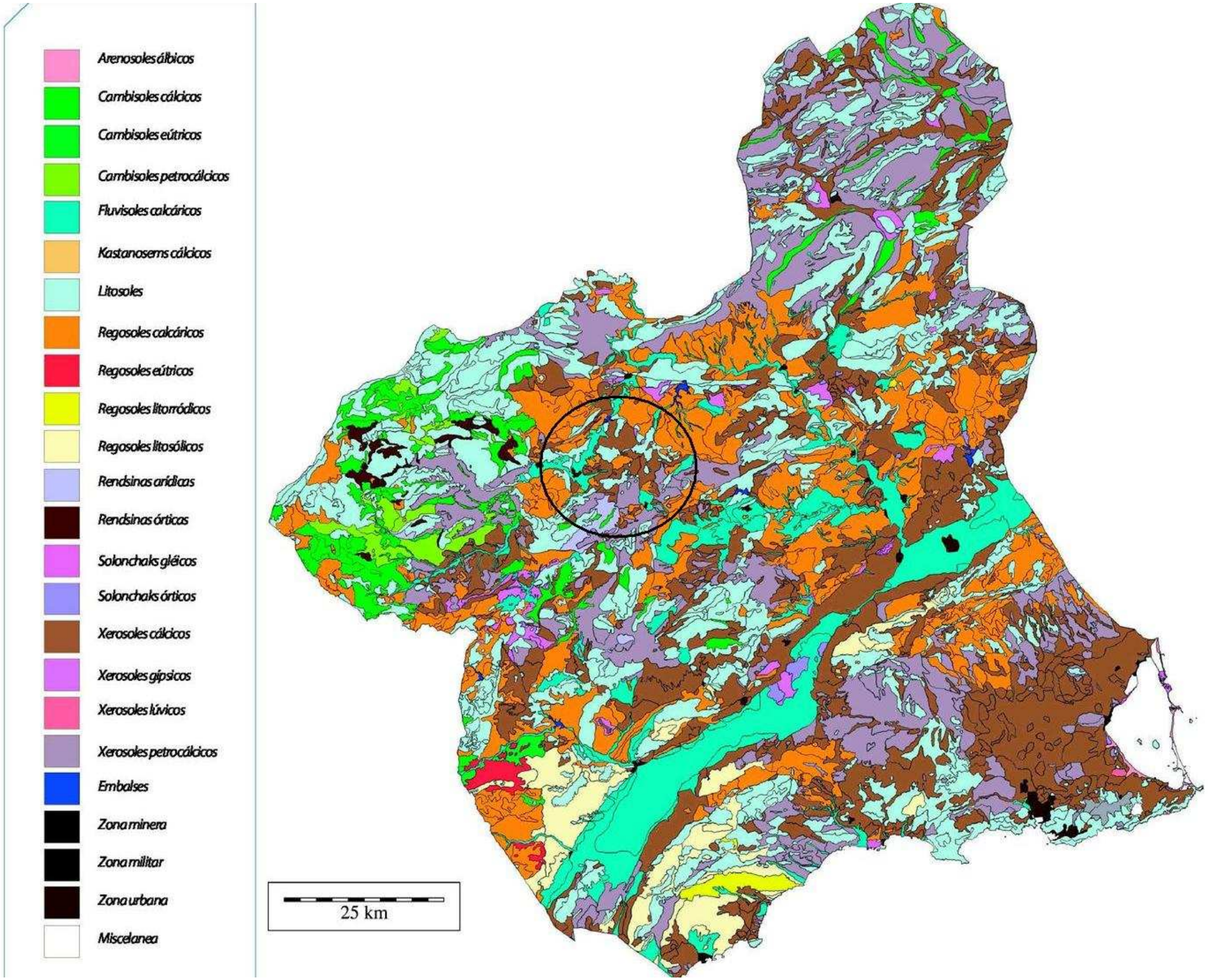



Figure 129. Local vegetation status

- Parent material:

Figure 130. Parental material in the Region of Murcia


Arenosoles álbicos
Cambisoles cálcicos
Cambisoles eútricos
Cambisoles petrocálcicos
Fluvisoles calcáricos
Kastanosems cálcicos
Litosoles
Regosoles calcáricos
Regosoles eútricos
Regosoles litorrádicos
Regosoles litosólicos
Rendsinas arídicas
Rendsinas órticas
Solonchaks gléicos
Solonchaks órticos
Xerosoles cálcicos
Xerosoles gípsicos
Xerosoles lúvicos
Xerosoles petrocálcicos
Embalses
Zona minera
Zona militar
Zona urbana
Miscelanea
25 km

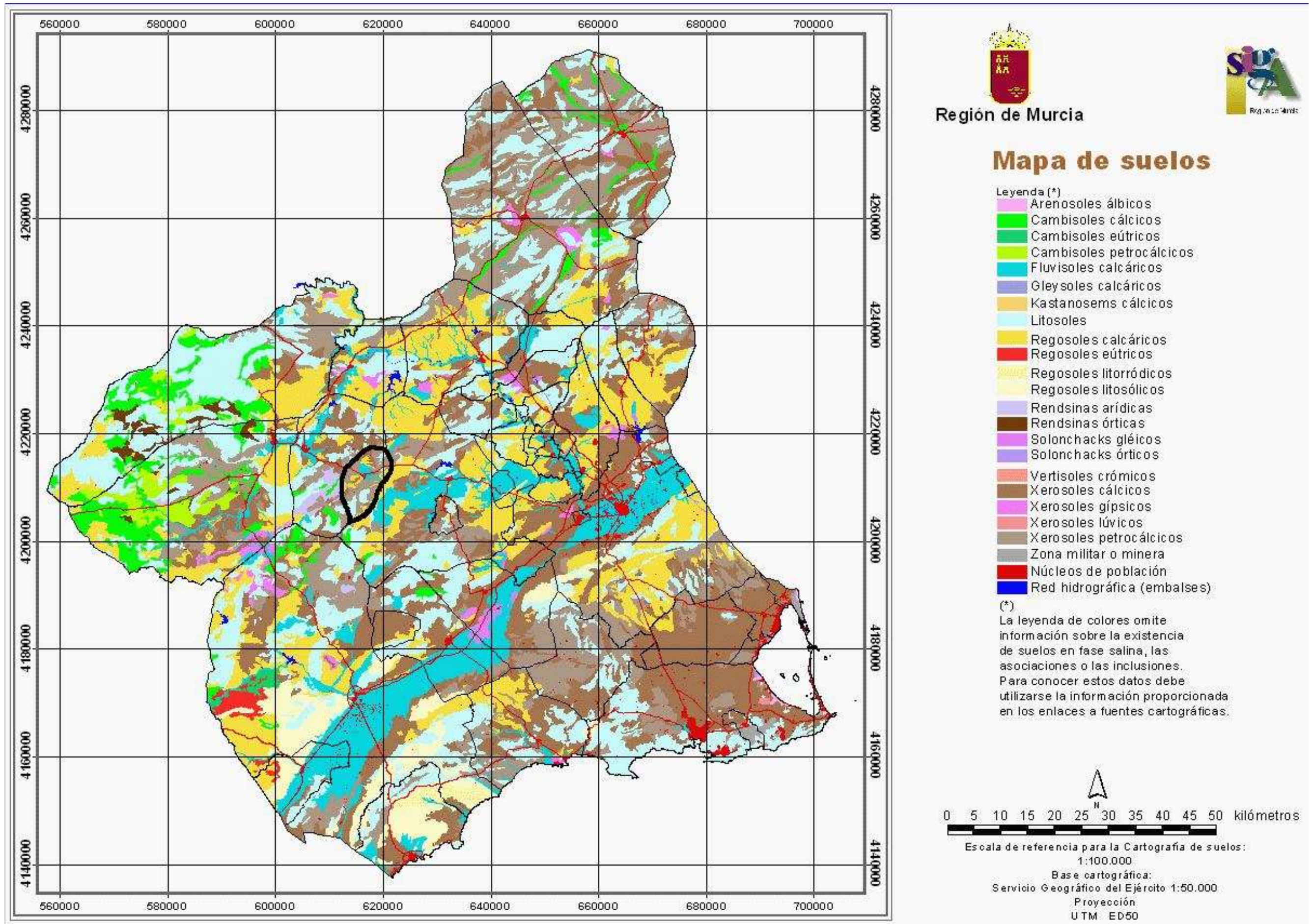



Figure 131. Soils types in the Region of Murcia

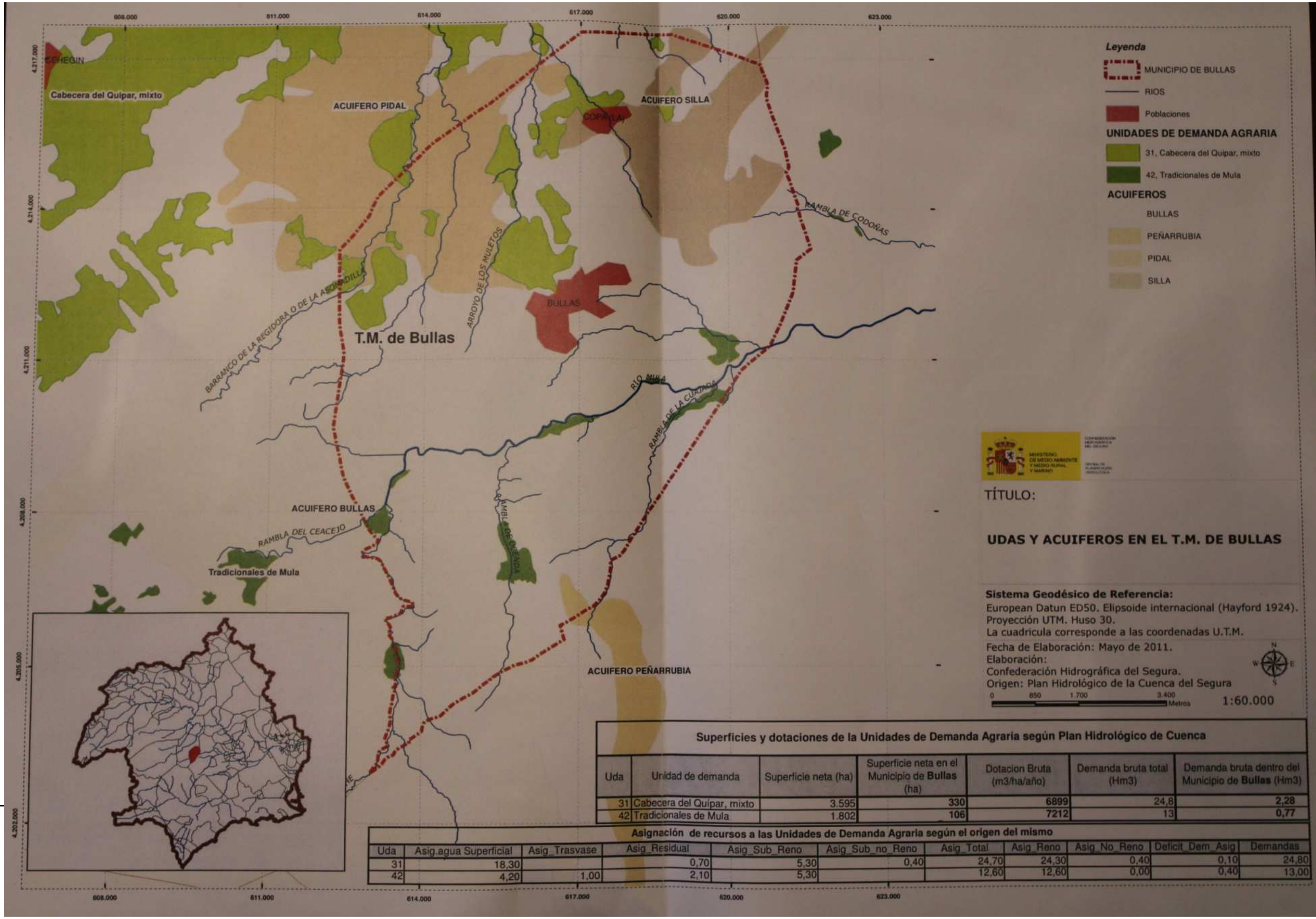
Bullas' soils types:

Table 48. Bullas' soil types.

| FAO-UNESCO | Soil type | |
|---|---|---|
| Lithosols (Orthent or Entisols) | Shallow or extremely gravelly soils: Leptosols | Poorly developed soils |
| | | |
| Calcaric fluvisols | Floodplains, tidal marshes: Fluvisols | |
| Calcaric regosols | Soils with no significant profile development: Regosols | |
| Calcic xerosols | Calcium carbonate: Calcisols | Accumulation of less soluble salts or non-saline substances |

- Groundwater recharge/availability:

Figure 132. Bullas' aquifers




**Superficies y dotaciones de la Unidades de Demanda Agraria según Plan Hidrológico de Cuenca**

| Uda | Unidad de demanda | Superficie neta (ha) | Superficie neta en el Municipio de **Bullas** (ha) | Dotacion Bruta (m3/ha/año) | Demanda bruta total (Hm3) | Demanda bruta dentro del Municipio de **Bullas** (Hm3) |
|---|---|---|---|---|---|---|
| 31 | Cabecera del Quípar, mixto | 3.595 | 330 | 6899 | 24,8 | 2,28 |
| 42 | Tradicionales de Mula | 1.802 | 106 | 7212 | 13 | 0,77 |

**Asignación de recursos a las Unidades de Demanda Agraria según el origen del mismo**

| Uda | Asig.agua Superficial | Asig_Trasvase | Asig_Residual | Asig_Sub_Reno | Asig_Sub_no_Reno | Asig_Total | Asig_Reno | Asig_No_Reno | Deficit_Dem_Asig | Demandas |
|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 18,30 | | 0,70 | 5,30 | 0,40 | 24,70 | 24,30 | 0,40 | 0,10 | 24,80 |
| 42 | 4,20 | 1,00 | 2,10 | 5,30 | | 12,60 | 12,60 | 0,00 | 0,40 | 13,00 |

- Compromised areas: The percentage of area where soil resilience is greatly weakened (more information in section B)

### 4.3.2.2 SENSITIVITY ASSESSMENT

*Table 49. Sensitivity*

| SENSITIVITY | | | | |
|---|---|---|---|---|
| **Impact** | **Existing stress unrelated to climate** | **Sensitive elements/groups** | **Factors influencing the sensitivity of a system/sector** | **Sensitivity** |
| Change in suitability of soil for wine production | Dependence on wine production that relies on current climate. | Farmers<br>Wine industry<br>Tourism | Los c | S4 |
| Fires frequency | Increased grazing frequency due to vegetation loss.<br>Dry climate. | Farmers<br>Wine industry<br>Tourism | | S2 |
| Vegetation loss | Decrease on "natural" land due to an increase on industrialization and social | | | S3 |

| | | | | |
|---|---|---|---|---|
| | infrastructures | | | |
| Biodiversity loss | Decrease on “natural” land due to an increase on industrialization and social infrastructures.<br>Increase of land used for wine production due its economic importance and tourism demand. | | | S3 |
| Aquifer<br>over-exploitation | Dry climate.<br>Increase of industrialization and population.<br>Tourists use more water than locals. | Farmers<br>Wine industry<br>Tourism | | S4 |
| Land abandonment | Due economic situation<br>Urbanization<br>Resources over-exploitation | Farmers<br>Employment<br>Wine industry | Young people don’t want to work in agriculture | S3 |

## 4.3.3 Potential impacts

### 4.3.3.1 POTENTIAL IMPACTS INDICATORS

Environmental indicators (see section B): Soil fertility loss, Organic matter decline, Salinization, Soil compaction, Soil erosion, Soil sealing,

Fires frequency.

*Figure 133. Number of fires (Murcia vs. Bullas)*

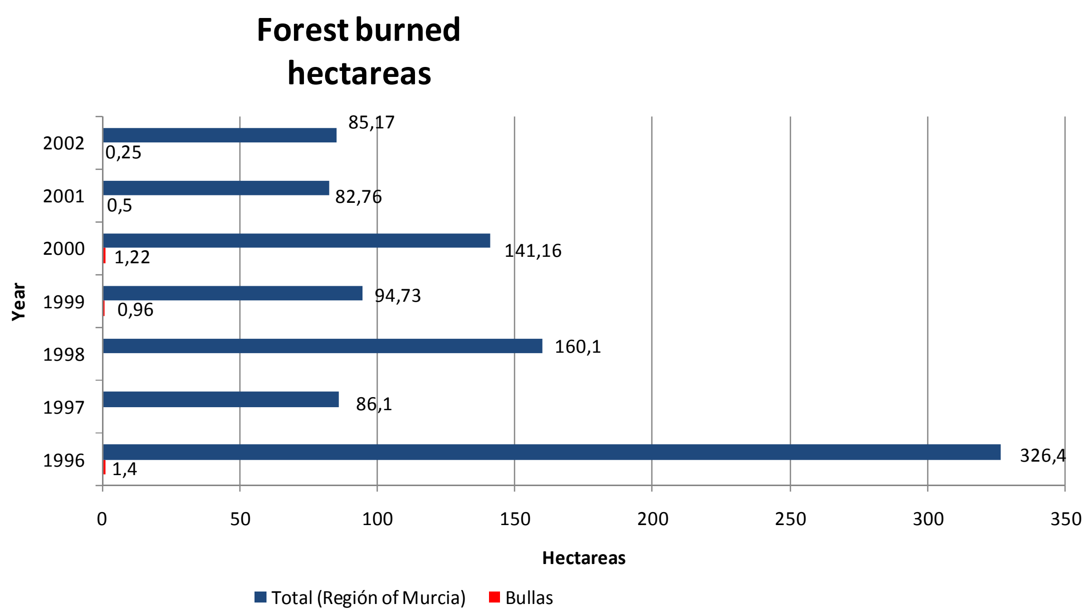



*Figure 134. Forest burned hectareas*

Socio-economic indicators: Land abandonment, Net farm income, Grazing intensity, Tourism change (See section B)

### 4.3.3.2 POTENTIAL IMPACTS ASSESSMENT

Projected climate change may exacerbate the problem of desertification, drought and soil degradation.

Higher air temperatures will be felt in the soil, where warmer conditions are likely to speed the natural decomposition of organic matter and to increase the rates of other soil processes that affect fertility. Additional application of fertilizer may be needed to counteract these processes and to take advantage of the potential for enhanced crop growth that can result from increased atmospheric $CO_2$. This can come at the cost of environmental risk, for additional use of chemicals may impact water and air quality. The continual cycling of plant nutrients -carbon, nitrogen, phosphorus, potassium, and sulfur- in the soil-plant-atmosphere system is also likely to accelerate in warmer conditions, enhancing $CO_2$ and $N_2O$ greenhouse gas emissions.

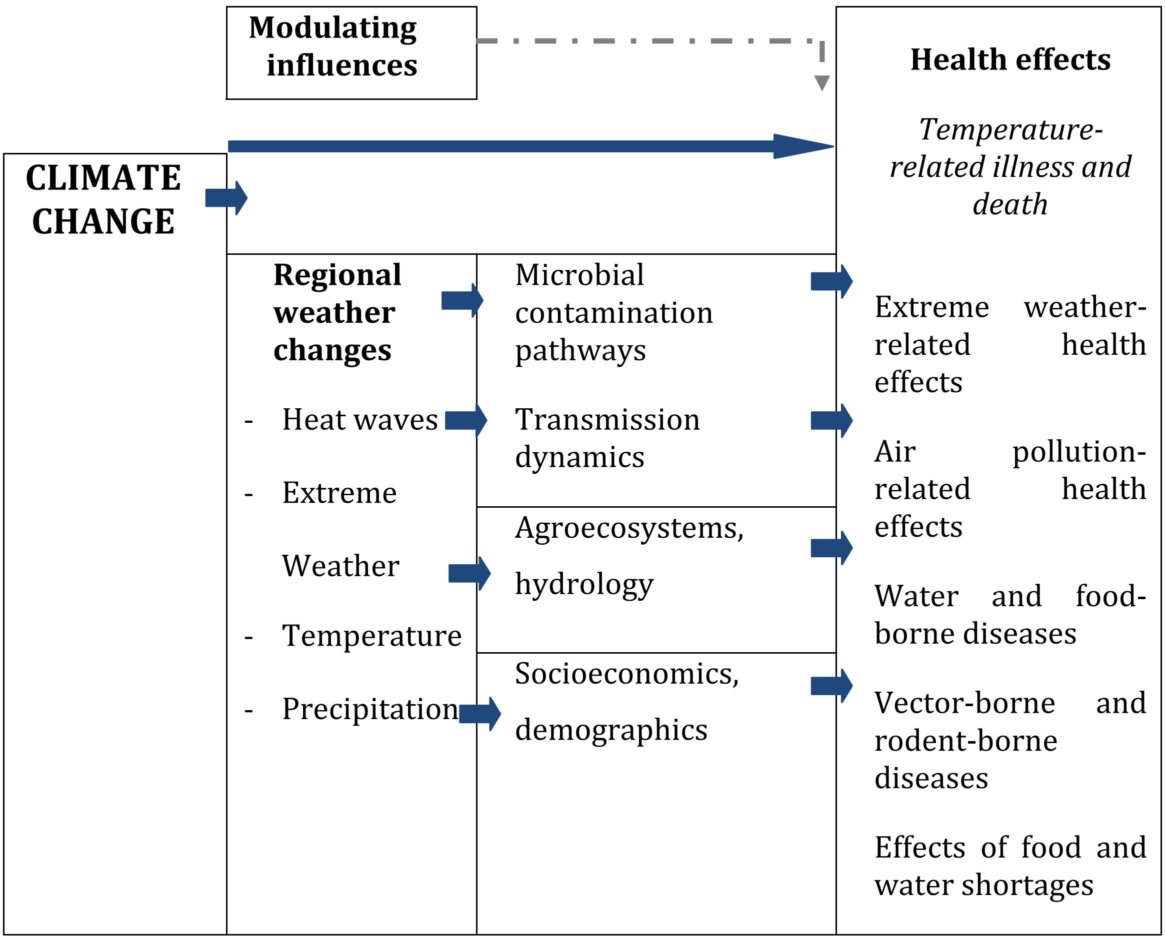
Nitrogen is made available to plants in a biologically usable form through the action of bacteria in the soil. This process of nitrogen fixation, associated with greater root development, is also predicted to increase in warmer conditions and with higher $CO_2$, if soil moisture is not limiting. Where they occur, drier soil conditions will suppress both root growth and decomposition of organic matter, and will increase vulnerability to wind erosion, especially if winds intensify. An expected increase in convective rainfall -caused by stronger gradients of temperature and pressure and more atmospheric moisture- may result in heavier rainfall when and where it does occur. Such "extreme precipitation events" can cause increased soil erosion.

Soil degradation is a major threat to the sustainability of Mediterranean’s land resources and may impair the ability of Mediterranean agriculture to adapt successfully to climate change. Mediterranean soils are currently experiencing a range of conservation problems, including high erosion rates (and erosion-derived agro-chemical pollution of waterways), declines in soil organic matter, and vulnerability of soil organic carbon pools. These are linked to site factors and changing land management practices and are being exacerbated by climate change and the increasing incidence of extreme weather events. Increased intensity of precipitation is likely to change patterns of erosion and accretion, increase the occurrence of storm flooding and storm damage and lead to greater incidences of waterlogging. The private adaptive capacity to this impact is considered low. (Towards adaptation of agriculture to climate change in the Mediterranean. Ana Iglesias - Raoudha Mougou - Marta Moneo - Sonia Quiroga).

# 4.4 Health

It's largely recognized that environmental consequences of climate change will affect human health both directly (e.g. effects of thermal stress or direct injuries from floods) and indirectly through increased risk of climate-sensitive diseases (e.g. water-related or vector borne diseases) mediated by changes in water-, air-, food quality and quantity, agriculture practices, ecosystems, and living environment. These direct and indirect exposures can cause death, disability, and suffering.[96]

The main pathways and categories of health impact of climate change are:




[96] Source: Confalonieri, U. B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revichand A. Woodward, 2007: Human health. Climate change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

| | | | |
|---|---|---|---|
| | | | Mental, nutritional, and other health effects. |

*Figure 135. Main pathways and categories of health impact of climate change*

## 4.4.1 EXPOSURE

### 4.1.1.1 EXPOSURE INDICATORS

In order to assess the health impacts that are more likely to happen in Bullas, to understand which demographic or geographical sub-populations may be most at risk is needed.

According to the socio-economic study of Bullas, population in Bullas has increased an average of 25 % in the last 25 years. Currently is composed of 12.424 inhabitants, where 6.322 are men and 6.102 women. Likewise, Bullas' age structure[97] is listed in the following tables and the figure showing the different distribution of population according the men and/or women category and the age range.

[97] *Source: National Statistics Institute (INE), (Spain). Chart: personal compilation based on INE data*

*Table 50. Age structure*

| Age structure (2010) | Total | Men | Women |
|---|---|---|---|
| 0-4 | 715 | 383 | 332 |
| 5- 10 | 689 | 351 | 338 |
| 10-4 | 697 | 350 | 347 |
| 15-19 | 750 | 370 | 380 |
| 20-24 | 792 | 393 | 399 |
| 25-29 | 877 | 481 | 396 |
| 30-34 | 965 | 508 | 457 |
| 35-39 | 974 | 506 | 468 |
| 40-44 | 993 | 547 | 446 |
| 45-49 | 939 | 478 | 461 |
| 50-54 | 814 | 418 | 396 |
| 55-59 | 601 | 310 | 291 |
| 60-64 | 528 | 249 | 279 |
| 65-69 | 531 | 261 | 270 |
| 70-74 | 466 | 221 | 245 |
| 75-79 | 506 | 226 | 280 |
| 80-84 | 383 | 182 | 201 |
| >85 | 204 | 88 | 116 |

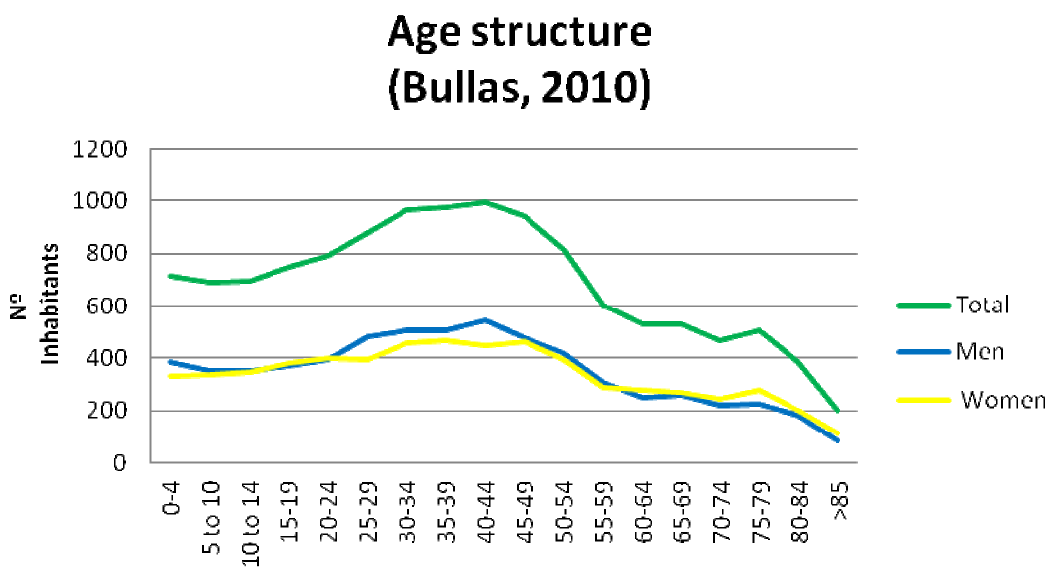



*Figure 136. Age structure*

Bullas has a relatively young population mostly in the ages between 20 and 50 and that, in general, there are a few more young men than women, while elder population is predominant feminine.

According to official statistics, the annual distribution of deaths in Bullas is:

Tables 51. Bullas' Annual distribution of deaths

| TOTAL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age of the deceased** | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
| Less than 1 year old | 7048 | 6644 | 5822 | 5285 | 4670 | 4071 | 4038 | 3789 | 3371 | 3179 |
| 1-4 years old | 1651 | 1540 | 1242 | 1299 | 1120 | 1010 | 924 | 791 | 793 | 788 |
| 5-9 years old | 1178 | 979 | 926 | 896 | 804 | 820 | 775 | 664 | 624 | 588 |
| 10-14 years old | 1003 | 971 | 851 | 869 | 848 | 860 | 793 | 745 | 733 | 754 |
| 15-19 years old | 1801 | 1806 | 1698 | 1848 | 1865 | 1751 | 1920 | 2153 | 2059 | 2196 |
| 20-24 years old | 2189 | 2208 | 2125 | 2313 | 2401 | 2524 | 2645 | 3026 | 3173 | 3360 |
| 25-29 years old | 2050 | 1981 | 1950 | 2156 | 2099 | 2297 | 2496 | 2757 | 3133 | 3603 |
| 30-34 years old | 2433 | 2273 | 2178 | 2276 | 2228 | 2257 | 2363 | 2647 | 2869 | 3220 |
| 35-39 years old | 2884 | 2889 | 2915 | 3062 | 3147 | 3099 | 3190 | 3254 | 3357 | 3383 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 40-44 years old | 4326 | 4107 | 3776 | 3798 | 4108 | 4189 | 4181 | 4497 | 4614 | 4757 |
| 45-49 years old | 7492 | 7535 | 7096 | 6923 | 6504 | 6305 | 6028 | 5762 | 5925 | 6190 |
| 50-54 years old | 11506 | 11487 | 11217 | 11184 | 10967 | 11149 | 10776 | 10611 | 10249 | 9461 |
| 55-59 years old | 16011 | 15855 | 15654 | 15946 | 16044 | 16090 | 16002 | 15774 | 16120 | 15961 |
| 60-64 years old | 19344 | 20060 | 19945 | 21135 | 22109 | 22540 | 22546 | 22385 | 22380 | 22171 |
| 65-69 years old | 28231 | 27850 | 26555 | 26866 | 26110 | 26826 | 27019 | 27721 | 29045 | 30004 |
| 70-74 years old | 40226 | 40068 | 38901 | 39959 | 38707 | 39403 | 37865 | 36781 | 36139 | 35741 |
| 75-79 years old | 47937 | 48421 | 47782 | 50588 | 49648 | 51758 | 50940 | 49750 | 50186 | 50143 |
| 80-84 years old | 44320 | 46236 | 46141 | 50736 | 51184 | 54481 | 53881 | 53900 | 55898 | 57071 |
| 85 years old and more | 47714 | 50476 | 49881 | 55430 | 54846 | 61102 | 62031 | 63066 | 68769 | 72226 |

| TOTAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Age of the deceased** | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
| Less than 1 year old | 3050 | 2846 | 2798 | 2581 | 2239 | 1996 | 2008 | 1856 | 1774 |
| 1-4 years old | 752 | 653 | 640 | 626 | 579 | 536 | 556 | 483 | 421 |
| 5-9 years old | 589 | 500 | 460 | 432 | 431 | 364 | 361 | 321 | 343 |
| 10-14 years old | 783 | 713 | 606 | 557 | 503 | 489 | 478 | 422 | 399 |
| 15-19 years old | 2172 | 2066 | 1808 | 1651 | 1400 | 1423 | 1367 | 1375 | 1298 |
| 20-24 years old | 3347 | 3385 | 3057 | 2618 | 2406 | 2344 | 2242 | 1943 | 2086 |
| 25-29 years old | 3754 | 4060 | 4050 | 3815 | 3764 | 3622 | 3347 | 2707 | 2505 |
| 30-34 years old | 3588 | 3974 | 4278 | 4405 | 4753 | 5027 | 4991 | 3905 | 3342 |
| 35-39 years old | 3511 | 3732 | 3810 | 3940 | 4272 | 4738 | 4833 | 4260 | 3957 |
| 40-44 years old | 4703 | 4744 | 4721 | 4750 | 4714 | 4848 | 5069 | 4777 | 4766 |
| 45-49 years old | 6161 | 6507 | 6512 | 6777 | 6973 | 6815 | 6575 | 6648 | 6415 |
| 50-54 years old | 9205 | 8781 | 8264 | 8294 | 8528 | 8758 | 9034 | 9094 | 9213 |
| 55-59 years old | 15578 | 15310 | 14816 | 13876 | 12988 | 12569 | 12091 | 11181 | 11211 |
| 60-64 years old | 22150 | 22406 | 22165 | 22047 | 21375 | 21322 | 20679 | 20056 | 19278 |
| 65-69 years old | 30731 | 30967 | 30036 | 30727 | 30057 | 30223 | 30204 | 29890 | 30139 |
| 70-74 years old | 36635 | 37131 | 37283 | 39405 | 39969 | 41084 | 41592 | 41379 | 42231 |
| 75-79 years old | 50245 | 49438 | 47719 | 47488 | 46259 | 47300 | 48799 | 50009 | 53856 |
| 80-84 years old | 58695 | 60073 | 58018 | 59287 | 58568 | 58968 | 59071 | 58291 | 59591 |
| 85 years old and more | 77493 | 80405 | 80474 | 86385 | 88464 | 93801 | 98152 | 100924 | 107686 |

Tables 52. Bullas' Annual distribution of deaths (men)

| MEN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age of the deceased | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
| Less than 1 year old | 4116 | 3876 | 3318 | 2989 | 2678 | 2350 | 2328 | 2233 | 1880 | 1806 |
| 1-4 years old | 938 | 898 | 733 | 739 | 628 | 586 | 550 | 438 | 437 | 466 |
| 5-9 years old | 713 | 592 | 578 | 563 | 496 | 498 | 445 | 405 | 384 | 343 |
| 10-14 years old | 618 | 601 | 525 | 561 | 530 | 533 | 478 | 473 | 459 | 453 |
| 15-19 years old | 1282 | 1297 | 1170 | 1284 | 1341 | 1270 | 1382 | 1550 | 1515 | 1607 |
| 20-24 years old | 1641 | 1644 | 1572 | 1757 | 1826 | 1933 | 2014 | 2294 | 2462 | 2663 |
| 25-29 years old | 1480 | 1422 | 1410 | 1572 | 1552 | 1735 | 1846 | 2075 | 2332 | 2774 |
| 30-34 years old | 1656 | 1551 | 1476 | 1569 | 1558 | 1571 | 1663 | 1911 | 2095 | 2412 |
| 35-39 years old | 1906 | 1950 | 1930 | 2052 | 2156 | 2164 | 2200 | 2273 | 2371 | 2449 |
| 40-44 years old | 2893 | 2805 | 2594 | 2590 | 2880 | 2885 | 2848 | 3061 | 3162 | 3288 |
| 45-49 years old | 5019 | 5052 | 4812 | 4693 | 4486 | 4394 | 4104 | 3943 | 4105 | 4332 |
| 50-54 years old | 7727 | 7819 | 7697 | 7610 | 7558 | 7801 | 7513 | 7294 | 7097 | 6582 |
| 55-59 years old | 10879 | 10822 | 10697 | 10863 | 11042 | 11136 | 11043 | 10824 | 11166 | 11201 |
| 60-64 years old | 12286 | 12737 | 13027 | 14072 | 14689 | 15263 | 15421 | 15206 | 15229 | 15166 |
| 65-69 years old | 17052 | 17157 | 16271 | 16411 | 16207 | 16631 | 17011 | 17635 | 18711 | 19739 |
| 70-74 years old | 22872 | 22922 | 22241 | 22692 | 22415 | 22734 | 21746 | 21266 | 21075 | 20698 |
| 75-79 years old | 24043 | 24636 | 24053 | 25652 | 25534 | 26737 | 25978 | 25615 | 25875 | 26055 |
| 80-84 years old | 18852 | 19558 | 19799 | 21859 | 22159 | 23833 | 23418 | 24018 | 24742 | 25624 |
| 85 years old and more | 16252 | 17098 | 17145 | 18847 | 18780 | 20780 | 20973 | 21377 | 23637 | 24706 |

| MEN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age of the deceased | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
| Less than 1 year old | 1616 | 1592 | 1472 | 1280 | 1100 | 1180 | 1049 | 991 |
| 1-4 years old | 368 | 370 | 333 | 337 | 290 | 319 | 264 | 226 |
| 5-9 years old | 302 | 258 | 250 | 244 | 213 | 211 | 173 | 219 |
| 10-14 years old | 439 | 352 | 369 | 303 | 286 | 294 | 248 | 237 |
| 15-19 years old | 1523 | 1328 | 1188 | 1030 | 1043 | 982 | 981 | 913 |
| 20-24 years old | 2669 | 2375 | 2024 | 1880 | 1791 | 1714 | 1499 | 1630 |
| 25-29 years old | 3191 | 3141 | 2905 | 2872 | 2792 | 2493 | 2072 | 1891 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 30-34 years old | 3058 | 3343 | 3406 | 3635 | 3884 | 3767 | 2925 | 2535 |
| 35-39 years old | 2706 | 2817 | 2898 | 3167 | 3447 | 3602 | 3108 | 2884 |
| 40-44 years old | 3284 | 3360 | 3333 | 3333 | 3400 | 3535 | 3370 | 3325 |
| 45-49 years old | 4550 | 4577 | 4851 | 4905 | 4875 | 4708 | 4731 | 4512 |
| 50-54 years old | 6070 | 5824 | 5833 | 6006 | 6192 | 6474 | 6508 | 6549 |
| 55-59 years old | 10861 | 10431 | 9766 | 9115 | 8955 | 8616 | 7923 | 8039 |
| 60-64 years old | 15464 | 15535 | 15308 | 14910 | 14998 | 14510 | 14000 | 13654 |
| 65-69 years old | 20700 | 20119 | 20625 | 20204 | 20362 | 20486 | 20236 | 20553 |
| 70-74 years old | 22139 | 22653 | 24160 | 24888 | 25820 | 26348 | 26185 | 26775 |
| 75-79 years old | 25666 | 25246 | 25023 | 24430 | 25279 | 26501 | 27684 | 30218 |
| 80-84 years old | 26981 | 26016 | 26826 | 26392 | 27062 | 26877 | 26797 | 27618 |
| 85 years old and more | 27757 | 27750 | 29942 | 30993 | 32699 | 34284 | 35342 | 37449 |

Tables 53. Bullas' Annual distribution of deaths (women)

| WOMEN | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age of the deceased | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
| Less than 1 year old | 2932 | 2768 | 2504 | 2296 | 1992 | 1721 | 1710 | 1556 | 1491 | 1373 |
| 1-4 years old | 713 | 642 | 509 | 560 | 492 | 424 | 374 | 353 | 356 | 322 |
| 5-9 years old | 465 | 387 | 348 | 333 | 308 | 322 | 330 | 259 | 240 | 245 |
| 10-14 years old | 385 | 370 | 326 | 308 | 318 | 327 | 315 | 272 | 274 | 301 |
| 15-19 years old | 519 | 509 | 528 | 564 | 524 | 481 | 538 | 603 | 544 | 589 |
| 20-24 years old | 548 | 564 | 553 | 556 | 575 | 591 | 631 | 732 | 711 | 697 |
| 25-29 years old | 570 | 559 | 540 | 584 | 547 | 562 | 650 | 682 | 801 | 829 |
| 30-34 years old | 777 | 722 | 702 | 707 | 670 | 686 | 700 | 736 | 774 | 808 |
| 35-39 years old | 978 | 939 | 985 | 1010 | 991 | 935 | 990 | 981 | 986 | 934 |
| 40-44 years old | 1433 | 1302 | 1182 | 1208 | 1228 | 1304 | 1333 | 1436 | 1452 | 1469 |
| 45-49 years old | 2473 | 2483 | 2284 | 2230 | 2018 | 1911 | 1924 | 1819 | 1820 | 1858 |
| 50-54 years old | 3779 | 3668 | 3520 | 3574 | 3409 | 3348 | 3263 | 3317 | 3152 | 2879 |
| 55-59 years old | 5132 | 5033 | 4957 | 5083 | 5002 | 4954 | 4959 | 4950 | 4954 | 4760 |
| 60-64 years old | 7058 | 7323 | 6918 | 7063 | 7420 | 7277 | 7125 | 7179 | 7151 | 7005 |
| 65-69 years old | 11179 | 10693 | 10284 | 10455 | 9903 | 10195 | 10008 | 10086 | 10334 | 10265 |
| 70-74 years old | 17354 | 17146 | 16660 | 17267 | 16292 | 16669 | 16119 | 15515 | 15064 | 15043 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 75-79 years old | 23894 | 23785 | 23729 | 24936 | 24114 | 25021 | 24962 | 24135 | 24311 | 24088 |
| 80-84 years old | 25468 | 26678 | 26342 | 28877 | 29025 | 30648 | 30463 | 29882 | 31156 | 31447 |
| 85 years old and more | 31462 | 33378 | 32736 | 36583 | 36066 | 40322 | 41058 | 41689 | 45132 | 47520 |

| WOMEN | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age of the deceased | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
| Less than 1 year old | 1334 | 1230 | 1206 | 1109 | 959 | 896 | 828 | 807 | 783 |
| 1-4 years old | 326 | 285 | 270 | 293 | 242 | 246 | 237 | 219 | 195 |
| 5-9 years old | 232 | 198 | 202 | 182 | 187 | 151 | 150 | 148 | 124 |
| 10-14 years old | 308 | 274 | 254 | 188 | 200 | 203 | 184 | 174 | 162 |
| 15-19 years old | 574 | 543 | 480 | 463 | 370 | 380 | 385 | 394 | 385 |
| 20-24 years old | 708 | 716 | 682 | 594 | 526 | 553 | 528 | 444 | 456 |
| 25-29 years old | 844 | 869 | 909 | 910 | 892 | 830 | 854 | 635 | 614 |
| 30-34 years old | 884 | 916 | 935 | 999 | 1118 | 1143 | 1224 | 980 | 807 |
| 35-39 years old | 1015 | 1026 | 993 | 1042 | 1105 | 1291 | 1231 | 1152 | 1073 |
| 40-44 years old | 1365 | 1460 | 1361 | 1417 | 1381 | 1448 | 1534 | 1407 | 1441 |
| 45-49 years old | 1816 | 1957 | 1935 | 1926 | 2068 | 1940 | 1867 | 1917 | 1903 |
| 50-54 years old | 2792 | 2711 | 2440 | 2461 | 2522 | 2566 | 2560 | 2586 | 2664 |
| 55-59 years old | 4702 | 4449 | 4385 | 4110 | 3873 | 3614 | 3475 | 3258 | 3172 |
| 60-64 years old | 6985 | 6942 | 6630 | 6739 | 6465 | 6324 | 6169 | 6056 | 5624 |
| 65-69 years old | 10433 | 10267 | 9917 | 10102 | 9853 | 9861 | 9718 | 9654 | 9586 |
| 70-74 years old | 14925 | 14992 | 14630 | 15245 | 15081 | 15264 | 15244 | 15194 | 15456 |
| 75-79 years old | 24048 | 23772 | 22473 | 22465 | 21829 | 22021 | 22298 | 22325 | 23638 |
| 80-84 years old | 32487 | 33092 | 32002 | 32461 | 32176 | 31906 | 32194 | 31494 | 31973 |
| 85 years old and more | 50585 | 52648 | 52724 | 56443 | 57471 | 61102 | 63868 | 65582 | 70237 |

On the other hand, the main causes of deaths in the Region are:

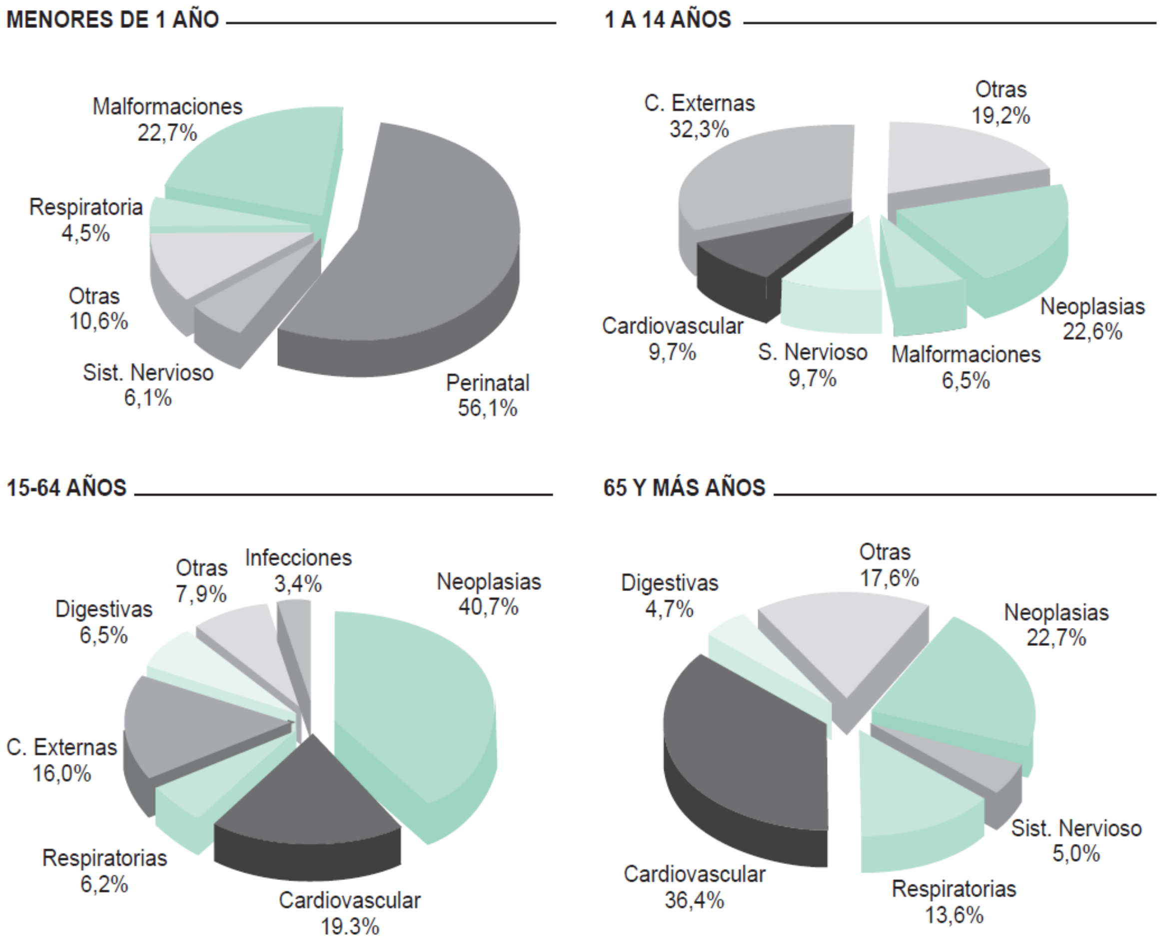



Figure 137. Mortality by groups of causes and age (both sexes). Region of Murcia, 2008

Table 54. Leading causes of death. Region of Murcia, 2008

| Causas Seleccionadas | casos | % | tasa* | tasa** |
|---|---|---|---|---|
| HOMBRES | | | | |
| Enfermedades isquémicas del corazón | 552 | 10,2 | 76,35 | 72,53 |
| Neoplasia maligna del pulmón | 431 | 8,0 | 59,61 | 59,09 |
| Enfermedades cerebrovasculares | 419 | 7,8 | 57,95 | 53,28 |
| Enfermedades crónicas de las vías respiratorias inferiores (excepto Asma) | 316 | 5,9 | 23,93 | 21,94 |
| Insuficiencia cardíaca | 173 | 3,2 | 23,79 | 21,53 |
| Neoplasia maligna de la próstata | 172 | 3,2 | 19,09 | 17,84 |
| Neoplasia maligna del colon | 138 | 2,6 | 17,84 | 17,84 |
| Neumonía | 129 | 2,4 | 15,21 | 16,39 |
| Cirrosis y otras enfermedades crónicas del hígado | 110 | 2,0 | 14,25 | 12,63 |
| Diabetes mellitus | 103 | 1,9 | 14,25 | 12,63 |
| **Total** | **5.397** | **100,0** | **746,47** | **707,53** |
| MUJERES | | | | |
| 42 Enfermedades cerebrovasculares | 614 | 12,3 | 87,33 | 49,89 |
| 40 Enfermedades isquémicas del corazón | 392 | 7,8 | 55,75 | 32,12 |
| 41 Insuficiencia cardíaca | 276 | 5,5 | 39,25 | 21,17 |
| 36 Enfermedad de Alzheimer | 201 | 4,0 | 28,59 | 14,78 |
| 19 Neoplasia maligna de la mama | 163 | 3,3 | 23,18 | 18,29 |
| 32 Trastornos mentales orgánicos senil y presenil | 140 | 2,8 | 19,91 | 10,06 |
| 38 Enfermedades hipertensivas | 139 | 2,8 | 19,77 | 10,74 |
| 56 Enfermedades del riñón y del uréter | 134 | 2,7 | 19,06 | 10,39 |
| 45 Neumonía | 118 | 2,4 | 16,78 | 9,74 |
| **Total** | **5.002** | **100** | **711,41** | **437,71** |

** Tasa por 100.000 habitantes.*
*** Tasa ajustada por edad, método directo a la población europea estándar y 100.000 habitantes.*

Human populations, as with individuals, vary in their vulnerability to certain health outcomes. A population's vulnerability is a joint function of, first the extent to which a particular health outcome is sensitive to climate change and, second, the population's capacity to adapt to new climatic conditions. The vulnerability of a population depends on factors such as population density, level of economic development, food availability, income level and distribution, local environmental conditions, pre-existing health status and the quality and availability of public health care[98]. Regarding to Bullas' population, the following groups are expected to need a higher attention because of their special vulnerability:

- Children
- Pregnant women
- Elderly
- Disable people (people with chronic health problems and under continuous medical monitoring)
- Poor, needy and homeless people
- Immigrants which are in social blockade from employment and social and health services
- Outside workers (i.g. buiding)

The following indicators provide an overview of potential health risks in Bullas from climate variability:

1. **Direct effects of heat and heat-waves:**

Human populations have, over time, acclimatized and adapted to local climates and also are able to cope with a range of weather changes. However, within populations, there is a range of individual sensitivity to extreme weather events. If heatwaves increase in frequency and intensity, the risk of death and serious illness would increase principally in the older age groups, those with pre-existing cardi-respiratory diseases, and the urban poor. The effects of an increase in heatwaves often would be exacerbated by increased humidity and urban air pollution. The

[98] Climate change and human health. Risks and responses. A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Elbi, A. Githeko, J.D. Scheraga, A. Woodward, Editors. WHO, WMO, UNEP.

greatest increases in thermal stress are forecast for areas like Bullas, especially in populations with unadapted architecture and limited air conditioning[99].

The main indicators are:

- Maximum and minimum temperature (see step 3)
- Extreme temperature[100]:

The daily extreme temperature index (IDET) is used to determinate the maximum and minimum temperature threshold that can affect health.

For the Region of Murcia, where Bullas is located, the maximum temperature threshold is set to 38.0 º C and minimum 22.0 ° C, according to the Ministry for Social Policy and Equality and the State Meteorological Agency (AEMET). With the daily list of maximum and minimum temperatures provided by the AEMET, and for the following four days, the daily rate (IDET) is calculated, as it is summarized in the next table:

[99] Climate change and human health. Risks and responses. A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Elbi, A. Githeko, J.D. Scheraga, A. Woodward, Editors. WHO, WMO, UNEP.

[100] Indicadores de salud en la Región de Murcia. Evolución anual y situación en 2010. Consejería de Sanidad y Consumo. Región de Murcia

Table 55. Daily extreme temperature index (IDET)

| Nivel | Índice | Previsión de n.º días que se superan simultáneamente las temperaturas umbrales max y mín | Color |
|---|---|---|---|
| 0 | 0 | 0 | Verde |
| 1 | 1 | 1 | Amarillo |
| | 2 | 2 | |
| 2 | 3 | 3 | Naranja |
| | 4 | 4 | |
| 3 | 5 | 5 | Rojo |

The IDET are calculated during the period June 1 to September 15. Next figure shows the IDET calculated with temperatures of recent years. From this figure, we can conclude that over the seasons analyzed are rarely achieved levels 1 and 2 of the Index.

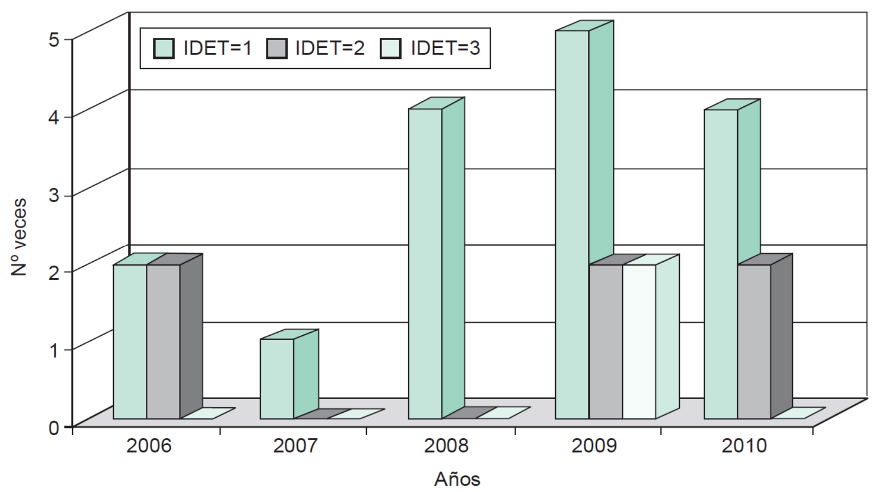



Figure 138. Annual level of Daily extreme temperature index (IDET). Region of Murcia 2006-2010.

The following figure shows the number of days in which temperatures have exceeded the maximum and minimum thresholds for the Region of Murcia during the annual periods for Preventive Action Plan against the effects of excessive temperatures on health.

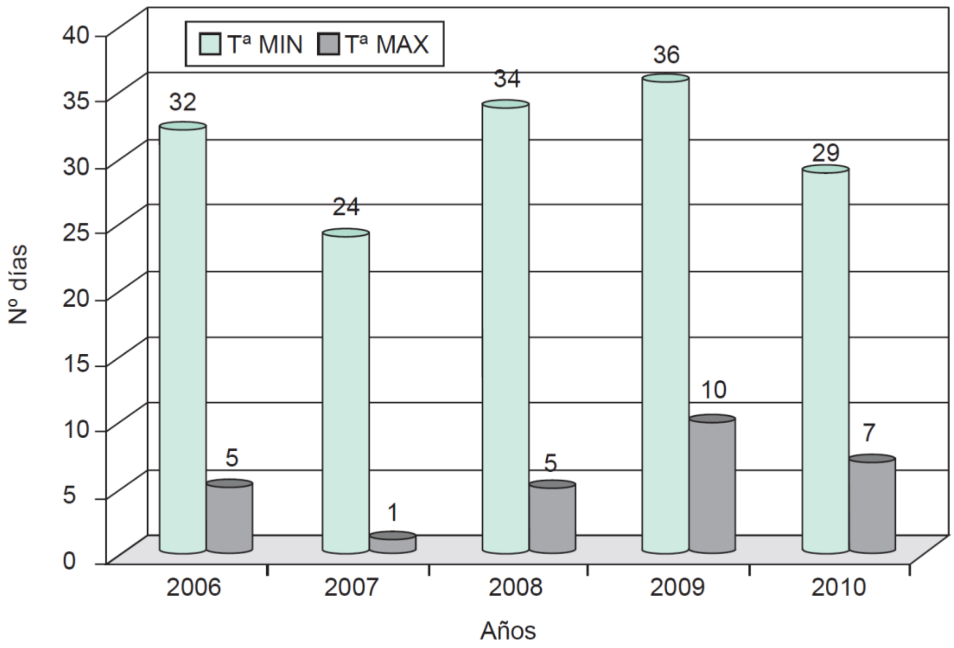



Figure 139. Number of days when temperatures exceed the maximum and minimum thresholds. Murcia, 2006-2010.

## 2. Influence of temperature on air quality. Anthropogenic pollutants

In relation to health, tropospheric ozone and particles are more worrying pollutants, exposure to which can have consequences ranging from minor effects on the respiratory system to premature mortality. Ozone is a secondary pollutant that is generated by reactions involving volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of sunlight, depending on its concentration greatly meteorology.

On the other hand, the dispersion of a pollutant in air is characterized, in addition to the properties of the emitting element (point source, source line or station surface), meteorology and topography of the area. The main atmospheric parameters involved in the dispersion of pollutants are speed and wind direction at source (horizontal dispersion), and thermal phenomena (vertical dispersion)-dependent atmospheric stability, by which changes in climate could increase the number of episodes of photochemical smog.

Ozone, considered one of the most worrying pollutants on health, is a respiratory irritant. The influence on the health of as pollutant ozone is based on their toxicity. Due to its small capacity of dissolution, ozone penetrates the respiratory tract and irritates the mucous membranes and lung tissues.

High concentrations of ozone, long temporary exhibitions and extensive degrees of physical activity during exposure cause serious health effects: decreased lung function, asthmatic worsening, and shortness of breath, chest pain with deep breathing, noise breathing and coughing.

Exposure to high concentrations of ozone is responsible for an increase in mortality, hospital admissions and emergency visits due to respiratory problems. Repeated exposure to ozone can make people more susceptible to respiratory infections, lung inflammation and may aggravate pre-existing as asthma, bronchitis and pulmonary fibrosis lung disease (Fenger et al., 1999).

The ozone concentration from which begins to observe an adverse effect on health will vary with the duration and the volume of air that inhale during the exhibition. Thus it has been observed:

- Results a decrease of 5 % of lung function in healthy young individuals when they have been exposed to controlled ozone concentrations of 250 $\mu gm^3$ and 120 $\mu gm^3$ averages of 1 and 8 hours respectively, being able to achieve pulmonary dysfunction of 20 % when, in these same hourly averages have been exposed to concentrations of 500 $\mu gm^3$ and 240 $\mu gm^3$ (WHO, 1995; WHO, 2000b)

- There is an increase of hospital admissions due to respiratory disorders up to a 5 % when it has happened an increase of 30 μgm³ and 25 μgm³ ozone concentration averages of 1 and 8 hours respectively. This increase in admissions may reach 20 % when the increase in ozone levels is 120 μgm³ and 100 μgm³ averages of 1 and 8 hours respectively (WHO, 1995;) WHO, 2000b).
- Increases 25 % symptoms of exacerbations among adult yasmáticos doing normal activity with of 200 hours average μgm³ and 100 average μgm³ octohorario average ozone concentrations. This increase comes to el 100 with concentrations of 800 hourly average μgm³ and 300 μgm³ average octohorarias (WHO, 1995;) WHO, 2000b).

Amongst the effects on human health referred to above, include the following:

- Eyes and respiratory tract irritation causing coughing, throat irritation and uncomfortable feeling in the chest (caused by elements that accompany the ozone), headache, and difficult breathing observed in concentrations exceeding the 200 μg/m³.
- Internal lung tissue irritation from the 160 μgm³ after 6 hours of exposure. It ignites and damages the cells that make up the lining of the lungs. After a few days the damaged cells are replaced and the old cells arise.
- Transient changes in lung function in exhibitions between 160 and 300 μgm³. The most sensitive population shows an average reduction in lung of 10 to 200 μgm³ function and a reduction of 30 to 300 μgm³. Normal deep and vigorous breathing is difficult. When this happens, breathing begins to feel uncomfortable.

- Physical capacity reduction (increase of fatigue), from 240 to 400 µgm3 in 15-30 % of discussed people. When carried out exercises or working in the outdoors, breathing is rapid and shallow than normal.
- Asthma worsening. When ozone levels are high, it increases the number of people with asthma suffer attacks and require the additional use of medicines or medical attention. This happens because the ozone makes people more susceptible to allergens, the agents that cause asthma attacks. Other severe effects for people with asthma are reduced lung function and caused the respiratory system irritation.
- Worsening chronic lung diseases such as emphysema and bronchitis and reduces the ability of the immune system to defend against bacterial infections to respiratory system.
- Causes permanent damage to the lung. Repeated damage in the short term in the Lung in children's development, can result in a reduced adult pulmonary function. In adults, exposure to ozone can accelerate the natural decline of lung function that occurs as part of the normal process of aging (WHO, 1995).

◈ Indicator of environmental concentrations of atmospheric pollutants

WHO (World health Organization) based its indicator on the surmounting of the reference value (120 µgm3) for the daily moving average for eight hours of the concentration of ozone. To the absence of these data has been as indicator the number of hours that the hourly average value has exceeded the values (180 µgm3) information and early warning (240 µg/m3).

Table 56 shows the number of crop per year of various pollutants regulated and monitored in the surveillance network of the Region of Murcia in the station of Caravaca (closest to Bullas and the one taken as a reference in the Northwest of the Region.)

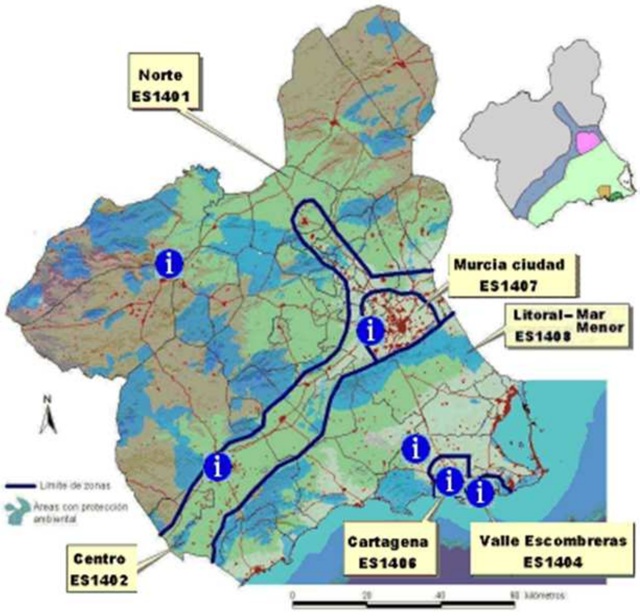



*Figure 140[101]. Quality air surveillance network stations in the Region of Murcia.*

*Table 56. Surmounting of the limit values in the station of Caravaca (Region of Murcia)*

[101] Source: http://www.carm.es/cmaot/calidadaire/portal/

| VL Contaminante | Caravaca | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Superación valor límite **horario $SO_2$** de protección de la Salud Humana:> 350 µg/m$^3$. No podrá superarse en más de 24 ocasiones por año civil | | PNM | |
| Superación valor límite **diario $SO_2$** de protección de la Salud Humana: > 125 µg/m$^3$. No podrá superarse en más de 3 ocasiones por año civil | | PNM | |
| Superación valor límite **horario $NO_2$** de protección de la Salud Humana: > 210 µg/m$^3$. No podrá superarse en más de 18 ocasiones por año civil | 93 | 0 h | NO |
| Superación valor límite **anual $NO_2$** de protección de la Salud Humana:> 42 µg/m$^3$ | 93 | 7 µg/m$^3$ | NO |
| Superación valor límite **diario $PM_{10}$** de protección de la Salud Humana: > 50 µg/m$^3$. No podrá superarse en más de 35 ocasiones por año civil | 99 | ** 2 días | NO |
| Superación valor límite **anual $PM_{10}$** de protección de la Salud Humana: > 40 µg/m$^3$ | 99 | ** 14 µg/m$^3$ | NO |
| Superación valor límite **anual benceno** de protección de la Salud Humana:> 6 µg/m$^3$ | | PNM | |
| Superación valor límite **máximo octohorario CO** de protección Salud Humana. Máxima media octohoraria día en un año civil: >10 mg/m$^3$ | | PNM | |

## 3. Thermal anomalies, pollens and allergy risk

Experimental research has shown that doubling $CO_2$ levels from about 300 to 600 ppm induces a four-fold increase in the production of ragweed pollen. Pollen counts from birch trees (the main cause of allergies in Europe) rise with increasing temperature[102].

According to the study "Allergies in the region of Murcia"[103] made from a sampling of 4991 patients, profile, by age and sex of patients with diseases of this type is as follows:

[102] Climate change and human health. Risks and responses. A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Elbi, A. Githeko, J.D. Scheraga, A. Woodward, Editors. WHO, WMO, UNEP.

[103] Dr. Juan Carlos Miralles López (Hospital Reina Sofía, Murcia) and Dr.José Mª Negro Álvarez (HU Virgen de la Arrixaca)

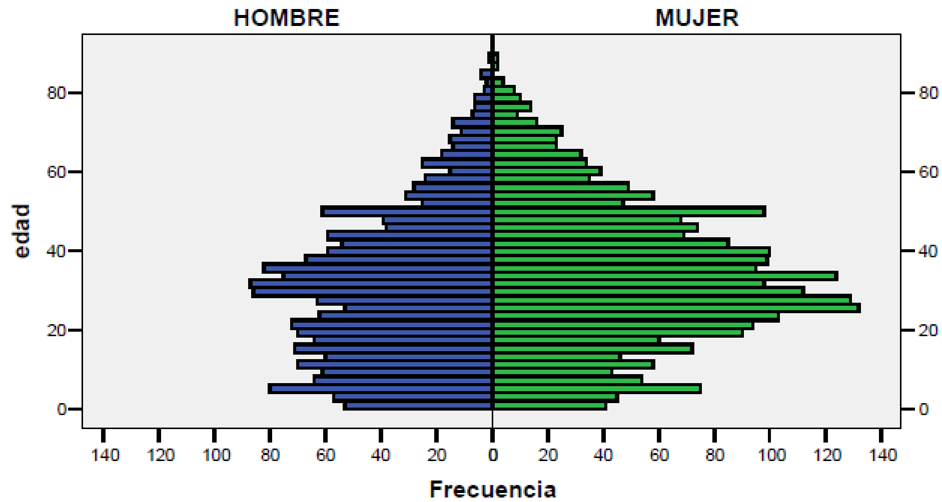



*Figure 141. By age and sex pyramid*

We can inffer from these data that allergies affect to more women (57.3) than men (42.7).

Distribution by Autonomous Communities is:

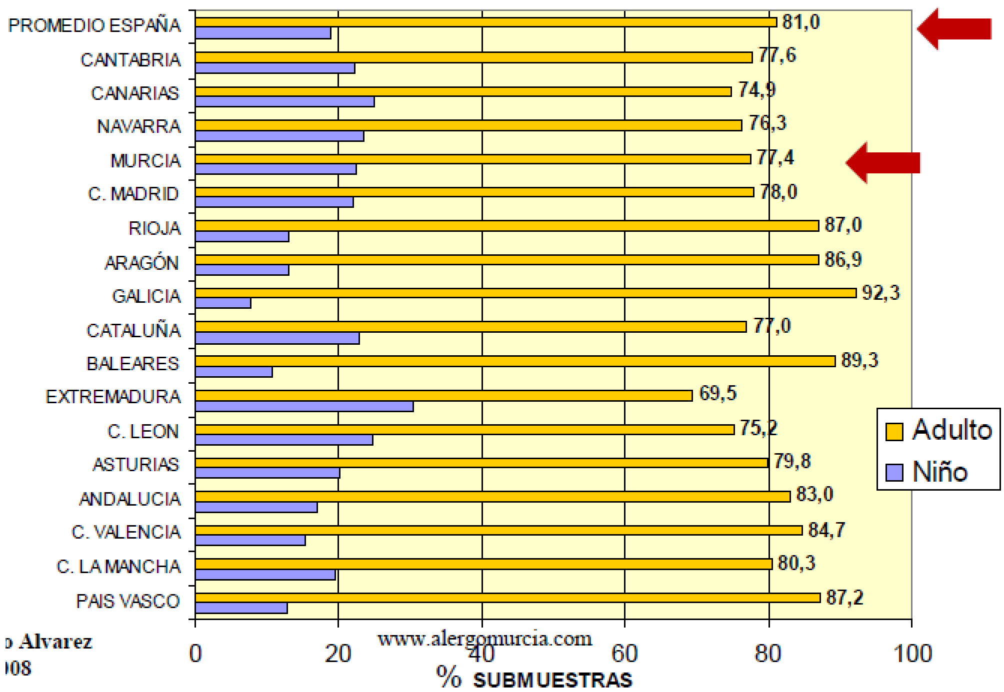


*Figure 142. Child/adult distribution by Autonomous Communities (2005)*

Next table shows the changes in the age of the patient between 1992 and 2005.

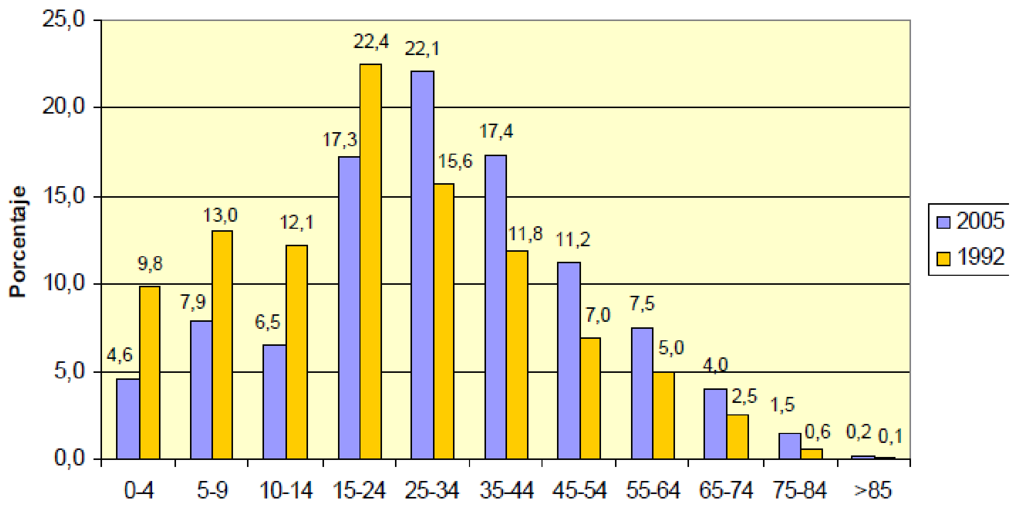



Figure 143. Age of the patients served (1992-2005)

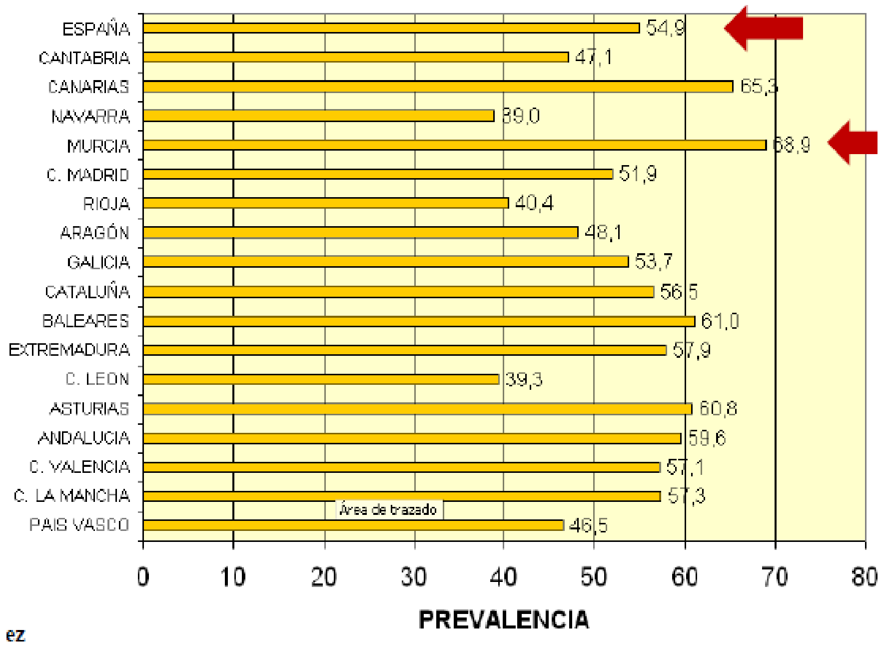



Figure 144. Allergic morbidity by Autonomous Communities: rhinitis-conjunctivitis

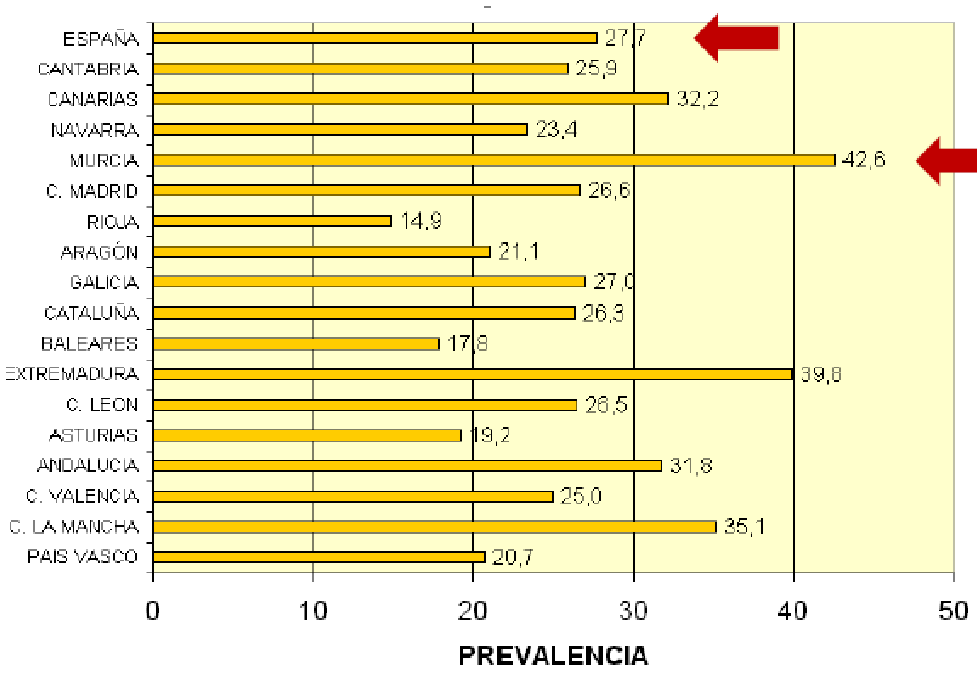



Figure 145. Allergic morbidity by Autonomous Communities: Asthma

Next figure shows labor school casualties in 2005 due to allergies by Autonomous Communities:

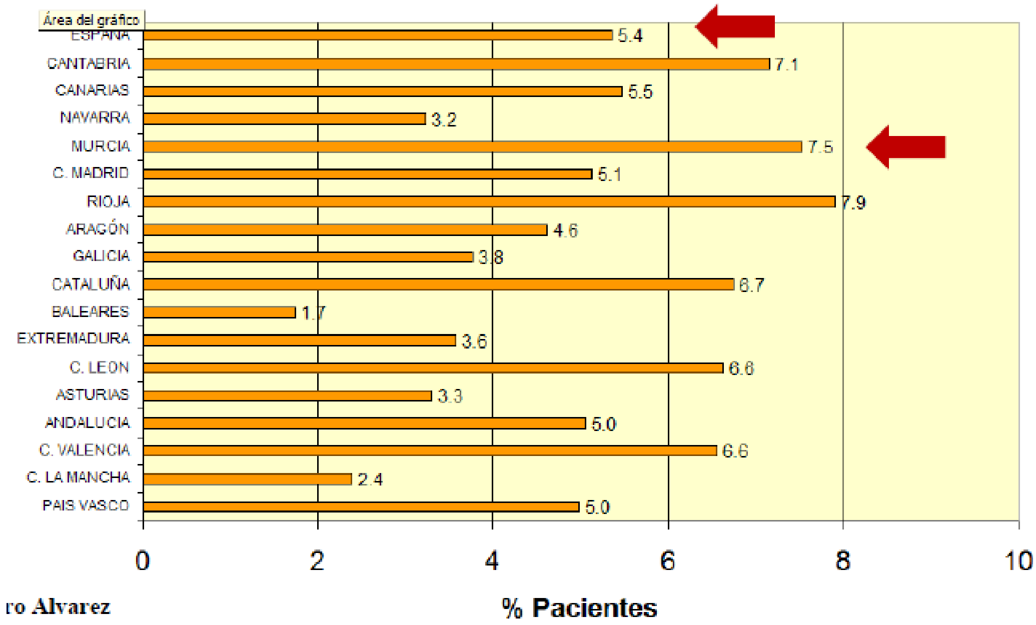



Figure 146. Allergy sick leaves

## 4. Climate change and vector borne diseases

Recent studies of disease associated with inter-annual climate variability have provided much useful evidence of the sensitivity to climate of many disease processes. This is particularly so for mosquito-borne diseases.

Higher temperatures, changes in precipitation and climate variability would alter the geographical range and seasonality of transmission of many vector-borne diseases. Mostly, range and seasonality would be extended; in some cases reduced. Higher temperatures in combination with conductive patterns of rainfall and surface water will extend the transmission season in some locations. Changes in climate mean conditions and variability would affect many other vector-bore infections (such as dengue, lishmaniasis, Lyme disease, and tick-borne encephalitis)

### 4.4.1.2 EXPOSURE ASSESSMENT

*Table 57. Bullas health exposure assessment*

| EXPOSURE | | | |
|---|---|---|---|
| **Impact** | **Factors influencing the exposure of a system/sector** | **Exposed sectors** | **Level of exposure** |
| Heat related hospital admission and/or mortality excess | High temperatures in summer (Daily index of thermal extremes, IDET)<br>Percentage and demographic distribution of population living in Bullas and in La Copa (urban areas) at risk of heat island phenomena.<br>Lack of appropriate heat wave early warning. | - Tourism<br>- Bullas population<br>- Bullas' vulnerable groups | Medium -high |
| Increase of hospital admission for cardiovascular and respiratory disorders caused by air pollution. | Air mass stagnation caused by bad horizontal atmospheric dispersion (episodes of photochemical smog).<br>$O_3$ daily average concentration.<br>Increase of anthropogenic emission. | - Tourism<br>- Bullas population<br>- Bullas' vulnerable groups | High |
| Increase of allergic popullation | Anomalies in pollen season.<br>Anomalies in distribution of allergenic plants. | - Tourism<br>- Bullas population | High |

| | | | |
|---|---|---|---|
| | Air pollution. | - Bullas' vulnerable groups | |
| Increase in hospital admissions for asthma or allergic crisis | Anomalies in pollen season.<br>Anomalies in distribution of allergenic plants.<br>Air pollution. | - Tourism<br>- Bullas population<br>- Bullas' vulnerable groups | High |
| Increase in anti-allergic drugs use | Anomalies in pollen season.<br>Anomalies in distribution of allergenic plants.<br>Air pollution. | - Bullas' vulnerable groups | High |
| Human cases of vector borne infectious diseases | Anomalies in vector distribution.<br>Environmental vector control campaigns. | - Tourism<br>- Bullas population<br>- Bullas' vulnerable groups | Medium -high |
| Increase in personal protection product sales (lotions, sprays, mosquito nets, etc.) | Anomalies in vector distribution.<br>Environmental vector control campaigns. | - Tourism<br>- Bullas population<br>- Bullas' vulnerable groups | Medium -high |
| Loss of | Health problems related with climate | - Tourism | Medium |

| | | | |
|---|---|---|---|
| working/school days for health diseases | change. | - Bullas population<br>- Bullas' vulnerable groups | -high |

## 4.4.2 Sensitivity

### 4.4.2.1 SENSITIVITY ASSESSMENT

*Table 58. Bullas' health sensitivity assessment*

| SENSITIVITY | | | | |
|---|---|---|---|---|
| **Impact** | **Existing stress unrelated to climate** | **Sensitive elements/groups** | **Factors influencing the sensitivity of a system/sector** | **Sensitivity** |
| Heat related hospital admission and/or mortality excess | Population growth.<br>Pollution.<br>Decrease in investments in air conditioning of households due to the rise in unemployment and economic crisis.<br>Increase in the number of immigrants found in conditions of unemployment. | Tourism<br>Bullas' vulnerable groups | The temperature in the summer months in Bullas is high in general.<br>Thermal stress caused by achieving several days during the months of July and August levels 1 and 2 of the IDET.<br>Ageing of the population. | S3: Yes - Functionality is likely to get worse |

| | | | | |
|---|---|---|---|---|
| | Possible problems of water due to drought (resources overexplotation) | | | |
| Increase of hospital admission for cardiovascular and respiratory disorders caused by air pollution. | Increase in the car park in Bullas, causes it an increase of volatile organic compounds (VOCs) and nitrogen oxides (NOx) precursors to photochemical ozone formation.<br>Increase in the buying and selling of second-hand, instead of last generation vehicles less polluting vehicles.<br>Lack of sufficient investment in renewable energy, which | Tourism<br>Bullas' vulnerable groups | High temperatures in the summer months in Bullas favour the formation of pollutants side as ozone. | S4: Yes - Functionality will get worse |

| | | | | |
|---|---|---|---|---|
| | leads to a high dependence on oil with the consequent emission of pollutants.<br>Promotion of tourism outdoor and sporting activities in the open air, which is an extra risk to health days with episodes of photochemical smog. | | | |
| Increase of allergic popullation | Agriculture is one of the economic engines of Bullas, finding a high percentage of the population in contact with allergen elements.<br>Increase in the use of chemicals that make it more vulnerable to the population. | Tourism<br>Bullas' vulnerable groups | Murcia is one of the autonomous regions with more cases of allergic rhinitis. | S4: Yes - Functionality will get worse |

| | | | | |
|---|---|---|---|---|
| Increase in hospital admissions for asthma or allergic crisis | Agriculture is one of the economic engines of Bullas, finding a high percentage of the population in contact with allergen elements.<br>Increase in the use of chemicals that make it more vulnerable to the population.<br>Promotion of outdoor physical activities. | Tourism<br>Bullas' vulnerable groups | Murcia is one of the autonomous regions with more cases of allergic asthma. | S4: Yes - Functionality will get worse |
| Increase in anti-allergic drugs use | Agriculture is one of the economic engines of Bullas, finding a high percentage of the population in contact with allergen elements.<br>Increase in the use of chemicals that make it more | Tourism<br>Bullas' vulnerable groups | Murcia is one of the autonomous communities with more cases of rhinitis and allergic asthma. | S4: Yes - Functionality will get worse |

| | | | | |
|---|---|---|---|---|
| | vulnerable to the population. Promotion of outdoor physical activities. | | | |
| Human cases of vector borne infectious diseases | | Tourism Bullas' vulnerable groups | - | S3: Yes - Functionality is likely to get worse |
| Increase in personal protection product sales (lotions, sprays, mosquito nets, etc.) | Common protectors products are ineffective, being necessary to use stronger and more expensive ones. | Tourism Bullas' vulnerable groups | - | S3: Yes - Functionality is likely to get worse |
| Loss of working/school days for health diseases | Agriculture is one of the economic engines of Bullas, finding a high percentage of the active population in | Tourism Bullas' vulnerable groups | Health problems related to climate change. | S3: Yes - Functionality is likely to get worse |

| | | | | |
|---|---|---|---|---|
| | contact with allergen elements. | | | |

## 4.4.3 Adaptive capacity

### 4.4.3.1 ADAPTIVE CAPACITY ASSESSMENT

*Table 59. Bullas' health adaptive capacity assessment*

| ADAPTIVE CAPACITY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Impact | Adaptation baseline (Underway and planned adaptation actions, etc) | Factors determining the adaptive capacity of the system/sector | Is the system already able to accommodate changes in climate with minimal costs and disruption? | Can the system/sector adjust to the projected impact with minimal cost and disruption? | Barriers to the system's ability to accommodate changes in climate | Existing stress unrelated to climate that limit the system's ability to accommodate changes in climate | Rate of projected climate change compared to the adaptability of the system | Adaptive capacity |
| Heat related hospital | Regional Plan of preventive actions | Availability of an early warning | Maybe | Maybe, but it will require some costs and | Economic barriers and politic/citizens | Urbanization Population growth | Slower than the adaptability | AC3: Maybe - Will require some costs |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| admission and/or mortality excess | for the effects of temperature excess on health since 2004 | system (There are plans both at regional as a national level for information and prevention from heat stroke). Measures are being taken on a local level as the installation of awnings on the streets to protect population from the sun. Future problems in water and electricity supply for conditioning | | staff intervention | awareness. Physical. | Pollution Resources overexploitation | of the sector/system | ($$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | houses and premises. | | | | | | |
| Increase of hospital admission for cardiovascular and respiratory disorders caused by air pollution. | There are numerous laws to prevent industrial pollution. There is legislation to secure a better environmental quality. Emissions from traffic, main cause of pollution in the city are not sufficiently regulated. | The centre of Bullas is being left only for pedestrian with the consequent restriction of traffic. There is not enough information or an early warning system. | There is not a high dependency on the car, which provides high concentrations of tropospheric ozone in the city. | No - will require significant cost and staff intervention | Limited financial resources. Economic and politic barriers. City heat island phenomenon. | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC2: No - Will require significant costs ($$$$) and staff intervention |
| Increase of allergic popullation | | | | No - will require significant cost and staff intervention | Limited financial resources. Economic and | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC2: No - Will require significant costs ($$$$) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | politic barriers. Fenómeno de isla de calor en la ciudad. | | | and staff intervention |
| Increase in hospital admissions for asthma or allergic crisis | - | | No | No - will require significant cost and staff intervention | Limited financial resources. Economic and politic barriers. Fenómeno de isla de calor en la ciudad. | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC2: No - Will require significant costs ($$$$) and staff intervention |
| Increase in anti-allergic drugs use | - | | No | No - will require significant cost and staff intervention | Limited financial resources. Economic and politic barriers. Fenómeno de | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC2: No - Will require significant costs ($$$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | isla de calor en la ciudad. | | | |
| Human cases of vector borne infectious diseases | - | - | Maybe | Maybe - will require some costs and staff intervention | Limited financial resources. Economic and politic barriers. Fenómeno de isla de calor en la ciudad. | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC3: Maybe - Will require some costs ($$$) and staff intervention |
| Increase in personal protection product sales (lotions, sprays, mosquito nets, etc.) | - | - | Maybe | Maybe - will require some costs and staff intervention | Limited financial resources. Economic and politic barriers. Fenómeno de isla de calor en la ciudad. | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC3: Maybe - Will require some costs ($$$) and staff intervention |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Loss of working/school days for health diseases | - | Resources to invest in adaptation | Maybe | Maybe | Physical Economic Social Political | Urbanization Population growth Pollution | Faster than the adaptability of the system | AC3: Maybe - Will require some costs ($$$) and staff intervention |

### 4.4.4 VULNERABILITY

#### 4.4.4.1 VULNERABILITY ASSESSMENT

***VULNERABILITY = function [exposure (+); sensitivity (+); adaptive capacity (-)]***

*Table 60. Sensitivity and adaptive capacity matrix*

| SENSITIVITY AND ADAPTIVE CAPACITY MATRIX | | | | | |
|---|---|---|---|---|---|
| | **S1** | **S2** | **S3** | **S4** | **S5** |
| **AC1** | V2 | V2 | V4 | V5 | V5 |
| **AC2** | V2 | V2 | V3 | V4 | V5 |
| **AC3** | V2 | V2 | V3 | V4 | V4 |
| **AC4** | V1 | V2 | V2 | V3 | V3 |
| **AC5** | V1 | V1 | V2 | V3 | V3 |

**VULNERABILITY SCALE:**
**V1: Low vulnerability**
**V2: Medium-Low Vulnerability**
**V3: Medium Vulnerability**
**V4: Medium-High vulnerability**
**V5: High vulnerability**

*Table 61. Vulnerability ratings*

| VULNERABILITY RATINGS | | | | |
|---|---|---|---|---|
| **High vulnerability (S5-AC1)=V5** | **Medium-High Vulnerability (S4-AC2)=V4** | **Medium Vulnerability (S3-AC2 or S3-AC3)=V3** | **Medium-Low Vulnerability (S2-AC3 or S2-AC2)=V2** | **Low Vulnerability (S1-AC5)=V1** |
| **Impact** | **Impact** | **Impact** | **Impact** | **Impact** |
| | Increase of hospital admission for | Heat related hospital admission and/or | | |

| | | | | |
|---|---|---|---|---|
| | cardiovascular and respiratory disorders caused by air pollution. | mortality excess | | |
| | Increase of allergic popullation | Human cases of vector borne infectious diseases | | |
| | Increase in hospital admissions for asthma or allergic crisis | Increase in personal protection product sales (lotions, sprays, mosquito nets, etc.) | | |
| | Increase in anti-allergic drugs use | Loss of working/school days for health diseases | | |

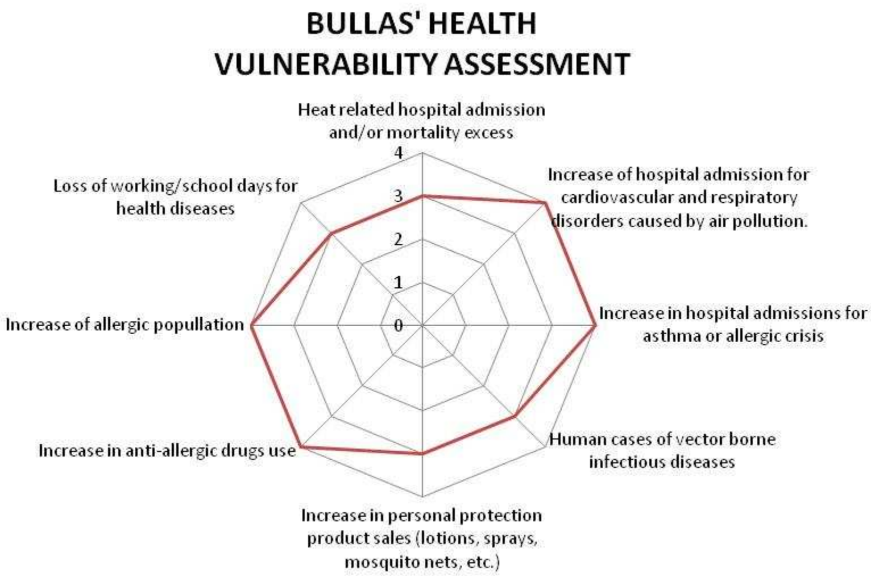



*Figure 52. Vulnerability assessment of Bullas' health*

# 4.5 Transportation infrastructure

The earth's climate is changing, due largely to greenhouse gas emissions resulting from human activity. These human-generated gases derive in part from aspects of the built environment such as transportation systems and infrastructure, building construction and operation, and land-use planning. Transportation, the largest end-use consumer of energy, affects human health directly through air pollution and subsequent respiratory effects, as well as indirectly through physical activity behavior. Buildings contribute to climate change, influence transportation, and effect health through the materials utilized, decisions about sites, electricity and water usage, and landscape surroundings. Land use, forestry, and agriculture also contribute to climate change and affect health by increasing atmospheric levels of carbon dioxide, shaping the infrastructures for both transportation and buildings, and affecting access to green spaces. Vulnerable populations are disproportionately affected with regard to transportation, buildings, and land use, and are most at risk for experiencing the effects of climate change[104].

On a global scale especially shifts in tourism and agricultural production due to increased temperatures may lead to shifts in passenger and freight transport. Climate change related shifts in weather patterns might also cause infrastructure disruptions. Clear patterns are that precipitation affects road safety by increasing accident frequency but decreasing severity. Precipitation also increases congestion, especially during peak hours.

Transport is an engine of economic growth: commerce, tourism, industrial development and urban mobility.

[104] Source: "The built environment, climate change, and health. Opportunities for co-benefits". Margalit Younger, MPH, Heather R. Morrow-Almeida, MPH, Stephen M. Vindigni, MPH, Andrew L. Dannenber, MD, MPH. American Journal of preventive medicine.

**Bullas transportation**

Bullas is a municipality in the Region of Murcia, Spain. It's located in the Northwest Region. It is divided between the municipality's urban center and its only hamlet, La Copa de Bullas.

It has a municipal area of 82.1 square kilometers. It’s the source of Mula river (a tributary of Segura river).

The city is located 651 meters above sea level, the second highest municipality in the Region of Murcia, after Moratalla. It is 52 kilometers from Murcia. Their main communication networks are illustrated in Figure 2: Bullas’ communication networks.

Bullas transportation infrastructures are reduced to highway and national road, while there is no other way of transportation except for private cars or by bus.

**The train**

The construction of Murcia Zaraiche – Caravaca railway line started in 1925,

and works completed in 1931, while the inauguration was delayed more than two years because of the Republic, and the service started 23th May 1933.

There was originally a morning service and an afternoon one in both directions for passengers and other goods, increasing after services as demand grew. The first trains were coal locomotive and wooden carriages.

*Figure 147. Coal train in the 50's*

In 1964 the original train was changed to a diesel train, pulled by diesel engines. This machine was like two buses connected by the tail, cockpit at both ends, to circulate in both directions.

*Figure 148. Diesel train "Ferrobús"*

Passenger service ceased on January 15, 1971, and in some parts of the line, rails were quickly removed due to busses companies' pressure.

The freight service continued a few years more serving manufacture of iron, fruit canneries, one cement and a fuel company, completely stopping the service in 1993.

In the mid 90's, the Autonomous Community of Murcia and the towns of Mula, Bullas, Cehegín and Caravaca, promoted the creation of the Northwest Greenway, between Los Baños de Mula and Caravaca de la Cruz, with a length of 48 Km., and was financed by the Ministry of Environment.

It serves an important role as far way of pilgrimage and leisure, and as a living museum of its stations, level crossings boxes, rails, needles or storage of cargo, where not yet been destroyed.

Bullas train station and all the railways still exist, but they are now turned into a green pathway

The Northwest Green Pathway is an important addition to Bullas tourism; it's a 48 Km., track, which offer the visitor the possibility to enjoy nature with badlands landscape and mountain areas with pines, and cultural heritage. See Figure 8. The northwest green pathway.

## 4.5.1 Exposure

### 4.5.1.1 EXPOSURE INDICATORS

While effects on principal economic sectors (primary industries, fisheries, forestry) begins to be explored and adaptation strategy include specific measures, there is still a lack of studies on infrastructure sector, including water facilities, energy, transportation and public health systems[105].

[105] Source: Assessment of climate change impacts and local vulnerabilities: Transportation infrastructure. ISPRA

The experience of transportation managers in facing environmental related risk and safety issues, make systems able to respond to a certain level of changing, which in itself it is and adaptation measure, and increase its adapative capacity.

In the Mediterranean area climate change impact transportation systems mainly trough changes in weather extremes because times of extreme events carry implications for planning, design, construction and maintenance of transportation infrastructures.

It is likely that extreme weather, including heavy precipitation will increase in frequency and intensity in Europe, with most severe effects expected in the second half of the century. Increases in annual globally averaged mean temperatures, in the number of warm days and nights and in temperature and precipitation extremes, are all projected to occur with a high degree of confidence.

Extreme events affects strongly mainly to coastal areas but also to river basins.

Moderate changes in the mean climate have little impact on transportation infrastructures and related operations in the short period, because the system is designed to accomodmodate changing weather conditions (i.e. Small gaps known as expansion joints are deliberately left between the rail ends to allow for expansion of the rails in hot weather) while climate extremes can have a considerable impact, together with changes in medium and long term. In particular, medium and lon term impacts will take place when climate changes push transportation infrastructures out of the range for whoch the system was designed, increasing the risk of premature system failure.

*Figure 149. Expansion joint in train rails.*

Climate changes of particular importance to transportation infrastructures in the Mediterranean area due to their estimated probability of occurrence during the 21st century are listed in table below:

*Table 62. Climate changes relevant for infrastuctures in the Mediterranean area*

| CLIMATE CHANGES RELEVANT FOR INFRASTRUCTURES IN THE MEDITERRANEAN AREA |
|---|
| **Temperature** |
| Increasing average and extreme Temperature<br>Increases in very hot days and heat waves<br>Decreases in very cold days |
| **Precipitation** |
| Increases in intense precipitations events<br>Increases in drought conditions for some regions<br>Changes in seasonal precipitation and flooding patterns |
| **Sea level** |

| |
|---|
| Sea level rise |
| **Extreme weather events** |
| Increases intensity of strong rainfalls, storms and tornadoes, increases in winds and in waves and storms surges and in col-season events (heavy snow, heavy fog, etc.) |

Most relevant changes for infrastructures in the Mediterranena area considering their probability of occurrence are[106]:

- Sea level rise: virtually certain
- Increases in intense precipitation events: very likely
- Increases in very hot days and heat waves: very likely
- Increases in storm intensity: likely

Of all of those Bullas will probably mainly suffer from the increase in very hot days and heat waves. Increases in storm intensity and intense precipitation events are also most likely to occur, even if Murcia region is the driest one in the Spanish Mediterranean are, with Murcia also been one of the driest regions in the country.

[106] The Intergovernmental Panel on Climate Change (IPCC) ("==/) Working Group I, established the following terminology to describe uncertainty, that is, the probably of occurrence: virtually certain > 99%; extremely likely > 95%; very likely > 90%; likely >66%; more likely than not >50%; unlikely <33%; very unlikely <10%; extremely unlikely <5%.

Exposure involves not only the probability of occurrence of the event (or change), but defining probability of a certain level of damage in consequence of a determined event.

Regarding magnitude and rate of change in the climatic conditions to which infrastructure is predicted to be exposed, it must be defined manner and degree of possible consequences (i.e. infrastructures in areas with high levels of erosion, land subsidence, loss of wetlands, as well as ports and facilities located on coastal areas, are exposed to coastal flooding).

*Figure 150. Flooding consequences*

To face climate change effects on infrastructures in a specific region, an entire network system or a portion managed at a local level, it must be considered as an “object” exposed and for which define the exposure level:

1. Physical infrastructure: structures of roadways, runways, rail lines, tunnels, airports, bridges, ports, etc., developing patterns, design criteria.
2. Services connected: functioning conditions (i.e. periods, weight allowed, interruptions), operation procedure, emergency management
3. Local community: people served, business assets, social activities, land use planning.

Estimating the level of projected exposure is the most ambiguous of all conceptual factors, due to the inherent uncertainties of climate science, especially at metropolitan and local level.

A probabilistic evaluation of exposure needs a calculation of exposition rate in given conditions. A comprehensive probabilistic approach is still difficult to apply at climate changes subsequently; a qualitative assessment of exposure may be the best option until regional analysis tools become more precise and widely available.

### 4.5.1.2 EXPOSURE ASSESSMENT

*Table 63. Exposure assessment*

| EXPOSURE | | | |
|---|---|---|---|
| **Impact** | **Factors influencing the exposure of a system/sector** | **Exposed elements/groups** | **Level of exposure** |
| Flooding and mudslides | Increased intense precipitation could augment the severity of flooding, and transportation routes can be severely damaged from it. | Railways, highways, national and local roads | Medium |
| Heat waves → wildfire | Heat waves may increase wildfires that can destroy transportation infrastructure. | Railways, highways, national and local roads | Medium-high |
| Increase in extreme temperatures | A medium and long term increase in temperatures push transportation infrastructures out of the range for which the system a nd the materials it was constructed with, were designed, increasing the risk of premature system failure.<br>Overheated vehicles and tire damage. | Railways, highways, national and local roads | Medium-high |
| Water shortage → droughts | Changes in precipitation, evaporation and factors that affect water availability can lead to a decrease in land quality such as high level of erosion.<br>Increased risk of subsidence.<br>Increased risk of forest fires with the result of closed roads. | National and local roads | Medium |
| Problems with energy supply | Extreme events can affect energy supply, and as for that some transportation infrastructures may suffer.<br>Energy cuts | Railways | Medium-high |
| Frost | Extremely low temperatures consistent with frosts can make transportation in | National and local roads | Medium |

| | | | |
|---|---|---|---|
| | certain roads dangerous due to black ice. | | |
| Damages in tourist infrastructures due to more frequent extreme events | Changes in frequency and intensity of extreme events related to the tourism industry<br>Suitability of rural accommodations due to extreme events.<br>Sensitivity of the grape vine to extreme events. | Rural housing<br>Wine industry | Medium |

## 4.5.2 SENSITIVITY

#### 4.5.2.1 SENSITIVITY INDICATORS

Every transportation system was designed and built for local weather and climate conditions, predicated on historical temperature and precipitation data. However, now in the face of new weather and climate extremes, climate predictions used by transportation planners and engineers may no longer be reliable.

Infrastructure pushed beyond the range for which it was designed can become stressed and fail. Sensitivity of transport infrastructures depends on capability of each single infrastructure to keep functioning even out of “design range conditions”, in terms of weather patters, that means in temperatures and precipitation conditions, but it also regards flexibility of networks.

**Bullas climate conditions**:

For its low latitudinal position (38.05° N), and more specifically in the southeast Iberian peninsula, on the shores of a sea as warm as the Mediterranean, Bullas would fall in all its essence the typical Mediterranean climate, but to be a remarkable altitude (654 meters) and to have a straight-line distance to the nearest coastal point about 70 km, together with the influence of moderately vigorous relief that hamper the maritime influence Bullas climate should be defined as a continental Mediterranean climate .[107]

It is a Mediterranean climate, mainly by the amount and spatial distribution of rainfall, they are scarce (365 mm) and irregular with a marked summer drought, typical of all Mediterranean climates. As for temperatures, the altitude conducive to the average temperature of Bullas drop to 15 º C, with cool winters and hot summers, typical of that continentalization.

**Temperature:** Since Bullas municipality it's not really an extent one (87 $Km^2$), there're no excessive altitude differences, and the ones that are present cover a very little land area.

January it's the coolest month, with a mean temperature around 7ºC in the urban center, decreases in higher altitudes, up to 4 º C average in the higher areas of the municipality, and reaching to 8 º C in the lower areas. The maximum mean temperature is at about 13 º C in winter, while the average minimum is around 5ºC. July it's the warmer month, a merely 0.5ºC higher than august, which coincide with 55% meteorological observatories of AEMET (National Agency of Meteorology) in Spain, hence the imposition of July as the hottest month on the peninsula.

Mean annual temperature in Bullas it is show in Figure 69.

**Precipitations:** The distinguishing feature of all Mediterranean populations is the rainfall shortage. The average rainfall of Bullas rises to 365 mm, the upper register of the lower territories of the Region of Murcia.

[107] Source: http://climadebullas.blogspot.com/2010/01/caracteristicas-del-clima-de-bullas.html

Also highlights the irregularity of rainfall, giving the maximum rainfall at the equinoxes, in autumn (34.15%) and spring (32.79%), followed by winter (24.59%), leaving the minimum in summer, with a very prominent drought, with only 8.47% of rainfall.

Bullas precipitation values and annual precipitation are show in Figures 23 and 75 respectively.

Snow isn't an unusual phenomenon in the municipality, but it can't either be considered as frequent. Only areas situated higher than 1.000 m have snow several days. In Bullas, the average of snows days it's around 1.8 days.

Sensitivity indicators or parameters to evaluate sensibility can be classified in:

- Physical elements of infrastructure (i.e. trench, viaduct, bridge, drainage channels)
- Presence of fixed parameters or difficult to change (i.e. Fixed pathway)

  Greenway pathway has to be conserved, as well as European natural protected zones such as Salto del Usero.
- Location (i.e. Landslides, high levels of erosion, land subsidence)

  Land is hilly with altitude typography upward from south to north. This typography does not result in broad valleys, but small ones with its own microclimate.
- Type of materials

  Hillsides soils are brown and so tough that they need to be open mechanically before planting the vines. They consist of land-brown limestone and limestone crust, low in organic matter, good drainage and high levels of limestone, as well as alluvial soils of highly variable soil characteristics.

Bullas is characterized as a zone of limestone in the Subbetica litosoils area and shallow soils over them. From the standpoint of growing importance soils are noted for their brown-limestone soils (moderately high water capacity and permeability is not very high, high percentage of 35-65% calcium carbonate, pH close to 8, living organic matter 1-2%) and limestone crust (extreme aridity, vegetation and difficult to accommodate easily eroded) and alluvial (water-holding capacity average around 30%, permeability is not very high percentages of calcium carbonate 40-60% active, pH 7-8, organic matter between 0.5-1%).

The low organic content of these soils, good soil drainage and the high level of limestone are favorable characteristics for growing quality vines.

Before studying the vulnerability of this sector, it's necessary to take into account the degree of erosion that Bullas' soil is suffering currently, there are different approaches to assess the soil loss risk. Data from "Geographic Atlas of the Region of Murcia", calculated with ULSE model, point out than the sediment loss in soil by rill and inter-rill erosion, caused by water in Murcia is between 50 and 200 t/Ha.year.

- Age of infrastructure and present maintenance condition

Roads are well maintained.

- Type of vehicle and costumers

Spanish vehicles fleet was of 2791 millions of vehicles in 2010 and older with each passing time due to actual economic situation. Old vehicles have a higher risk of malfunctioning and has a worst combustion system, which lead to more greenhouse gas emissions.

Bullas first transportation system is privates' vehicles, mainly used by a single person.

- Level of importance of infrastructure (i.e. Urban road or runaway), traffic (average number of vehicle)

  Urban roads are highly important for Bullas' communication system since there is not a railway connection anymore for the city itself, thus people and merchandise transportation is made by that way.

- Intermodal connections and function as evacuation routes.

  Only evacuation routes are national and local roads.

- Criticality of infrastructure components (i. E. Congestion, bottlenecks).
- Lack of alternative paths

  There aren't alternative paths available for transportation purposes.

- Population density and land extension served

  Bullas population density can be seen in Table 2 and Figure 7.

- Facilities connected and business assets served

  Since national and regional roads are the only communication way Bullas have, hence those being the only communication way for business and facilities.

#### 4.5.2.2SENSITIVITY ASSESSMENT

*Table 64. Sensitivity assessment*

| Impact | Existing stress unrelated to climate | Sensitive elements/groups | Factors influencing the sensitivity of a system/sector | Sensitivity |
|---|---|---|---|---|
| Flooding and mudslides | The municipality's economy is based on agriculture, in particular depending on wine quality and production of other key sectors for economic development of the municipality, which need transportation routes to be available at every time of the year. | Urban transportation. | Intermodal connections and function as evacuation routes.<br>Level of importance of infrastructure.<br>Type of materials.<br>Location.<br>Physical elements of infrastructure.<br>Age of infrastructure.<br>Maintenance condition.<br>Type of soil. | S3- Yes - Functionality is likely to get worse |
| Heat waves → wildfire | Lack of proper firewalls.<br>Uncooperative population.<br>Pyromaniacs.<br>Increased grazing frequency due to vegetation loss.<br>Dry climate. | National and local roads (mainly mountain ones).<br>Farmers. | Amount of forest land.<br>Vegetation type.<br>Recurrence of precipitations in the area.<br>Number of workers dedicated to the maintenance of forest proper conditions against fire. | S3- Yes - Functionality is likely to get worse |
| Increase in extreme temperatures | Age of infrastructure and present maintenance condition | Railways and national and local roads. | Age of infrastructure.<br>Maintenance condition.<br>Available money for road reparations | S2- Unlikely - Functionality will likely stay the |

| | | | | |
|---|---|---|---|---|
| | | | | same |
| Water shortage → droughts | The Region of Murcia has currently serious problems with water supply. | Mountain roads | Type of soil.<br>Type of materials.<br>Infrastructure maintenance condition. | S2- Unlikely - Functionality will likely stay the same |

## 4.5.3 Potential impacts

The impacts of climate change on transportation infrastructure differ depending on the particular mode of transportation its geographic location, and its condition.

They vary also depending on time, in terms of short or long period for upcoming of climate changes, the relation with time life of infrastructure and the scheduled frequency of maintenance, retrofitting and new planning.

Present impacts of climate changes on transportation infrastructure regards inadequate risk management systems.

Future impacts, both direct and indirect, cover a wide range of typologies.

- Direct impacts of potential future climate changes are due to extreme events and changing in temperature and precipitation, including effects on infrastructure produced by different conditions of environment in which the infrastructure is located.
- Indirect impacts are considered as failure of transportation network that leads to and affection in the proper functioning of other areas such as markets, by the closure of roads, etc.

### 4.5.3.1 POTENTIAL IMPACTS INDICATORS

- Environmental indicators: Such as soil compaction, soil erosion, fires frequency, precipitation frequency (Seen in Figures 23, 75, 133 and 134).
- Socio-economic indicators: Land abandonment, solvent regional government.

## 4.5.4 ADAPTIVE CAPACITY

### 4.5.4.1 ADAPTIVE CAPACITY INDICATORS[108]

- Local and regional land plans that include analysis of vulnerability to climate change.
- Transport services plans.
- Availability of different transport systems and alternative path.
- Availability of early warning systems.
- Monitoring systems.
- Presence of public and private bodies in transport sector for each infrastructure system.
- Research and development on materials (i.e. resistance to high temperature, porous pavement for fast drainage, etc.).

[108] Source: "Assessment of climate change impacts and local vulnerabilities. Transportation infrastructure". Francesca Assennato (ISPRA) (2010)

### 4.5.4.2 ADAPTIVE CAPACITY ASSESSMENT

*Table 20. Adaptive capacity assessment*

| Impact | Adaptation baseline (Underway and planned adaptation actions, etc) | Factors determining the adaptive capacity of the system/sector | Is the system already able to accommodate changes in climate with minimal costs and disruption? | Can the system/sector adjust to the projected impact with minimal cost and disruption? | Barriers to the system's ability to accommodate changes in climate | Existing stress unrelated to climate that limit the system's ability to accommodate changes in climate | Rate of projected climate change compared to the adaptability of the system | Adaptive capacity |
|---|---|---|---|---|---|---|---|---|
| Impact on wine production and commercialization<br><br>(If there is not a working transportation system, products , raw materials, etc., can't be delivered where demanded) | Emergency Plan | Alternative transportations routes | no | yes | Current financial situation | Current financial situation | Same | AC4: Yes – But will require some slight costs ($$) and staff interventions |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Damages in tourist infrastructures due to more often extreme events | Emergency Plan | High investments required. Businesses are usually not well prepared for hazards (large businesses are generally better prepare than smaller ones, making the sector usually more vulnerable because it's traditionally dominated by small and medium-sized enterprises) | No, because it requires a high level of investments. | No, it will require significant cost and staff intervention | Economic (sector dominated by small and medium-sized enterprises). | No, there aren't big damages from previous disasters | Faster than the adaptability of the sector/system | AC3. Maybe – Will require some costs ($$$) and staff intervention |
| Loss of lives | Emergency Plan. Maintenance of infrastructures. Informing | Local and National government financial destination to | Yes | No, it will require significant cost | Current financial situation. Population unwariness. | Current financial situation. | Faster than the adaptability of the sector/system | AC3. Maybe – Will require some costs ($$$) and staff |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | population | infrastructures improvement. | | | | | | intervention |
| Concerns regarding pavement integrity, rail-track deformities | Maintenance of infrastructures. | Local and National government financial destination to infrastructures improvement. | Yes | No, it will require significant cost | Current financial situation | Current financial situation | Faster than the adaptability of the sector/system | AC3. Maybe – Will require some costs ($$$) and staff intervention |
| Unavailable roads | Maintenance of infrastructures.<br>Prevention plans.<br>Early awarning system.<br>Land planning. | Local and National government financial destination to infrastructures improvement.<br>Alternative transportations routes. | Yes | No, it will require significant cost | Current financial situation.<br>Population unwariness. | Current financial situation.<br>Lack of prevention. | Faster than the adaptability of the sector/system | AC3. Maybe – Will require some costs ($$$) and staff intervention |

### 4.5.5 VULNERABILITY ASSESSMENT

Vulnerability of the built environment including infrastructure pose a specific threat to the urban environment, particularly in coastal areas and river basins, producing changes in the ways people use transportation.

*Table 21. Sensitivity and adaptive capacity matrix. Vulnerability scale*

***VULNERABILITY = function [exposition (+); sensitivity (+); adaptive capacity (-)]***

| SENSITIVITY AND ADAPTIVE CAPACITY MATRIX | | | | | |
|---|---|---|---|---|---|
| | **S1** | **S2** | **S3** | **S4** | **S5** |
| **AC1** | V2 | V2 | V4 | V5 | V5 |
| **AC2** | V2 | V2 | V3 | V4 | V5 |
| **AC3** | V2 | V2 | V3 | V4 | V4 |
| **AC4** | V1 | V2 | V2 | V3 | V3 |
| **AC5** | V1 | V1 | V2 | V3 | V3 |

**VULNERABILITY SCALE:**
**V1: Low vulnerability**
**V2: Medium-Low Vulnerability**
**V3: Medium Vulnerability**
**V4: Medium-High vulnerability**
**V5: High vulnerability**

*Table 22. Vulnerability ratings*

| VULNERABILITY RATINGS | | | | |
|---|---|---|---|---|
| **High vulnerability (S5-AC1)=V5** | **Medium-High Vulnerability (S4-AC2)=V4** | **Medium Vulnerability (S3-AC2 or S3-AC3)=V3** | **Medium-Low Vulnerability (S2-AC3 or S2-AC2)=V2** | **Low Vulnerability (S1-AC5)=V1** |
| **Impact** | **Impact** | **Impact** | **Impact** | **Impact** |
| | Impact on wine production and commercialization | Damages in tourist infrastructures due to more often extreme events | | |
| | | Loss of lives | | |
| | | Concerns regarding pavement integrity, rail-track deformities | | |
| | | Unavailable roads | | |

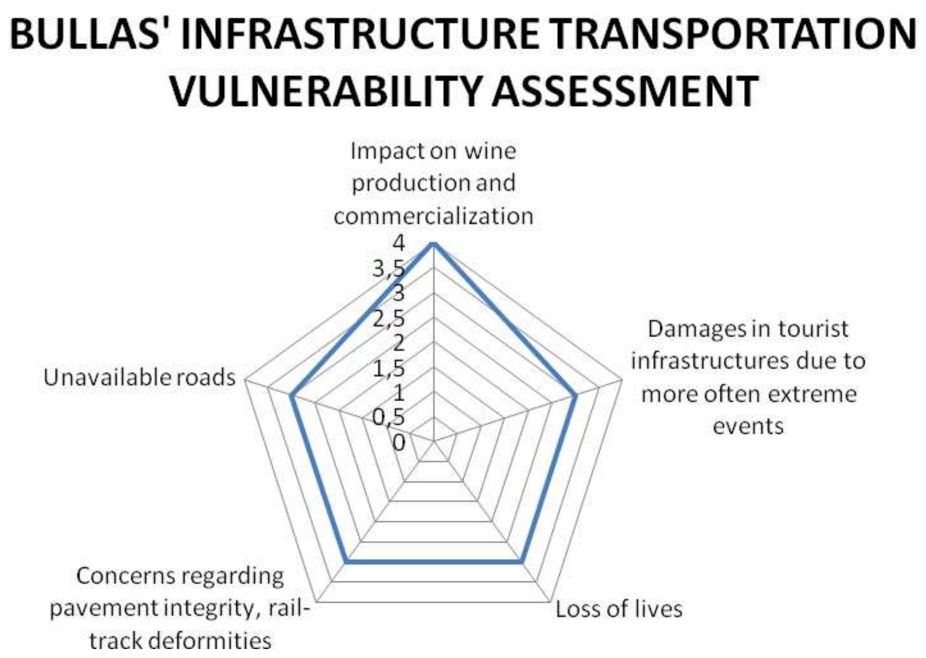



*Figure 52. Vulnerability assessment of Bullas' transportation infrastructure*

# ADAPTATION TO CLIMATE CHANGE

# 5

*Figure 5.1. Zacatin local market.*

**"BULLAS, A CLIMATE RESILIENT COMMUNITY"**

***This chapter covers specific measures for each one of the selected sectors providing a list and a description of all the measures selected as more suitable for this Local Adaptation Plan.***

The primary *objective* of this chapter is to identify climate change adaptation actions that are applicable to Bulla's climatic conditions and climate impact risks as currently predicted and that can be implemented by Bullas local government. Those actions should produce benefits other than those that are strictly tied to climate change and in particular provide a net economic, social or environmental benefit no matter what level of climate change occurs. Nevertheless, it is necessary to bear in mind that adaptation is an ongoing process. This adaptation plan should be consider as an action framework to cope with climate change projected impacts. Therefore, a deeply review must be done each year in order to enclose the specific actions that would be carried out.

In *Chapter 4* a vulnerability assessment has been made in order to identify priority planning areas – areas of particular importance to the community or government which are vulnerable to climate change impacts and the associated risks – to help with the task of selecting the different adaptation options that suit better the true nature of climate change in Bullas.

The adaptation actions that have been identified during this study are those that provide a net economic, social or environmental benefit no matter what level of climate change occurs.

## 5.1 Climate framework[109]

### 5.1.1 MEAN AND EXTREME TEMPERATURE

Despite the amount of available climate data, the assessment of climate trends for the area of Bullas was not performed. Recordings of the station Bullas - Depuradora cover a 13-year period (from 1997 to 2009), well below the requirement of 40 years. On the other hand, the observation period of the station Bullas is longer than 40 years, but its recordings end in 1976. A trend assessment without the climate information of the last few decades is not useful for the purposes of the project. [110]

Temperature projections for 2100 (compared to the period 1961-1990) in the area of Bullas were extracted from the gridded fields generated by two high-resolution Global Climate Models – GCMs (CNRM, INGV) and three Regional Climate Models – RCMs (CNRM-RM+5.1, KNMI-RACMO2, SMHIRCA). The results for the GCMs are available for the A2 (pessimistic), A1B (intermediate) and B1 (optimistic) scenarios, while for the RCMs are available only for the A1B scenario (intermediate).

Furthermore, as GCMs projections have a too coarse spatial resolution (around 100-300 km) for the evaluation of climate change impacts at local scale, temperature

[109] ROAD MAP FOR THE LOCAL ADAPTATION PLANS. F. Giordano (ISPRA), R. Mascolo (ISPRA).
[110] Desiato et al, 2010.

projections (2046-2065, 2081-2100 with respect to the climatological values of the period 1961-1990) were estimated through the statistical downscaling, which has been developed to estimate the local-scale information (50 km or less).

Tables 5.1 and 5.2 illustrate the range (minimum and maximum values) of change predicted for temperature and temperature extremes to 2100. It is important to underline that such a range is the result obtained from a limited number of models and that it could change to some extent if different models were used.

| CLIMATE SCENARIOS (2100)<br>MEAN TEMPERATURE (°C) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Winter | | Spring | | Summer | | Autumn | | Annual |
| **GCMs** | +1.6,+2.8 | | +2.4,+5.5 | | +3.3,+6.5 | | +2.0,+4.5 | | **+2.5,+4.8** |
| **RCMs** | +2.8,+3.6 | | +2.0,+3.3 | | +4.9,+5.6 | | +4.0,+4.3 | | **+3.7,+4.0** |
| **Downscaling** | **I** | **II** | **I** | **II** | **I** | **II** | **I** | **II** | |
| | **+0.4,+1.3** | **+1.0,+2.2** | **+1.0,+1.9** | **+1.9,+3.0** | **+1.7,+2.2** | **+2.5,+3.2** | **+0.7,+1.4** | **+1.2,+2.1** | |

*Table 5.1. Municipality of Bullas – Projections for seasonal and annual mean temperature.*

*Legend: I = 2046-2065; II = 2081-2100.*

GCMs projections predict the maximum increase for the mean temperature (6.5°C) in the summer, while the minimum increase (1.6°C) is predicted to occur during the winter.

The three RCMs estimate a rise of the mean air temperature at the end of the century between 3.7 °C and 4.0 °C. The most intense warming would occur in summer (4.9 °C-5.6 °C), while the least intense in spring (2.0 °C-3.3 °C).

Uncertainty due to the opposite scenarios (i.e. A2 and B1) could in some cases be equal to around 2.0 °C. This uncertainty is likely to be wider when more GCMs are considered.

Two out of three models used in statistical downscaling are in agreement in predicting that the highest temperature variations occur in summer. Winter is for Bullas the season with the lowest variations.

| CLIMATE SCENARIOS (2046-2065, 2081-2100) HEATWAVES | | | | | | |
|---|---|---|---|---|---|---|
| | HWII | | LWII | | NWII | |
| **Downscaling** | I | II | I | II | I | II |
| | +3.0,+26.9 | +14.0,+77.6 | +3.8,+16.1 | +14.3,+50.6 | +0.6,+1.1 | **+1.9,+3.0** |
| | SU | | TR | | FD | |
| | I | II | I | II | I | II |
| | **+10.4,+100.5** | **+19.9,+126.9** | **+9.1,+21.2** | **+18.2,+63.1** | **-12.1,-13.6** | **-13,-13.6** |

*Table 5.2. Municipality of Bullas – Projections for temperature extremes (2046-2065; 2081-2100).*

*Legend: HWII = Average intensity of heatwaves; LWII = Average number of days of each heatwave event; NWII = Average number of heatwaves. I = 2046-2065; II = 2081-2100. SU = Summer Days; TR = Tropical Nights; FD = Frost Days.*

Heat waves are predicted to severely increase in the future decades in particular in terms of average intensity and length, but relatively large uncertainty characterizes their prediction.

For example, in the period 2081-2100 the average intensity increase is predicted to range between 14.0 and 77.6, while the average length increase is projected to range between 14.3 and 50.6. A relatively large uncertainty characterizes also the projections of summer days, tropical nights and frost days. Lower uncertainties characterise the prediction of the decrease of frost days (Desiato et al., 2010).

### 5.1.2 CUMULATED PRECIPITATION AND DRY DAYS

Precipitation projections to 2100, indicated as percentage variation with respect to the period 1961-1990, were extracted from the gridded fields generated by two high-resolution Global Climate Models – GCMs (CNRM, INGV) and three Regional Climate Models – RCMs (CNRM-RM+5.1, KNMI-RACMO2, SMHIRCA). The results for the GCMs are available for the A2 (pessimistic), A1B (intermediate) and B1 (optimistic) scenarios, while for the RCMs are available only for the A1B scenario (intermediate).

In general, it is important to highlight that the uncertainty for the projections of precipitation is higher than the uncertainty for the temperature projections, as demonstrated by the relatively wide range of variation along with the rather irregular behaviour over the decades.

The following table illustrates the ranges (minimum and maximum values) of change predicted for cumulated precipitation to 2100.

| CLIMATE SCENARIOS (2100) CUMULATED PRECIPITATION (%) | | | | | |
|---|---|---|---|---|---|
| | **Winter** | **Spring** | **Summer** | **Autumn** | **Annual** |
| **GCMs** | -60.5,-18.6 | -68.7,-38.2 | -56.0,-3.0 | -35.2,-1.0 | **-37.8,-26.3** |
| **RCMs** | **-42.6,-16.8** | **-48.2,-27.9** | **-50.0,-34.6** | **-33.5,-27.2** | **-39.0,-29.7** |

*Table 5.3. Municipality of Bullas – Projections for seasonal and annual cumulated precipitation (2100).*

All the results show a decreasing seasonal and annual trend over the whole century.

With regards to GCMs, the drop of annual precipitation is predicted to range between -37.8 and -26.3. Stronger decreasing trends are identified for summer and spring in particular.

The three RCMs predict a reduction of the annual cumulated precipitation at the end of the century, ranging between - 29.7% and - 39.0%. The relatively wide range of the variation reflects the high uncertainty which characterises precipitation projections. No seasonal precipitation increase has been identified[111].

## 5.2 Impacts, vulnerabilities and adaptive capacity

A great number of observations and evidences show that climate change is already affecting natural systems and social and economic sectors in the area of Bullas (for more information see chapter 4).

It is necessary to bear in mind that all of the consequences arising from gradual change cannot be attributed just to climate change, since they are affected by other

[111] Desiato et al., 2010.

stresses such as, for example, population growth, urbanization, overexploitation of resources, or in general by economic or social change. But very often climate change represents the triggering or the accelerating factor.

In the last decades Bullas experienced heavy precipitation events, in particular during spring and autumn, while drought episodes occurred in other times of the year. Rain usually concentrates in a short time, alternating with long dry periods. Late frosts also occur, with consequent damages to cultivations. Furthermore, variability of precipitation makes it difficult to plan for irrigation needs.

Such climatic events not only affect agriculture in Bullas, but also produce hillside erosion thus contributing to the risk of desertification.

The economy of Bullas is mainly agricultural and thanks to its geographical location and climate, the municipality, together with other municipalities, has got the Designation of Origin "Bullas" (an official certificate for wine quality standards). Grapevine and olive are among the most representative agricultural crops in Bullas. The first one is very important for the economic role that wine producers play at national and international levels, while the latter is important both for the income it generates and its contribution to landscape.

Unfortunately, economic losses have been already experienced in agriculture, in some case due to climatic factors. Some adaptation measures are already in place in agriculture, such as the development of new varieties adapted to the lack of water or the exploitation of temperature increase in order to anticipate the harvests. These measures can be effective in some cases, but they are not really the final solution of the problem.

Furthermore, Bullas in recent years has begun to exploit cultural and rural tourism. Rural tourism, in particular, currently represents an important income for many farmers and other MSE (Medium and Small-sized enterprises), such as vineries, hotels, rural houses, restaurants, outdoors activities.

The local products market Zacatìn is a traditional market where visitors can find a wide range of typical local products. In addition, the Wine Route passes through a number of locations, both inside and outside the village, linked to local wine production. Also the Wine Museum represents a tourist attraction of the town.

Agriculture and tourism are therefore strictly linked and can be considered as key sectors for the economy of Bullas and its sustainable development. Negative effects on the first one could lead to further consequences on the second one[112].

| | | | |
|---|---|---|---|
| | Effects on grapevine phenology, quality and yield. | Wine industry, rural housing, hotel and restaurant business, museums. | |
| **Soil degradation and desertification** | Increase of desertification risk. | on qualitative assessment. High erosion risk area. | of the Bullas Origin Denomination is in charge of advising farmers in cultivar development and helping them to adapt to new situation |
| | Increase of soil erosion and desertification risk (Murcia). | | |
| | Land use change. | | Crop insurance. |
| | Increase in irrigation requirements (Murcia). | | Clean Agriculture Program |
| | | | Agro-climatic Information System for Irrigation (SIAR). |
| **Tourism** | Decrease in comfort conditions for tourism activity between June and September (2050 and 2100). "Acceptable" conditions will be always guaranteed. | Rather low vulnerability in summer (tourist flows: about 1500 out of 8500 in 2010). | Low adaptive capacity due to a low diversification of tourist activities. |
| | The remaining months will maintain the same conditions, with the peak of climatic comfort in May, but in general "excellent" and even "ideal" climate conditions in the other months during Spring and Autumn (2050 and 2100). | | |
| | Water shortages. | Population.<br>Tourism industry. | |

[112] Municipality of Bullas - Questionnaire on past, current, future impacts, vulnerability, policies related to climate risk, 2010.

*Table 5.4. Municipality of Bullas – Impacts, vulnerabilities and adaptive capacity*

Predictions of future impacts of climate change are obviously affected by large uncertainties. The results should therefore be handled with particular attention. In most cases the magnitude of changes has been assessed, but due to the lack of appropriate data some approximations and assumptions have been adopted. The results represent one of the possible approximations that scientific analysis is able to provide with the current data availability, but still further investigation is needed in order to get more reliable predictions. However, the key aspect in the first step towards adaptation is being aware about the direction of future changes.

In Bullas, the expected change in temperature and precipitation may have increasing negative effects in the coming decades on agriculture. The combination of long-term changes and the increase in the frequency of extreme weather events is likely to have adverse impacts, in terms of change in crop area, change in crop productivity and quality, change in crop phenology and many others[113].

Regarding to tourism, the TCI (Tourism Climate Index) has been calculated for different scenarios (see figure 5.2.) based on different climate change models. Although the calculation suffers from lack of some data, it has been possible to show that in the future (2050 e 2100) climate conditions, for the so called "light outdoors (touristic) activities", will show a bimodal-shoulder peaks distribution, being worse between June and September, when show less attractive climate conditions, compared to the same months of the baseline year 2010. The remaining months will maintain the same conditions, with the peak of climatic comfort in May, but in general "excellent" and even "ideal" climate conditions in the other months during Spring and Autumn.

[113] Local Impact Assessment on agriculture, 2011

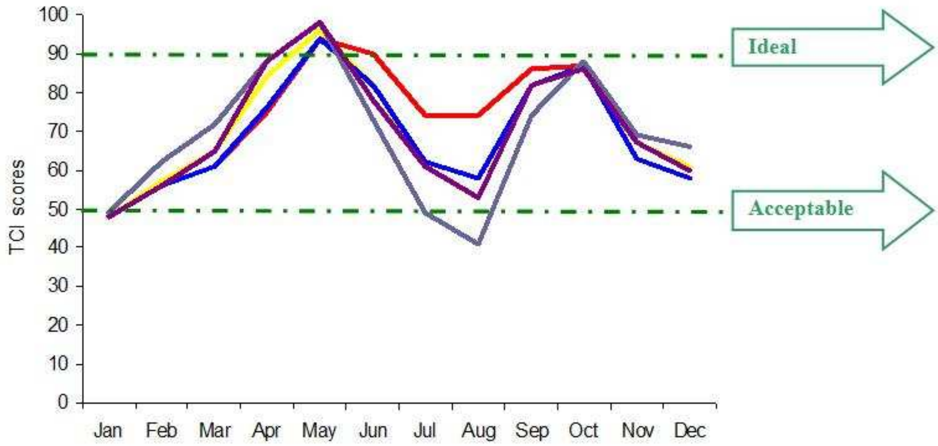



*Figure 5.2. : Comparison of TCI scores for the baseline year (2010) and for the future scenarios (2046-2065 and 2081-2100)*

The direct impact of climate change on tourism in Bullas will be likely not really significant, because during summer time tourist flows are usually lower even today. However, due to the potential impacts of climate change on agriculture and water resources the indirect impact on rural tourism should be further investigated[114].

Furthermore, projected climate change may exacerbate the problem of desertification, drought and soil degradation[115].

The results of climate projections give reason to expect further impacts which may concern other important sectors of the municipality of Bullas. In fact, natural resources, such as biodiversity, and socio-economic sectors such as health and infrastructure which are currently considered to be less vulnerable to climate change, in the coming decades may rapidly start to suffer from its negative effects.

[114] Local Impact Assessment on tourism, 2011
[115] Local Impact Assessment on soil, 2011

## 5.3 Identification of knowledge gaps and needs

More knowledge is needed on climate science, vulnerability and impacts of climate change so that appropriate policy responses can be developed. In fact, enhancing and developing the knowledge base, thus bridging as much as possible the gaps and reducing the uncertainties, will mean to empower decision-makers to formulate more scientifically-sound policies and to better address the challenges posed by climate change.

However, bridging the knowledge gaps represents a very challenging issue. Research on this issue is already considerable, but results are not always downscaled at local level and shared among the local decision-makers.

For this reason in addressing adaptation to climate change, the municipality of Bullas will have to manage a number of knowledge gaps and uncertainties. In most cases, the municipality will not be able to bridge them by itself as many knowledge gaps and uncertainties concern global and regional level and have to be developed at a higher scale. However, based on its administrative competences, financial resources and available technical expertise, the municipality will be able to reduce the knowledge deficit on local issues.

Table 5.5 lists the main gaps and needs on the way towards the adaptation process of the municipality of Bullas.

| CLIMATE SCIENCE | |
|---|---|
| **GAPS** | **NEEDS** |
| Scarce availability of expertise on climate change at local level. | Awareness raising, formation, capacity building of local technicians and managers. |
| | Awareness raising, formation, capacity building of local policy-makers. |
| Scarce availability of continuous and complete observed meteorological data series. | Strengthening the local equipment of meteorological stations. |
| Lack of precipitation extreme events projections. | Strengthening research. |

| IMPACTS, VULNERABILITIES, ADAPTATION | |
|---|---|
| **GAPS** | **NEEDS** |
| Scarce availability of expertise on climate change impacts, vulnerability and adaptation at local level | Awareness raising, formation, capacity building of local managers. |
| | Awareness raising, formation, capacity building of local policy-makers. |
| Scarce availability of sufficiently long series of observed data on impacts and vulnerability. | Strengthening the local equipment of monitoring systems. |
| Scarce availability of methods for monitoring climate change impacts and vulnerability. | Advances in research. |

| VULNERABLE SECTORS | | |
|---|---|---|
| **GAPS** | | **NEEDS** |
| **Agriculture** | Lack of data at local level (interpoled from regional ones). | Data collection at local level such as production for single crops, total water amount (precipitation plus irrigation) received by the crop, irrigation (only available at regional level). |
| | Lack of projections at local level (interpoled from regional ones). | Enhance transfer of knowledge from research communities to local decision makers. |
| **Tourism** | Lack of climate predicted data for the appropriate calculation of TCI (sunshine, wind, humidity). | Advances in research.<br>Enhance transfer of knowledge from research communities to local decisions makers.<br>Data collection at local level. |
| | Lack of sufficiently long time series of data on past tourist arrivals in Bullas. | |
| | Further investigation of indirect impact on rural tourism due to climate | |

| | | |
|---|---|---|
| | change. | |
| **Soil degradation and desertification** | Lack of a local assessment of desertification. | Downscaling of assessment from the Mediterranean scale to the local scale |
| | Lack of a local assessment of soil erosion. | Experimental stations able to monitor the processes of runoff and soil loss. Alternatively, in absence of field data, the downscaling of assessment from available regional scale to the local scale can be modelled (through dedicated software). |
| | Lack of future projections of the risk of desertification. | Enhance transfer of knowledge from research communities to local decisions makers**.** |
| **Other sectors** | Lack of quantitative analysis of other potential impacts and vulnerabilities to climate change. | Quantitative impact assessment of climate change impacts on other relevant sectors (i.e. biodiversity, health)**.** |

*Table 5.5. Municipality of Bullas – Main knowledge gaps and needs. Uncertainties to manage*

## 5.4 Uncertainties to manage

The use of models for the prediction of global, regional and local climate change and its consequences involves a number of uncertainty factors. In fact, it is not possible to know with an absolute certainty the way how climate will change in the future in the area of Bullas and which the effects on people, natural systems and society will be: not only climate change will have different impacts in different places, but the likelihoods of those impacts will vary significantly.

Projections of trends in emissions of greenhouse gases and aerosols are still very uncertain, as they depend on various socio-economic factors. Furthermore, climate change models predict temperature increases reasonably well, but uncertainty still surrounds the intensity and frequency of extreme weather events and moreover precipitation patterns. However, where different models come to similar results it is already possible to make first reliable statements about the direction and/or range of possible changes. Nevertheless, even with further refinement of climate scenarios, future impacts of climate change will remain uncertain and need to be continuously updated over time.

Not only uncertainty affects the knowledge of global and regional processes, but the more the projections go into the future and the smaller the size of the regions considered, the more the results will be uncertain. Therefore in its adaptation process the municipality of Bullas will have to deal with uncertainties at different levels (table 5.6).

| UNCERTAINTIES ABOUT THE FUTURE | |
|---|---|
| **GLOBAL AND REGIONAL LEVEL** | |
| Greenhouse gases emissions scenarios | |
| Socio-economic scenarios | |
| Projections of climate variables, in particular extreme events and precipitation patterns | |
| Projections of climate change impacts on natural systems and socio-economic sectors | |
| **LOCAL LEVEL** | |
| Projections of climate variables at local scale | |
| Agriculture | Projections of climate change impacts on agriculture |
| Tourism | Projections of sunshine, wind, humidity |
| Soil degradation | Projections of climate change impacts on soil |

*Table 5.6. Municipality of Bullas – Main uncertainties to manage*

## 5.5 Preparedness: goals and actions, guiding principles

As explained before, preparing for climate change is not a “one size fits all” process. Just as the impacts of climate change will vary from place to place, the combination of institutions and legal and political tools available to public decision-makers are unique from region to region. For these reasons, preparedness actions will need to be tailored to the circumstances of each moment at Bullas municipality.

Through this Adaptation Plan, Bullas Council takes an active role in preparing the municipality for climate change, because it is in their jurisdictions that climate change impacts are felt and understood most clearly.

The problem is that political backing could change during time, that’s why it is necessary to keep it strong. Political leaders, business managers, decision-makers shoud be aware that climate change will very likely keep on going forward over the next decades. Thus, they should take responsibility for building long-term capacity for society and ecosystems to adapt to climate change. Additionaly, effective coordination (horizontal and vertical) is needed.

Once identified risks and opportunities that climate change will pose to Bullas, the priority planned areas selected (see Chapter 4), and the knowledge gaps and needs, and uncertainties taked into account, the next step is to set preparedness goals and develop preparedness actions to address the system stresses that climate change will impose in these areas. In order to achieve this, the following steps related to this goal- and action-setting stage must be taken:

– Establish a vision to make Bullas a climate resilient community.

– Develop, select and prioritize preparedness actions for Bullas.

A climate resilient community is one that takes proactive steps to prepare for projected climate change impacts. Among the variety of possible measures applicable to transform Bullas into a resilient community, the specific actions that are selected in this report have been developed through:

– Literature Review: A review was undertaken of the existing literature and information on climate change adaptation actions available at both the international and domestic level that are relevant to the key responsibilities of local government (See Bibliography).

– Key Informant Interviews: To support the review of relevant information addressing climate change adaptation strategies and the development of possible new strategies, informal discussions were held with the adaptation team and with Bullas' citizens[116]. During these discussions, stakeholder and citizens views were obtained on the possible types of adaptation strategies, existing local government initiatives that were of relevance to climate change adaptation, and recommendations of possible mechanisms for implementation (See Annexes).

[116] ACT Day, Bullas, February 4th 2012.

To achieve this goal, there must be taken into account the existence of various types of adaptation, including policy-driven adaptation and autonomous adaptation.

Policy driven adaptation is “the result of a deliberate policy decision”. This kind of adaptation is therefore associated with authorities consisting of setting policies to encourage and inform adaptation or taking direct action, such as public investment. In contrast autonomous adaptation describes actions “taken ‘naturally’ by private actors, such as individuals, households, businesses in response to actual or expected climate change, without the active intervention of policy”[117].

| TYPE OF ADAPTATION[118] | | CHARACTERISTICS |
|---|---|---|
| **Policy-driven adaptation** | **Building adaptive capacity** | Creating the information and conditions (regulatory, institutional and managerial) that enable adaptation actions to be undertaken. |
| | **Taking adaptive action** | Taking actions that will help reduce vulnerability to climate risk or exploit opportunities. |
| **Autonomous or unassisted adaptation** | | Adaptation that occurs naturally or arises not as a conscious response to changing climate. |

*Table 5.7. Municipality of Bullas – Types of adaptation*

Therefore this Adaptation Plan is a Policy-driven one, and consequently the only proposed measures are those that can be achieved by Bullas Council.

At this stage, the **guiding principles** for planning concrete adaptation actions that allow the transformation of Bullas into a resilient community and overcome the adaptation barriers (gaps and needs) identified during the whole process are needed. The mesearues chosen should try to cover the following aspects:

1. Provide useful information to overcome the knowledge gaps. Some measures are chosen in order to collect information and develop the knowledge base to

[117] Source: “The Stern Review on the Economics of Climate Change”. Nicholas Stern. 2006.
[118] Source: “Adaptation to Climate Change in the Agricultural Sector AGRI-2006-G4-05”. AEA Group.

establish trends to strengthen and build the adaptive capacity of Bullas. Data collecting and monitoring: trends, tools and models. These measures included: Compilation of data, research, strengthening the local equipment of monitoring systems select best available technical options, etc.

2. Offer an effective communication system to increase the awareness, information and formation of stakesholders and to allow them to act in advance to potential risks. (technicians, local managers, policy makers). It is necessary to enhance the transfer of the updated knowledge to stakeholders.

3. Select specific measures for the vulnerable areas.

## 5.6 Identification of existing and potential adaptations

Once a wide expectrum of adaptation options have been explored from the literature review, has been proposed by the technician and the adaptation team has been consulted, the next stage is to develop specific adaption options or policies for Bullas. With this purpose potential and existing adaptation measures all around the world have been identified and only the ones that can be used at any length in Bullas Adaptation Plan are selected and included in this document.

Firstly, some general interdisciplinary adaptation measures are proposed. Secondly, both existing and potential adaptations measures are presented according to the priority planning areas previously selected, and lastly other potential adaptations measures for some major resources or areas that are important for human life such as water, energy, $CO_2$ emissions, industry, etc, can be seen in the Annexes.

### 5.2.1 INTERDISCIPLINARY ADAPTATIONS MEASURES

A commonly used denominator for municipal hiring's could be the level of climate change adaptation measures each of the applicants applies. That can also be taken into consideration in local proceedings, taxes, permissions, etc.

## 5.2.2 Specific sectorial adaptation measures

The following measures are the ones specifically selected for Bullas municipality, taking into account its particular characteristics and the impacts that will most likely affect the region, identified in the vulnerability assessment.

For each one of the selected areas – tourism, agriculture and soil, health, transportation infrastructure- the methodology used is based in the following four steps:

**STEP 1:** Identification of current adaptation options.

**STEP 2:** How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

**STEP 3:** How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?

**STEP 4:** How to prioritize these adaptation options? How to integrate them into existing policies?

**STEP 5:** Best options for Bullas

The variety of measures proposed can be achieved at different extents that will vary pending on timely considerations made by the local government according to the availability of personnel and budget each year.

# TOURISM

Leisure tourism in general, is among the most vulnerable tourist sectors. They are not only exposed and sensitive to climate change, but their adaptive capacity is usually low.

Knowledge about vulnerability to climate change will therefore play an important role in present and future management strategies of tourism destinations and will help policy makers and resource managers determine the areas of highest priority for early action.

Regarding Bullas, tourists[119] have the greatest adaptive capacity (depending on three key resources; money, knowledge and time) with relative freedom to avoid destinations impacted by climate change or shifting the timing of travel to avoid unfavourable climate conditions. In contrast, tourism service suppliers and operators in Bullas have less adaptive capacity.

As illustrated in the figure 5.2. the worsening of climatic conditions will occur during the summer season, while Spring and Autumn will have excellent and even ideal climatic conditions. Furthermore, as summer is the period in which the lowest tourist flows are registered, the impact of climate change on tourism in Bullas will be likely scarcely significant.

The main objective of the following adaptation measures is to adapt Bullas touristic offer to climate change enhancing Bullas Natural Winery as a sustainable tourism option, giving value to climate change mitigation and adaptation measures.

The proposed measures have been selected after a meticulouse evaluation of the impacts identified in the *ad hoc* assessment (key vulnerabilities) in order to overcome knowledge gaps and potential barriers to adaptation.

As adaptation capacity of this sector is a weak spot, some of the proposed actions pretend to improve it, on one hand via collecting indicators that shows real tourist

[119] Source: UNWTO-UNEP-WMO 2008

trends according to meteorology in order to inform stakeholders so they will be able to act in advance toward climate change and on the other hand, through an effective communication system to keep them punctually informed and to boost awareness among tourists and other stakeholders.

With the objective to build adaptive capacity, tourist operators will be informed by the local government with a wider range of leisure options for the less touristic months so that they can take adaptive action.

Bullas municipality aware of the importance of wine and eco-tourism in its economy has begun to take measures to maintain the quality of the production and to be known as wine producers. With this aim Bullas is a partner in the Vinest Project (The network for small European wine areas). Vinest is an European network for sharing experience and know-how in the wine sector, that tries to promote the interplay of small European wine areas in order to protect and enhance the variety and individuality of their wines, lands and cultures[120].

**IMPACT: CHANGE IN SEASONAL TOURIST FLOW**

**STEP 1: Identification of current adaptation options**

- ✓ Compilate of a *Register of Tourism Indicators* by the Wine Museum and Tourism Office.
- ✓ Provide tourist information and guided visits in other languages.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Make a more comprehensive and systematic record that complements the previous one and includes indicators of sustainable tourism, such as: average stay of tourists, tourism spending, level of satisfaction of tourists and preferences (best value for money, state of natural areas, tourist offer, service offered by the

[120] http://www.vinest.net

tourist office, accesses,...), number of employees in the tourism sector steady and seasonal.

✓ Collect meteorological data in order to update the TCI index[121], which is:

$$TCI = 2\,[(4 \times CID) + CIA + (2 \times P) + (2 \times S) + W]$$

| Sub-Index | Monthly Climate Variables | Influence on TCI | Weighting in TCI |
|---|---|---|---|
| Daytime Comfort Index (CID) | Maximum daily temperature (in ºC) & minimum daily relative humidity (%) | Represents thermal comfort when maximum tourist activity occurs | 40 % |
| Daily Comfort Index (CIA) | Mean daily temperature (in ºC) & mean daily relative humidity (%) | Represents thermal comfort over the full 24 hour period, including sleeping hours | 10 % |
| Precipitation (P) | Total precipitation (in mm) | Reflects the negative impact that this element has on outdoor activities and holiday enjoyment | 20 % |
| Sunshine (S) | Total hours of sunshine | Rated as positive for tourism, but acknowledged can be negative because of the risk of sunburn and added discomfort on hot days | 20 % |
| Wind (W) | Average wind speed (in m/s or km/h) | Variable effect depending on temperature (evaporative cooling effect in hot climates rated positively, while "wind chill" in cold climates rated negatively) | 10 % |

[121] TCI index stands for Tourist Climate Index of Mieczkowski see *Chapter 4*. TCI is the most common index used to analyze the potential impacts of climate change on the number of tourists visiting a specific region. This index is based on the notion of "human comfort" and consists of five sub-indices, each represented by one or two monthly climate variables.

For it, the following data must be collected yearly:

| Max. Mean T (ºC) | Min. Daily Rel. Humidity | Mean Daily Rel. Humidity | Effective T (CID) (ºC) | Mean T (ºC) | Effective T (CIA) (ºC) | Precipitation (mm) | Sunshine (h/month) | Mean Daily sunshine (h) | Wind speed (km/h) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |

- ✓ Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.
- ✓ Provide tourist information and guided visits in more languages than already are.
- ✓ Suggest a variety of leisure options to lure tourist during the low-season (i.e., Salto del Usero, roman baths, Mula's river spring, etc.).
- ✓ Go on promoting and facilitate rural accommodation, encouraging the owners of second homes in the area to rent them, and include it within the tourist offer.
- ✓ Encourage the development of thematic and seasonal tourist packages that include, not only a range of activities appropriate for the less touristic months, but also the possibility of accommodation. Therefore middle and long distance (not regional) tourism is boosted.
- ✓ Assure that Bullas' tourist offer is included within the main itinerary of tourist routes of the Region (i.e.: arrange an information point at Cartagena port cruise pier offering all include experiences - transport, food, winery visits, and the Museum of wine, etc.).

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Review the recorded indicators and include or eliminate those considered significant or not, so that the tourist offer is adapted to reality.
- ✓ Continue compiling meteorological data in order to keep on updating the TCI.

- ✓ Adapt tourist and commercial schedules to reality according to the tourist indicators collected.
- ✓ Keep promoting tourist information and guided visits in other languages (the ones selected using tourist indicators).
- ✓ Keep on suggesting different leisure alternatives to lure tourist during the low-season.
- ✓ Carry on working to promote rural allocation in order to attract middle and long distance (not regional) tourism.
- ✓ Encourage stakeholders to assure that thematic and seasonal tourist packages are conformed to visitors' preferences (identified using the recorded tourist indicators).
- ✓ Guarantee that the tourist information provided in large tourist influx points – such as Cartagena port cruise pier- is updated.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

## IMPACT: TOURISTS' HEALTH PROBLEMS

### STEP 1: Identification of current adaptation options

- ✓ Awareness campaigns including self-protection measures against heat strokes promoted by competent governments (Ministry/ Autonomous Communities)
- ✓ Wine Museum has different schedules in winter and summer in order to avoid higher periods of sunshine.
- ✓ Existing accessible air conditioned public facilities against thermal stress.
- ✓ Awnings over strategic streets to supply shade in hottest months are placed.
- ✓ Water spraying systems are placed in the terraces of some catering businesses in order to minimise clients' thermal sensation in summertime.

### STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ In collaboration with nearby public health centres try to collect data about the number of tourists treated for heat strokes, and other health problems – related to climate change.
- ✓ Gather daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.).
- ✓ Increase public awareness about the public health implications of climate change, including risks and the need for emergency preparedness and translate it into other languages.
- ✓ Be attentive to national health alerts and recommendations –related to climate change- to be able to act in advance.
- ✓ Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.
- ✓ Provide accessible air conditioned public facilities.
- ✓ Evaluate the possibility to place awnings over more streets to supply shade.

- ✓ Consider the viability of seed plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area.
- ✓ Give information to catering businesses about different cooling options both inside and outside (trying to promote the more efficient ones).
- ✓ Study the feasibility of placing more outdoor drinking facilities.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Keep collecting data about number of tourists treated for health problems related to climate change.
- ✓ Carry on with the compilation of daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.)
- ✓ Increase public awareness about the public health implications of climate change, including risks and the need for emergency preparedness and translate it into the languages selected using the data compiled by the Wine museum and Tourist office.
- ✓ Be attentive to national health alerts and recommendations –related to climate change- to be able to act in advance.
- ✓ Adopt heat-emergency contingency plans for recreational/tourist events, health within local council area (state governments are responsible for emergency services but local governments are usually first in line for provision of services) Local governments approve applications for tourism events and can be involved in emergency contingency planning.
- ✓ Adapt the schedules of municipal touristic facilities taking into account the collected data about tourist influx.

- ✓ Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.
- ✓ Encourage scheduling recreational, tourist and sporting events and activities to avoid the hottest part of the day and at shady locations where possible.
- ✓ Provide accessible air conditioned public facilities.
- ✓ Keep on increasing the number of awnings over streets.
- ✓ Restudy the possibility of seeding more plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area.
- ✓ Include provision of shade structures in design of new council recreational facilities.
- ✓ Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres and in any development plans for picnic areas, playgrounds etc.
- ✓ Continue giving information to catering businesses about different cooling options both inside and outside (trying to promote the more efficient ones).
- ✓ Study the feasibility of placing more outdoor drinking facilities.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: WATER SHORTAGES**

**STEP 1: Identification of current adaptation options**

- ✓ High awareness of citizens for water management due to water shortages in the Region of Murcia.
- ✓ Current regional laws[122] stating the need for information about water shortages and perceptiveness about the need to avoid water waste.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Compile a database that contains data of water consumption, total volume of water consumed, etc, to include it in the Register of Tourism Indicators. To be able to act preventively in case of water shortages.
- ✓ Since tourists typically use relatively more water than local inhabitants (in part because of additional water uses such as garden irrigation, cleaning, swimming pools, etc.) manage additional awareness campaigns for sustainable water consumption.
- ✓ Investigate the possibility of a deeper management and water control at a local level.
- ✓ Evaluate the application of mulches in more parks than already have, to avoid evapotranspiration as well as weds.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Carry on and, if necessary, improve the acquisition of data for the Register of Tourism Indicators of water consumption, total volume, etc.

[122] *Law 6/2006, 21 July, about increasing the measures for the savings and conservation of water consumption in the Murcia Autonomous Community. Murcia, Spain.*

- ✓ Increase awareness campaigns for sustainable water consumption amongst tourist and local population.
- ✓ Keep looking into the possibility of water controls and management being tailored for specific council areas
- ✓ Increase application of mulches in more parks to avoid evapotranspiration and weds, if applicable.
- ✓ Promote water controls and management being tailored for specific council areas.
- ✓ Analyze water requirements for new recreational facilities/areas and the way to manage them if needed.
- ✓ Inquiry and advertise new ways to save, reuse, and manage water efficiently.
- ✓ Develop a guide for homeowners, developers, architects, etc., to educate them about the significance of water saving options.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: PROBLEMS WITH ENERGY SUPPLY**

**STEP 1: Identification of current adaptation options**

- ✓ Signature of Bullas municipality government adhesion to the Covenant of Mayors to committee to local sustainable energy.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Include information of energy consumption and its origin (% renewable energies) in the Data Register.
- ✓ Engage energy providers to enhance local renewable generation opportunities.
- ✓ Work actively in the Covenant of Mayors.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Take steps to decrease municipal and community energy consumption.
- ✓ Increase municipal and community energy security, use of renewable resources, and overall energy efficiency.
- ✓ Work toward the increase of the resiliency of emergency energy systems.
- ✓ Engage energy providers to enhance local renewable generation opportunities.
- ✓ Inquiry and advertise new ways to save, reuse, and manage energy efficiently.
- ✓ Develop a guide for homeowners, developers, architects, etc., to educate them about the significance of sustainable energy consumption and renewable energies.
- ✓ Keep working actively in the Covenant of Mayors.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: IMPACTS ON BIODIVERSITY. CHANGES IN FLORA, FAUNA AND LANDSCAPES**

**STEP 1: Identification of current adaptation options**

- ✓ There are currently areas protected by European laws (LIC, ZEPA, etc.).
- ✓ Maintenance of the Green Pathway.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Compile indicators that show tourist preferences related to activities concerning flora, fauna and landscapes.
- ✓ Study the feasibility of upgrading the length of the Green Pathway or to propose alternatives routes with a variety of landscape.
- ✓ Dedicate additional resources to the provision and maintenance of parks, forests and other green areas in case of budget excess.
- ✓ Try to provide for increased regular maintenance of park/green space in council management plans and council budgets.
- ✓ Take steps to protect habitats and migration routes in collaboration with regional, national and European authorities.
- ✓ Aware private forest owners about the importance of maintenance of the land and the need to work more in the prevention *"better safe than sorry"*.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Take advantage of changes of local flora and fauna to be able to offer new activities taking into account tourist preferences identified from the collected indicators.

- ✓ Promote and improve those activities identified as tourist favorites using the compiled data.
- ✓ Dedicate additional resources to the provision and maintenance of parks, forests and other green areas in case of budget excess.
- ✓ Try to provide for increased regular maintenance of park/green space in council management plans and council budgets.
- ✓ Take steps to protect habitats and migration routes in collaboration with regional, national and European authorities.
- ✓ Increase public awareness.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: IMPACTS ON AGRICULTURE, FORESTRY AND WINE PRODUCTION**

These impacts are studied in deep in the following section.

**IMPACT: DAMAGES IN TOURIST INFRASTRUCTURES DUE TO MORE FREQUENT EXTREME EVENTS**

These impacts are studied in deep in the following section.

| TOURISM |
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| **STEP 5: BEST OPTIONS FOR BULLAS** |
| **GENERAL MEASURES** |
| BUILDING ADAPTATIVE CAPACITY (Policy-driven adaptation): Improve the **Register of Tourism Indicators** that is being compiled by the Wine Museum and Tourism Office adding at least data about:  average stay of tourists, tourism spending, level of satisfaction of tourists and preferences (best value for money, state of natural areas, tourist offer, service offered by the tourist office, accesses, etc.), number of employees in the tourism sector steady and seasonal, water consumption, total volume of water consumed,  energy consumption and its origin (% renewable energies), number of tourist treated for climate change related health issues. |
| BULDING ADAPTATIVE CAPACITY BY KEEPING INFORMED STAKEHOLDERS (Policy-driven adaptation): Develop an **ecotourism website** (as an effective communication system) where Bullas Council can share the trends getted from the Register of Tourist Indicators, practical information on adaptation measures, options and advices, etc. with stakeholders, including the actions (among the proposed ones) that Bulls Council is taking each year.  In this website, every Bullas touristic offer will be advertised and promoted.<br><br>It is necessary to bear in mind that for transferring updated knowledge to stakeholders, technician from Bullas Council must be formed. Bullas Council should assure periodical training in these issues to its workers. |
| GENERAL SPECIFIC MEASURE: Promote sustainable tourism as Bullas Natural winery giving value to climate change mitigation and adaptation |

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| measures that Bullas Council is carrying-out and awaring tourists.<br><br>To achieve this goal a **green or natural passport**[123] can be designed. This passport can include issues like:<br><br>– General tourist information (different options, touristic routes, accomodation, restaurant bussiness, presents, etc.)<br><br>– Awareness campaigns (health, water, energy, etc.).<br><br>– Sustainable activities for children (games, workshops, etc., to raise awareness of the importance of the conservation of the natural environment and sustainable tourism. For each overcame activity, kids will acquire stamps that will result in prizes or discounts). | | |
| **SPECIFIC MEASURES (FOR EACH SELECTED IMPACT)** | | |
| **Impacts** | **Short and medium-term measures** | **Long-term measures** |
| Change in seasonal tourist flow | ✓ Make a more comprehensive and systematic record that complements the previous one and includes indicators of sustainable tourism, such as: average stay of tourists, tourism spending, level of satisfaction of tourists and preferences (best value for money, state of natural areas, tourist offer, service offered by the tourist office, accesses,...), number of employees in the tourism sector steady and seasonal. | ✓ Review the recorded indicators and include or eliminate those considered significant or not, so that the tourist offer is adapted to reality.<br><br>✓ Continue compiling meteorological data in order to keep on updating the TCI.<br><br>✓ Adapt tourist and commercial schedules to reality according to the tourist indicators collected. |

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| | ✓ Collect meteorological data in order to update the TCI index: Max. Mean T (ºC), Min. Daily rel. Humidity, mean daily rel. Humidity, effective T (CID) (º C), mean T (º C), effective T (CIA) (º C), precipitation (mm), sunshine (h/month), mean daily sunshine (h) and wind speed (km/h).<br>✓ Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.<br>✓ Provide tourist information and guided visits in other languages.<br>✓ Suggest a variety of leisure options to lure tourist during the low-season (i.e., Salto del Usero, roman baths, Mula's river spring, etc.).<br>✓ Go on promoting and facilitate rural accommodation, encouraging the owners of second homes in the area to rent them, and include it within the tourist offer.<br>✓ Encourage the development of thematic and seasonal | ✓ Keep promoting tourist information and guided visits in other languages (the ones selected using tourist indicators).<br>✓ Keep on suggesting different leisure alternatives to lure tourist during the low-season.<br>✓ Carry on working to promote rural allocation in order to attract middle and long distance (not regional) tourism.<br>✓ Encourage stakeholders to assure that thematic and seasonal tourist packages are conformed to visitors' preferences (identified using the recorded tourist indicators).<br>✓ Guarantee that the tourist information provided in large tourist influx points – such as Cartagena port cruise pier- is updated. |

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| | tourist packages that include, not only a range of activities appropriate for the less touristic months, but also the possibility of accommodation. Therefore middle and long distance (not regional) tourism is boosted.<br>✓ Assure that Bullas' tourist offer is included within the main itinerary of tourist routes of the Region (i.e.: arrange an information point at Cartagena port cruise pier offering all include experiences - transport, food, winery visits, and the Museum of wine, etc.). | |
| Tourists' health problems | ✓ In collaboration with nearby public health centres try to collect data about the number of tourists treated for heat strokes, and other health problems – related to climate change.<br>✓ Gather daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.).<br>✓ Increase public awareness about the public health | ✓ Keep collecting data about number of tourists treated for health problems related to climate change.<br>✓ Carry on with the compilation of daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.)<br>✓ Increase public awareness about the public health implications of climate change, including risks and the |

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| | implications of climate change, including risks and the need for emergency preparedness and translate it into other languages.<br>✓ Be attentive to national health alerts and recommendations –related to climate change- to be able to act in advance.<br>✓ Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.<br>✓ Provide accessible air conditioned public facilities.<br>✓ Evaluate the possibility to place awnings over more streets to supply shade.<br>✓ Consider the viability of seed plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area.<br>✓ Give information to catering businesses about different cooling options both inside and outside (trying to promote the more efficient ones). | need for emergency preparedness and translate it into the languages selected using the data compiled by the Wine museum and Tourist office.<br>✓ Be attentive to national health alerts and recommendations –related to climate change- to be able to act in advance.<br>✓ Adopt heat-emergency contingency plans for recreational/tourist events, health within local council area (state governments are responsible for emergency services but local governments are usually first in line for provision of services) Local governments approve applications for tourism events and can be involved in emergency contingency planning.<br>✓ Adapt the schedules of municipal touristic facilities taking into account the collected data about tourist influx.<br>✓ Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.<br>✓ Encourage scheduling recreational, tourist and sporting |

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| | ✓ Study the feasibility of placing more outdoor drinking facilities. | events and activities to avoid the hottest part of the day and at shady locations where possible.<br>✓ Provide accessible air conditioned public facilities.<br>✓ Keep on increasing the number of awnings over streets.<br>✓ Restudy the possibility of seeding more plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area.<br>✓ Include provision of shade structures in design of new council recreational facilities.<br>✓ Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres and in any development plans for picnic areas, playgrounds etc.<br>✓ Continue giving information to catering businesses about different cooling options both inside and outside (trying to promote the more efficient ones).<br>✓ Study the feasibility of placing more outdoor drinking |

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| | | facilities. |
| Water shortages | ✓ Compile a database that contains data of water consumption, total volume of water consumed, etc, to include it in the Register of Tourism Indicators. To be able to act preventively in case of water shortages.<br>✓ Since tourists typically use relatively more water than local inhabitants (in part because of additional water uses such as garden irrigation, cleaning, swimming pools, etc.) manage additional awareness campaigns for sustainable water consumption.<br>✓ Investigate the possibility of a deeper management and water control at a local level.<br>✓ Evaluate the application of mulches in more parks than already have, to avoid evapotranspiration as well as weds. | ✓ Carry on and, if necessary, improve the acquisition of data for the Register of Tourism Indicators of water consumption, total volume, etc.<br>✓ Increase awareness campaigns for sustainable water consumption amongst tourist and local population.<br>✓ Keep looking into the possibility of water controls and management being tailored for specific council areas<br>✓ Increase application of mulches in more parks to avoid evapotranspiration and weds, if applicable.<br>✓ Promote water controls and management being tailored for specific council areas.<br>✓ Analyze water requirements for new recreational facilities/areas and the way to manage them if needed.<br>✓ Inquiry and advertise new ways to save, reuse, and manage water efficiently. |

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| | | ✓ Develop a guide for homeowners, developers, architects, etc., to educate them about the significance of water saving options. |
| Problems with energy supply | ✓ Include information of energy consumption and its origin (% renewable energies) in the Data Register.<br>✓ Engage energy providers to enhance local renewable generation opportunities.<br>✓ Work actively in the Covenant of Mayors. | ✓ Take steps to decrease municipal and community energy consumption.<br>✓ Increase municipal and community energy security, use of renewable resources, and overall energy efficiency.<br>✓ Work toward the increase of the resiliency of emergency energy systems.<br>✓ Engage energy providers to enhance local renewable generation opportunities.<br>✓ Inquiry and advertise new ways to save, reuse, and manage energy efficiently.<br>✓ Develop a guide for homeowners, developers, architects, etc., to educate them about the significance of sustainable energy consumption and renewable energies. |

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| | | ✓ Keep working actively in the Covenant of Mayors. |
| Impact on biodiversity. Changes in flora, fauna and landscape. | ✓ Compile indicators that show tourist preferences related to activities concerning flora, fauna and landscapes.<br>✓ Study the feasibility of upgrading the length of the Green Pathway or to propose alternatives routes with a variety of landscape.<br>✓ Dedicate additional resources to the provision and maintenance of parks, forests and other green areas in case of budget excess.<br>✓ Try to provide for increased regular maintenance of park/green space in council management plans and council budgets.<br>✓ Take steps to protect habitats and migration routes in collaboration with regional, national and European authorities.<br>✓ Aware private forest owners about the importance of | ✓ Take advantage of changes of local flora and fauna to be able to offer new activities taking into account tourist preferences identified from the collected indicators.<br>✓ Promote and improve those activities identified as tourist favorites using the compiled data.<br>✓ Dedicate additional resources to the provision and maintenance of parks, forests and other green areas in case of budget excess.<br>✓ Try to provide for increased regular maintenance of park/green space in council management plans and council budgets.<br>✓ Take steps to protect habitats and migration routes in collaboration with regional, national and European authorities.<br>✓ Increase public awareness. |

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| | maintenance of the land and the need to work more in the prevention *"better safe than sorry"*. | |
| Impact on agriculture, forestry and wine production | These impacts are studied in deep in the following section. | |
| Damages in tourist infrastructures due to more frequent extreme events | These impacts are studied in deep in the following section. | |

# AGRICULTURE AND SOIL

Agricultural adaptation to climate change involves adjustments in natural or human systems in response to climatic conditions or risks, to maintain, preserve, or enhance the viability of agricultural systems.[124]

The agricultural sector is one in which autonomous adaptation is a particularly important category because farmers have traditionally adapted their methods in response to felt changes, whilst policy driven ones at a local level has little to none effect in this sector because most applicable laws for agriculture are state level ones.

The proposed measures have been selected after a meticulouse evaluation of the impacts identified in the *ad hoc* assessment (key vulnerabilities) in order to overcome knowledge gaps and potential barriers to adaptation.

Taking into account that adaptation capacity of the agricultural sector is primordial, some of the proposed actions pretend to improve it, on one hand via collecting a wide range of indicators (see general measure *Standarised Record*) to evaluate trends and create models in order to inform stakeholders so they will be able to act in advance toward climate change and on the other hand, through an effective communication system to keep farmers punctually informed (see general measure about the *Knowledge Sharing Platform*).

Besides, the displayed measures expect raising awareness amongst farmers, and supply the means to adapt agriculture to climate change creating a knowledge-sharing platform with restricted access for the involved stakeholders, with local early alert systems (meteorological, weeds and pest, etc.), and practical information about new technology, crops variety, best available techniques (BAT), etc., will be given.

It is necessary to bear in mind that for transferring updated knowledge to stakeholders, technician from Bullas Council must be formed. Bullas Council should assure periodical training in these issues to its workers.

Additionally, as said in section 5.2.2 concerning tourism, Bullas municipality is a partner in the Vinest Project (The network for small European wine areas). Agriculture is a core sector for the Municipality not only because of its economy is based to a large extends in farming activities, but also due to its tourism relies in agriculture in general and in wine culture in particular. Vinest project, which aims are the following, complement this Plan in some aspects:

- Improve product quality in each area.
- Heighten the presence of tourists in small-scale wine producing areas.
- Increase the number of young people working in the wine sector.
- Protect terroirs from any changes that may prove harmful.
- Keep traditions alive.

Bullas aim in the project is to achieve the following specific objectives:

- Study of new production technologies.
- Technical support and assistance to the winemakers and farmers involved in the sector.
- Development and promotion of wine tourism, which will create a route of wine and a wine Museum.

Ultimately, all of this can help spread a peculiar culture around the wine activities with impact and participation of the sector and the development of thematic tourism, which can greatly assist the endogenous development of these areas and thus achieve the objectives in this transnational cooperation.

**IMPACT: CROP AREA CHANGES (INCLUDING IMPACTS IN NATIVE PLANTS AND CROPS) AND CROP QUALITY AND PRODUCTIVITY CHANGES**

### STEP 1: Identification of current adaptation options

- ✓ Specific farm-level measures are being developed by private owners (for instance: nowadays Bullas' farmers tend to seed at higher altitudes, changing harvest dates, switching to more climate and pest resistances varieties, etc).

### STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ Ensure that there is a **Standardised Record** with updated data regarding crop area (crop varieties; irrigated/ non irrigated areas; biologic/traditional agriculture).
- ✓ Seek and inform farmers about new crop varieties, including hybrids, to increase the tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions.
- ✓ Encourage the diversification of crop types and varieties, including crop substitution, to address the environmental variations and economic risks associated with climate change.
- ✓ Seek and inform farmers about farm-level resource management innovations to address the risk associated with changing temperature, moisture and other relevant climatic conditions.
- ✓ Inform about the use of alternative fallow and tillage practices to address climate change-related moisture and nutrient deficiencies.
- ✓ Encourage farmers to change the location of crop production to address the environmental variations and economic risks associated with climate change, when possible.

- ✓ Develop and implement policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions.
- ✓ Provide updated local weather forecast in order to help farmers with timing of farm operations to address the changing duration of growing seasons and associated changes in temperature and moisture.
- ✓ Promote the development of private insurances to reduce climate-related risks at farm-level production.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Encourage farmers to participate in the knowledge-sharing platform by enhancing its benefits.
- ✓ Keep informing farmers about new crop varieties suitable to foreseeable future according to the trends show by collected indicators.
- ✓ Go on promoting the diversification of crop types and varieties, taking into account the weather and crop correlated data, to address the environmental variations and economic risks associated with climate change.
- ✓ Continue informing farmers about farm-level resource management innovations to address the risk associated with changing temperature, moisture and other relevant climatic conditions.
- ✓ Inform about the use of alternative fallow and tillage practices to address climate change-related moisture and nutrient deficiencies.
- ✓ Encourage farmers to change the location of crop production to address the environmental variations and economic risks associated with climate change, when possible.

- ✓ Develop and implement policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions.
- ✓ Provide updated local weather forecast in order to help farmers with timing of farm operations to address the changing duration of growing seasons and associated changes in temperature and moisture.
- ✓ Make sure that farmers are properly informed about the importance having a private insurance to reduce climate-related risks at farm-level production.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: AGRICULTURAL PESTS, DISEASES, AND WEEDS**

**STEP 1: Identification of current adaptation options**

- ✓ Farm-level private control, for instance: choosing more climate and pest resistances varieties.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Promote awareness to local communities of potential weed risks resulting from climate change in the local area.
- ✓ Daily monitoring of pests by farm workers and a periodic follow up by municipal technicians.
- ✓ An effective **Pest Communication System** between municipal technicians and farmers. Thus when a new plague is detected an alert system starts up with an action protocol to avoid its thrive.
- ✓ Advice farmers to review mowing and weed control schedules to take into account changed climatic conditions that affect growth and dispersion.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Stress the importance of awareness regarding potential weed risks resulting from climate change in the local area.
- ✓ Continue with daily monitoring of pests by farm workers and a periodic follow up by municipal technicians.
- ✓ Try to improve – if possible- and maintain an effective **Pest Communication System** between municipal technicians and farmers. Thus when a new plague is detected an alert system starts up with an action protocol to avoid its thrive.

- ✓ Study the possibility of developing a pest, weed and invasive species management policy/ strategy that takes into account changed climatic conditions.
- ✓ Advice farmers to review mowing and weed control schedules to take into account changed climatic conditions that affect growth and dispersion.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

## IMPACT: SOIL EROSION, SALINITY AND DESERTIFICATION

### STEP 1: Identification of current adaptation options

- ✓ National Plans for water resources.

### STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ Change farming practices to conserve soil moisture and nutrients, reduce runoff and control soil erosion.
- ✓ Change timing of farm operations to better fit new climatic conditions.
- ✓ Use different crops or varieties to match to match changing water supply and temperature conditions.
- ✓ Introduce artificial systems to improve water use and availability and control soil erosion.

### STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?

- ✓

### STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: IRRIGATION REQUIREMENTS (WATER AVAILABILITY)**

## STEP 1: Identification of current adaptation options

- ✓ High awareness of farmers for water management due to water shortages in the Region of Murcia.
- ✓ Bullas use high efficient irrigation techniques for its cultivations, with a large degree of drip irrigation use, and other water management technologies.

## STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ Work towards the creation of the adaptation framework enabling information exchange such as general advice and information on conservation, tactical irrigation guidance, rainwater recovery and advice on leakage and educating citizens. [125]
- ✓ Inform farmers regularly about water management innovations, including irrigation, to address the risk of moisture deficiencies and increasing frequency of droughts and promote the use of irrigation practices to address the moisture deficiencies associated with climate change and reduce the risk of income loss due to recurring drought.
- ✓ Study the feasibility of developing and implementing policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions.
- ✓ Encourage competent authorities the creation of drought and water conservation plans that includes irrigation, drought monitoring and communication systems.
- ✓ Check old drainage systems and study the possibility of investing in water transfer infrastructure improvement for a greater efficiency in distribution that will entail leakage reduction.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Keep working towards the creation of the adaptation framework enabling information exchange such as general advice and information on conservation, tactical irrigation guidance, rainwater recovery and advice on leakage and educating citizens.
- ✓ Ensure that farmers are regularly informed about water management innovations, including irrigation, to address the risk of moisture deficiencies and increasing frequency of droughts and promote the use of irrigation practices to address the moisture deficiencies associated with climate change and reduce the risk of income loss due to recurring drought.
- ✓ Take steps on creating the conditions (regulatory, institutional, and managerial) that enable adaptation actions to be undertaken.[126] Including irrigation regulations, water-saving policies, thieves control amongst others, when needed and force its binding by Municipality Laws.
- ✓ Make a follow-up with competent authorities about the creation of drought and water conservation plans that includes irrigation, drought monitoring and communication systems.
- ✓ Re-check old drainage systems and continue studying the possibility of investing in water transfer infrastructure improvement for a greater efficiency in distribution that will entail leakage reduction.
- ✓ Water availability for drought seasons.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

## IMPACT: WINE QUALITY AND WINE PRODUCTION

Adaptation options proposed for crop area, crop quality and productivity changes are also applicable in this section.

### STEP 1: Identification of current adaptation options

- ✓ The Regulation Council of Bullas Denomination of Origin guides the production and quality of wines elaborated within its demarcation.

### STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ Encourage the Regulation Council of Bullas Denomination of Origin to continue with its guidance work and promote the inclusion of hazards climate change related.

### STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?

- ✓ Keep encouraging the Regulation Council of Bullas Denomination of Origin to continue with its guidance work and promote the inclusion of hazards climate change related.

### STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

| AGRICULTURE AND SOIL |
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| **STEP 5: BEST OPTIONS FOR BULLAS** |
| **GENERAL MEASURES** |
| BUILDING ADAPTATIVE CAPACITY (Policy-driven adaptation): Create a **standarised record** that includes at least the following items to provide farmers with updated information and trends to be able to act upon time when needed:<br>✓ Meteorology<br>✓ Crop production (including wine production)<br>✓ Crop area (irrigated and non irrigated areas)<br>✓ Phenology<br>✓ Pest and weeds<br>✓ Wine quality data<br>The aim of this standarised record is to collect indicators to be correlated with meteorology data in order to foresee trends (and research in models). Having correlated information about crop production, phenology, wine quality, etc., with climate conditions allows stakeholders to predict and to be able to act in advance when needed.<br>In order to achieve this measure, Bullas Council should assure that its technicians are correctly formed and trained. |
| BULDING ADAPTATIVE CAPACITY BY KEEPING INFORMED STAKEHOLDERS (Policy-driven adaptation): Create a **knowledge-sharing platform** where all concerned parties can learn and exchange practical information regarding energy efficiency, irrigation, farm-level adaptation options, new technology, other innovations, etc (see specific measures).<br>Furthermore, in this platform, Bullas local government should include the data from the Standarised Record created.<br>The aim of this measure is to offer an effective communication system to increase the awareness, information and |

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| formation of stakesholders and to allow them to act in advance to potential risks.<br>It is necessary to bear in mind that for transferring updated knowledge to stakeholders, technician from Bullas Council must be formed. Bullas Council should assure periodical training in these issues to its workers. |
| BULDING ADAPTATIVE CAPACITY BY KEEPING INFORMED STAKEHOLDERS (Policy-driven adaptation): Attempt to provide a **local early climate warning system** for daily weather predictions, seasonal forecasts and weather alerts, within the limits of the knowledge-sharing platform. |
| BULDING ADAPTATIVE CAPACITY BY KEEPING INFORMED STAKEHOLDERS (Policy-driven adaptation): Develop an **early alert system** with consultation forums regarding **weeds and pests** so that farmers are informed in time of new pests, action protocols, new methods of prevention, etc, within the limits of the knowledge-sharing platform.<br>Bullas municipality should assure that municipal technicians identify and control pest arrival and proliferation by asking farmers regularly. |

**SPECIFIC MEASURES (FOR EACH SELECTED IMPACTS)**

| Impacts | Short and medium-term measures | Long-term measures |
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| Crop area changes (including impacts in native plants and crops) | ✓ Ensure that there is a **Standardised Record** with updated data regarding crop area (crop varieties; irrigated/ non irrigated areas; biologic/traditional agriculture).<br>✓ Seek and inform farmers about new crop | ✓ Encourage farmers to participate in the knowledge-sharing platform by enhancing its benefits.<br>✓ Keep informing farmers about new crop varieties suitable to foreseeable future |

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| Crop quality and productivity changes. | | |

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| | changed climatic conditions that affect growth and dispersion. | and invasive species management policy/ strategy that takes into account changed climatic conditions.<br>✓ Advice farmers to review mowing and weed control schedules to take into account changed climatic conditions that affect growth and dispersion. |
| Irrigation requirements (Water availability) | ✓ Work towards the creation of the adaptation framework enabling information exchange such as general advice and information on conservation, tactical irrigation guidance, rainwater recovery and advice on leakage and educating citizens. [127]<br>✓ Inform farmers regularly about water management innovations, including irrigation, to address the risk of moisture | ✓ Keep working towards the creation of the adaptation framework enabling information exchange such as general advice and information on conservation, tactical irrigation guidance, rainwater recovery and advice on leakage and educating citizens.<br>✓ Ensure that farmers are regularly informed about water management innovations, including irrigation, to address the risk of |

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| | deficiencies and increasing frequency of droughts and promote the use of irrigation practices to address the moisture deficiencies associated with climate change and reduce the risk of income loss due to recurring drought.<br>✓ Study the feasibility of developing and implementing policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions.<br>✓ Encourage competent authorities the creation of drought and water conservation plans that includes irrigation, drought monitoring and communication systems.<br>✓ Check old drainage systems and study the possibility of investing in water transfer | moisture deficiencies and increasing frequency of droughts and promote the use of irrigation practices to address the moisture deficiencies associated with climate change and reduce the risk of income loss due to recurring drought.<br>✓ Take steps on creating the conditions (regulatory, institutional, and managerial) that enable adaptation actions to be undertaken.[128] Including irrigation regulations, water-saving policies, thieves control amongst others, when needed and force its binding by Municipality Laws.<br>✓ Make a follow-up with competent authorities about the creation of drought and water conservation plans that includes irrigation, drought monitoring and communication systems. |

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| | infrastructure improvement for a greater efficiency in distribution that will entail leakage reduction. | ✓ Re-check old drainage systems and continue studying the possibility of investing in water transfer infrastructure improvement for a greater efficiency in distribution that will entail leakage reduction. |
| Wine Quality[129]<br>Wine Production | ✓ Encourage the Regulation Council of Bullas Denomination of Origin to continue with its guidance work and promote the inclusion of hazards climate change related. | ✓ Keep encouraging the Regulation Council of Bullas Denomination of Origin to continue with its guidance work and promote the inclusion of hazards climate change related. |

# HEALTH

Health legal capacities at a local level are very limited. The proposed measures are aimed at improving the awareness of citizens about climate change associated risks, at making the information provided at the regional, national and European level more accessible, as well as delivering behavior advices and recommendations in case of extreme events situations.

**POTENTIAL IMPACTS OF THERMAL STRESS:**

- **Heat related hospital admission and/or mortality excess.**
- **Increased temperatures and changes in rainfall patterns- changes in disease patterns.**
- **Loss of working/school days for health diseases.**

### STEP 1: Identification of current adaptation options

- ✓ The European Emergency number 112 provides more information about health and climate change and assists people when needed.
- ✓ Currently there are awareness campaigns including self-protection measures against heat strokes promoted by competent governments (Ministry/ Autonomous Communities)[130].
- ✓ Ministry competent in health and the State Agency of Meteorology (AEMET) have an information system about extreme temperatures with predictions of daily temperatures.
- ✓ At Autonomous Community level, recommendations to protect citizens from the heat are proposed on the Murcian Service of Health´s webpage[131].It includes additional information about studies, indicators, etc which will update.
- ✓ Civil protection has a protocol warning and tracking adverse meteorological phenomena in the Region of Murcia[132].
- ✓ In hottest months awnings are placed over strategic streets to supply shade.

- ✓ Existing accessible air conditioned public facilities against thermal stress.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ The municipality of Bullas should be attentive to national health alerts and recommendations –related to climate change- to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.
- ✓ Increase public awareness and educate citizens about health implications of climate change, (dangers of sun exposure, symptoms of heat stress, etc.) including risks and the need for emergency preparedness.
- ✓ Reduce the impact of thermal stress via advice on how to stay cool including the use of portable fans, improved ventilation of homes, public buildings, and other residential institutions and workplaces.
- ✓ Study the possibility of developing a Public Health Plan that looks at the current health and wellbeing of the communities within the council area and develop Wellbeing Indicators so that the program can be assessed over future years.
- ✓ In collaboration with nearby public health centres try to collect data about the number of citizens treated for heat strokes, and other health problems – related to climate change.
- ✓ The municipality of Bullas should take into account specific measures as provide accessible air conditioned in public facilities; evaluate the possibility to place awnings over more streets to supply shade; consider the viability of seed plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area; study the feasibility of placing more outdoor drinking facilities, etc.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ The municipality of Bullas should carry on being attentive to national health alerts and recommendations –related to climate change- to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.

- ✓ Keep on increasing public awareness and educate citizens about health implications of climate change, (dangers of sun exposure, symptoms of heat stress, etc.) including risks and the need for emergency preparedness and provide it in other languages.
- ✓ Reduce the impact of thermal stress via advice on how to stay cool including the use of portable fans, improved ventilation of homes, public buildings, and other residential institutions and workplaces.
- ✓ Keep on working in the Public Health Plan that looks at the current health and wellbeing of the communities within the council area and develop Wellbeing Indicators so that the program can be assessed over future years.
- ✓ Keep collecting data about the number of citizens treated for heat strokes, and other health problems – related to climate change- in collaboration with nearby public health centres.
- ✓ The municipality of Bullas should carry on developing account specific measures such as provide accessible air conditioned in public facilities; evaluate the possibility to place awnings over more streets to supply shade; consider the viability of seed plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area; study the feasibility of placing more outdoor drinking facilities, etc.
- ✓ Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres and in any development plans for picnic areas, playgrounds etc.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**POTENTIAL IMPACTS OF VECTOR BORNE INFECTIOUS DISEASES:**

- **Human cases of vector borne infectious diseases.**
- **Increase in personal protection product sales (lotions, sprays, mosquito nets, etc.).**
- **Changes in disease patterns.**
- **Loss of working/school days for health diseases.**

**STEP 1: Identification of current adaptation options**

- ✓ Currently there are awareness campaigns about vector borne infectious diseases promoted by competent governments[133] (Ministry/ Autonomous Communities).
- ✓ Ministry competent in health provides information about vector borne infectious diseases in its Web.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ In collaboration with nearby public health centres try to collect data about the number of citizens treated for heat strokes, and other health problems – related to climate change (including monitoring for waterborne diseases (such as E. coli, toxic algae, and viruses))
- ✓ Provide public education on mosquito and tick protection and disease prevention.
- ✓ Educate residents about disease risks, precautions and symptoms.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ In collaboration with nearby public health centres keep collecting data about the number of citizens treated for heat strokes, and other health problems – related to climate change (including monitoring for waterborne diseases (such as E. coli, toxic algae, and viruses)) and evaluate this information to be able to act in advance if needed.

- ✓ Develop a program that identifies various vector control methods and local policies to apply those methods.
- ✓ Increase council-run immunization programs to address any increased threats where possible (should be undertaken in collaboration with state health programs/agencies).
- ✓ Intensify public education on mosquito and tick protection and disease prevention.
- ✓ Continue educating residents about disease risks, precautions and symptoms.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**<u>POTENTIAL IMPACTS OF AIR POLLUTION:</u>**

- **Increase of hospital admission for cardiovascular and respiratory disorders caused by air pollution.**
- **Increase of allergic population.**
- **Increase in hospital admissions for asthma or allergic crisis.**
- **Increase in anti-allergic drugs use.**
- **Loss of working/school days for health diseases.**

**STEP 1: Identification of current adaptation options**

✓ There are several air quality (air pollution) monitoring stations in Murcia that provide data and information related to the amount of air pollutants emitted into the atmosphere from different anthropogenic (human-made) sources as well as measured ambient air pollution across the Region.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Try to gather local daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.).
- ✓ The municipality of Bullas should be attentive to regional air quality alerts and recommendations to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.
- ✓ Increase public awareness and educate citizens about health implications of air pollution, including risks and the need for emergency preparedness.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Carry on with the compilation of daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.)
- ✓ The municipality of Bullas should carry on being attentive to national air quality alerts and recommendations to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.
- ✓ Keep on increasing public awareness and educate citizens about health implications of air pollution including risks and the need for emergency preparedness and provide it in other languages.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

| HEALTH | | |
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| **STEP 5: BEST OPTIONS FOR BULLAS** | | |
| **SPECIFIC MEASURES (FOR EACH SELECTED IMPACT)** | | |
| **Impacts** | **Short and medium-term measures** | **Long-term measures** |
| **THERMAL STRESS** | ✓ The municipality of Bullas should be attentive to national health alerts and recommendations –related to climate change- to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.<br>✓ Increase public awareness and educate citizens about health implications of climate change, (dangers of sun exposure, symptoms of heat stress, | ✓ The municipality of Bullas should carry on being attentive to national health alerts and recommendations –related to climate change- to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.<br>✓ Keep on increasing public awareness and educate citizens about health implications of climate change, (dangers of sun exposure, symptoms of heat stress, |

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| | etc.) including risks and the need for emergency preparedness.<br>✓ Reduce the impact of thermal stress via advice on how to stay cool including the use of portable fans, improved ventilation of homes, public buildings, and other residential institutions and workplaces.<br>✓ Study the possibility of developing a Public Health Plan that looks at the current health and wellbeing of the communities within the council area and develop Wellbeing Indicators so that the program can be assessed over future years.<br>✓ In collaboration with nearby public health centres try to collect data about the number of citizens treated for heat strokes, and other health problems – related to climate change.<br>✓ The municipality of Bullas should take into account specific measures as provide accessible air | etc.) including risks and the need for emergency preparedness and provide it in other languages.<br>✓ Reduce the impact of thermal stress via advice on how to stay cool including the use of portable fans, improved ventilation of homes, public buildings, and other residential institutions and workplaces.<br>✓ Keep on working in the Public Health Plan that looks at the current health and wellbeing of the communities within the council area and develop Wellbeing Indicators so that the program can be assessed over future years.<br>✓ Keep collecting data about the number of citizens treated for heat strokes, and other health problems – related to climate change- in collaboration with nearby public health centres.<br>✓ The municipality of Bullas should carry on developing account specific measures such as provide accessible |

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| | conditioned in public facilities; evaluate the possibility to place awnings over more streets to supply shade; consider the viability of seed plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area; study the feasibility of placing more outdoor drinking facilities, etc. | air conditioned in public facilities; evaluate the possibility to place awnings over more streets to supply shade; consider the viability of seed plants in parks and open spaces (where awnings cannot be placed) that are indigenous to the local council area; study the feasibility of placing more outdoor drinking facilities, etc.<br>✓ Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres and in any development plans for picnic areas, playgrounds etc. |
| **VECTOR BORNE INFECTIOUS DISEASES** | ✓ In collaboration with nearby public health centres try to collect data about the number of citizens treated for heat strokes, and other health problems – related to climate change (including monitoring for waterborne diseases (such as E. coli, toxic algae, and viruses)) | ✓ In collaboration with nearby public health centres keep collecting data about the number of citizens treated for heat strokes, and other health problems – related to climate change (including monitoring for waterborne diseases (such as E. coli, toxic algae, and viruses)) and evaluate this information to be able to |

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| | ✓ Provide public education on mosquito and tick protection and disease prevention.<br>✓ Educate residents about disease risks, precautions and symptoms. | act in advance if needed.<br>✓ Develop a program that identifies various vector control methods and local policies to apply those methods.<br>✓ Increase council-run immunization programs to address any increased threats where possible (should be undertaken in collaboration with state health programs/agencies).<br>✓ Intensify public education on mosquito and tick protection and disease prevention.<br>✓ Continue educating residents about disease risks, precautions and symptoms. |
| **AIR POLLUTION** | ✓ Try to gather local daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.). | ✓ Carry on with the compilation of daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.) |

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| | ✓ The municipality of Bullas should be attentive to regional air quality alerts and recommendations to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.<br>✓ Increase public awareness and educate citizens about health implications of air pollution, including risks and the need for emergency preparedness. | ✓ The municipality of Bullas should carry on being attentive to national air quality alerts and recommendations to be able to act in advance and ensure that all the information and awareness campaigns carried out by the Autonomous Community and by the competent Ministry reach the citizens.<br>✓ Keep on increasing public awareness and educate citizens about health implications of air pollution including risks and the need for emergency preparedness and provide it in other languages. |

# TRANSPORTATION INFRASTRUCTURE[134,135,136]

Taking into account that Bullas' transportation infrastructures are reduced to highway and national road and there is no other way of transportation except for private cars or by bus, the measures proposed here try to prevent the deterioration of existing transportation infrastructures due to climate change, and mainly to establish some plans to review them and to study alternatives when an important infrastructure is located in a risky area.

## IMPACT: FLOODING AND MUDSLIDES

### STEP 1: Identification of current adaptation options

- ✓ Studies prior to construction against possible natural disasters.
- ✓ Study of zones at risk if there is any.
- ✓ Prevention flood plan for certain neighborhoods.
- ✓ Regional planning disaster contingency including evacuation.
- ✓ Protocol of warning and follow-up of extreme events weather related in the Region of Murcia.

### STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ Awareness rising for transportation infrastructure use during extreme events.
- ✓ Revision of the flood management activities to improve the process and planning for future events.

- ✓ Flood-proof or re-site infrastructure and plan transport routes and roads to avoid disruption by flooding activities.
- ✓ Establish a plan for review and verification of transportation infrastructures against flooding and mudslides.
- ✓ Review of facilities with more than 50 years or those present in areas where the terrain has changed significantly in order to asses new situations of risk.
- ✓ Identify areas where increased infrastructure capacity is needed to hold/divert water and include replacement or upgrade in Local Improvement Program.
- ✓ Identify areas within the City that have infill or redevelopment potential and are outside an area of potential significant impact to flooding. Aim to have 50% of these areas developed by a certain year.
- ✓ Devise incentives to foster infill development in areas within the City that have been identified as being at high risk for flooding.
- ✓ Update the City's Infrastructure Standards to ensure public safety in the event of major flooding or severe storm events.
- ✓ Incorporate sustainable storm water design and management techniques to lessen the ecological footprint of new development, and take into account the potential for greater storm loads, floods and mudslides.
- ✓ Change design requirements for new or refurbished roadways to include different pitches combined with storm water design and/or use of more permeable surfaces to effectively remove water from the roadway.
- ✓ Flood insurance.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Increase awareness rising for transportation infrastructure use during extreme events.
- ✓ Continue the revision of the flood management activities to improve the process and planning for future events.
- ✓ Revision of flood-proof or re-site infrastructure and plan transport routes and roads to avoid disruption by flooding activities.
- ✓ Restudy, and improve if possible the plan for review and verification of transportation infrastructures against flooding and mudslides.
- ✓ Review of facilities with more than 50 years or those present in areas where the terrain has changed significantly in order to asses new situations of risk.
- ✓ Keep on identifying areas where increased infrastructure capacity is needed to hold/divert water and include replacement or upgrade in Local Improvement Program.
- ✓ Carry on identifying areas within the City that have infill or redevelopment potential and are outside an area of potential significant impact to flooding. Keep track of the percentage of these areas developed each passing year.
- ✓ Continue devising incentives to foster infill development in areas within the City that have been identified as being at high risk for flooding.
- ✓ Review the City's Infrastructure Standards to ensure public safety in the event of major flooding or severe storm events.
- ✓ Be attentive and try to incorporate sustainable storm water design and management techniques to lessen the ecological footprint of new

development, and take into account the potential for greater storm loads, floods and mudslides.

- ✓ Restudy changing design requirements for new or refurbished roadways to include different pitches combined with storm water design and/or use of more permeable surfaces to effectively remove water from the roadway.
- ✓ Promote flood insurance for business in case their activity might suffer from transportation problems due to floods and mudslides.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: HEAT WAVES → WILDFIRE**

**STEP 1: Identification of current adaptation options**

- ✓ Maintenance of firewalls by regional government.
- ✓ Protocol of warning and follow-up of extreme events weather related in the Region of Murcia.
- ✓ Plan of civil emergency protection from forest fires in the Region of Murcia (INFOMUR).

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Awareness rising for transportation infrastructure use during wildfire.
- ✓ Evaluate bushfire risks.
- ✓ Maintenance of firewalls.
- ✓ Grazing in the forest area when possible due to its private ownership.
- ✓ Study the feasibility of use of fire adapted vegetation at least surrounding transportation routes.
- ✓ Encourage new developments, or changes to existing developments, to include improved protection and adaptations to increased bushfire risk.
- ✓ Improve community disaster preparedness and response systems.
- ✓ Ensure that 'fire management zones' have been identified.
- ✓ Establish a plan for review and verification of the infrastructures.
- ✓ Risk assessment to ensure new infrastructure is not placed in fire-prone areas.
- ✓ For those infrastructures where location is not flexible, investigate standards of construction that reduce their sensitivity to fire.

- ✓ Review local disaster management plans.
- ✓ Preparation of evacuation.
- ✓ Cool areas on red/orange alert.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Increase awareness rising for transportation infrastructure use during wildfire.
- ✓ Revaluate bushfire risks if pre-existing conditions have change.
- ✓ Assure that maintenance of firewalls is being made properly.
- ✓ Promote grazing in the forest area to private owners.
- ✓ Continue using fire adapted vegetation at least surrounding transportation routes, when possible, if previous studies show its validity.
- ✓ Keep encouraging new developments, or changes to existing developments, to include improved protection and adaptations to increased bushfire risk.
- ✓ Continue improving community disaster preparedness and response systems.
- ✓ Assure that existing “fire management zones” have been identified and new ones are included if necessary.
- ✓ Re-evaluate the established plan for review and verification of the infrastructures, if necessary.
- ✓ Improve the existing risk assessment to ensure new infrastructure is not placed in fire-prone areas when needed.

- ✓ Keep on researching standards of construction that will reduce infrastructure sensitivity to fire.
- ✓ Continue improving local disaster management plans.
- ✓ Have an updated preparation of evacuation.
- ✓ Keep on with cooling areas on red/orange alert.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

**IMPACT: INCREASE IN EXTREME TEMPERATURES**

**STEP 1: Identification of current adaptation options**

- ✓ Quality control of building materials when manufactured and in construction sites.
- ✓ Study of zones at risk if there is any.

**STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?**

- ✓ Awareness rising for transportation infrastructure use during extreme events.
- ✓ Introduction of planning disaster contingency.
- ✓ Establish a plan for infrastructures review and verification in municipal bylaws.
- ✓ Review of infrastructure over a certain number of years.
- ✓ Encourage the research of roadway materials that may be utilized in road construction that are more tolerant to quick changes in hot or cold weather in order to decrease repair costs, enhance safety, and increase longevity of road surfaces.
- ✓ Promote the design of buildings related to transportation infrastructures (e.g. train station, etc) to allow for ease of future adaptation (e.g. have the ability for significant amounts of shade to be added or removed from a façade).
- ✓ For infrastructure developments with a lifetime greater than 50 years, design for staged construction to allow future climate change impacts to be taken into account.

**STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?**

- ✓ Continue improving awareness rising for transportation infrastructure use during extreme events.
- ✓ Study the establishment of planning disaster contingency.
- ✓ Review the inclusion of the plan for infrastructures verification in municipal bylaws.
- ✓ Ensure that infrastructure over a certain number of years are reviewed.
- ✓ Keep encouraging the research of roadway materials that may be utilized in road construction that are more tolerant to quick changes in hot or cold weather in order to decrease repair costs, enhance safety, and increase longevity of road surfaces.
- ✓ Continue the promotion for designs of buildings related to transportation infrastructures (e.g. train station, etc) to allow for ease of future adaptation (e.g. have the ability for significant amounts of shade to be added or removed from a façade).
- ✓ For infrastructure developments with a lifetime greater than 50 years, keep-on with designing for staged construction to allow future climate change impacts to be taken into account.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

## IMPACT: WATER SHORTAGE → DROUGHTS

### STEP 1: Identification of current adaptation options

- ✓ Irrigators associations keep control of water in the area.
- ✓ Protocol of warning and follow-up of extreme events weather related in the Region of Murcia.

### STEP 2: How do these options need to be improved to deal with today's climate? Reduce vulnerability today? Additional strategies identified?

- ✓ Promote water sensitive urban design at the plan-making and development assessment stages of the planning process.
- ✓ Encourage the development of roadsides/utility corridors as native vegetation corridors, in consultation with relevant road authorities to ensure road use safety is protected.
- ✓ Introduction of planning disaster contingency.

### STEP 3: How do these options need to be improved to deal with future integrate climate change and variability? Reduce vulnerability in the future? Additional strategies identified?

- ✓ Keep promoting water sensitive urban design at the plan-making and development assessment stages of the planning process.
- ✓ Continue to develop roadsides/utility corridors as native vegetation corridors, in consultation with relevant road authorities to ensure road use safety is protected.
- ✓ Review of existing planning disaster contingency.

**STEP 4: How to prioritize these adaptation options? How to integrate them into existing policies?**

- ✓ Each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

| TRANSPORTATION INFRASTRUCTURES |
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| **STEP 5: BEST OPTIONS FOR BULLAS** |
| **GENERAL MEASURES** |
| Awareness rising for transportation infrastructure use during extreme events. |
| Inventorying process of critical transportation infrastructure. |
| Identify alternate routes and modes for goods transport and evacuation efforts during emergency situations. |
| Identify and obtain funds (local, regional, national) for the development of a local public transportation system that connects with the regional transportation system. |
| Local policy makers to make changes in transportation policy to support the development of state-wide multimodal transportation infrastructure in areas less susceptible to significant climate impacts. |
| Increase multi-modal trail infrastructure throughout the City to connect people from where they live to services and work through walking, |

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| bicycling, etc. Changes in site plan, subdivision, and land use policies may support the development of a more comprehensive system. | | |
| Investigate design standards for buildings that currently handle weather conditions similar to the climate forecast Bullas can expect in the future. | | |
| Explore the use of traditional and alternative building materials for added strength and durability of construction to improve the longevity of buildings and then incorporate these materials into building code requirements. | | |
| Update City code to include green building standards for all major renovations. | | |
| **SPECIFIC MEASURES (FOR EACH SELECTED IMPACT)** | | |
| **Impacts** | **Short and medium-term measures** | **Long-term measures** |
| Flooding and mudslides | ✓ Awareness rising for transportation infrastructure use during extreme events.<br>✓ Revision of the flood management activities to improve the process and planning for future events.<br>✓ Flood-proof or re-site infrastructure and plan transport | ✓ Increase awareness rising for transportation infrastructure use during extreme events.<br>✓ Continue the revision of the flood management activities to improve the process and planning for future events.<br>✓ Revision of flood-proof or re-site infrastructure and plan |

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| | routes and roads to avoid disruption by flooding activities.<br><br>✓ Establish a plan for review and verification of transportation infrastructures against flooding and mudslides.<br><br>✓ Review of facilities with more than 50 years or those present in areas where the terrain has changed significantly in order to asses new situations of risk.<br><br>✓ Identify areas where increased infrastructure capacity is needed to hold/divert water and include replacement or upgrade in Local Improvement Program.<br><br>✓ Identify areas within the City that have infill or redevelopment potential and are outside an area of potential significant impact to flooding. Aim to have 50% of these areas developed by a certain year.<br><br>✓ Devise incentives to foster infill development in areas | transport routes and roads to avoid disruption by flooding activities.<br><br>✓ Restudy, and improve if possible the plan for review and verification of transportation infrastructures against flooding and mudslides.<br><br>✓ Review of facilities with more than 50 years or those present in areas where the terrain has changed significantly in order to asses new situations of risk.<br><br>✓ Keep on identifying areas where increased infrastructure capacity is needed to hold/divert water and include replacement or upgrade in Local Improvement Program.<br><br>✓ Carry on identifying areas within the City that have infill or redevelopment potential and are outside an area of potential significant impact to flooding. Keep track of the percentage of these areas developed each passing year.<br><br>✓ Continue devising incentives to foster infill development in |

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| | within the City that have been identified as being at high risk for flooding.<br>✓ Update the City's Infrastructure Standards to ensure public safety in the event of major flooding or severe storm events.<br>✓ Incorporate sustainable storm water design and management techniques to lessen the ecological footprint of new development, and take into account the potential for greater storm loads, floods and mudslides.<br>✓ Change design requirements for new or refurbished roadways to include different pitches combined with storm water design and/or use of more permeable surfaces to effectively remove water from the roadway.<br>✓ Flood insurance. | areas within the City that have been identified as being at high risk for flooding.<br>✓ Review the City's Infrastructure Standards to ensure public safety in the event of major flooding or severe storm events.<br>✓ Be attentive and try to incorporate sustainable storm water design and management techniques to lessen the ecological footprint of new development, and take into account the potential for greater storm loads, floods and mudslides.<br>✓ Restudy changing design requirements for new or refurbished roadways to include different pitches combined with storm water design and/or use of more permeable surfaces to effectively remove water from the roadway.<br>✓ Promote flood insurance for business in case their activity |

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| | | might suffer from transportation problems due to floods and mudslides. |
| Heat waves → wildfire | ✓ Awareness rising for transportation infrastructure use during wildfire.<br>✓ Evaluate bushfire risks.<br>✓ Maintenance of firewalls.<br>✓ Grazing in the forest area when possible due to its private ownership.<br>✓ Study the feasibility of use of fire adapted vegetation at least surrounding transportation routes.<br>✓ Encourage new developments, or changes to existing developments, to include improved protection and adaptations to increased bushfire risk.<br>✓ Improve community disaster preparedness and response systems. | ✓ Increase awareness rising for transportation infrastructure use during wildfire.<br>✓ Revaluate bushfire risks if pre-existing conditions have change.<br>✓ Assure that maintenance of firewalls is being made properly.<br>✓ Promote grazing in the forest area to private owners.<br>✓ Continue using fire adapted vegetation at least surrounding transportation routes, when possible, if previous studies show its validity.<br>✓ Keep encouraging new developments, or changes to existing developments, to include improved protection and adaptations to increased bushfire risk. |

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| | ✓ Ensure that 'fire management zones' have been identified.<br>✓ Establish a plan for review and verification of the infrastructures.<br>✓ Risk assessment to ensure new infrastructure is not placed in fire-prone areas.<br>✓ For those infrastructures where location is not flexible, investigate standards of construction that reduce their sensitivity to fire.<br>✓ Review local disaster management plans.<br>✓ Preparation of evacuation.<br>✓ Cool areas on red/orange alert. | ✓ Continue improving community disaster preparedness and response systems.<br>✓ Assure that existing "fire management zones" have been identified and new ones are included if necessary.<br>✓ Re-evaluate the established plan for review and verification of the infrastructures, if necessary.<br>✓ Improve the existing risk assessment to ensure new infrastructure is not placed in fire-prone areas when needed.<br>✓ Keep on researching standards of construction that will reduce infrastructure sensitivity to fire.<br>✓ Continue improving local disaster management plans.<br>✓ Have an updated preparation of evacuation.<br>✓ Keep on with cooling areas on red/orange alert. |
| Increase in | ✓ Awareness rising for transportation infrastructure use | ✓ Continue improving awareness rising for transportation |

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| extreme temperatures | during extreme events.<br>✓ Introduction of planning disaster contingency.<br>✓ Establish a plan for infrastructures review and verification in municipal bylaws.<br>✓ Review of infrastructure over a certain number of years.<br>✓ Encourage the research of roadway materials that may be utilized in road construction that are more tolerant to quick changes in hot or cold weather in order to decrease repair costs, enhance safety, and increase longevity of road surfaces.<br>✓ Promote the design of buildings related to transportation infrastructures (e.g. train station, etc) to allow for ease of future adaptation (e.g. have the ability for significant amounts of shade to be added or removed from a façade).<br>✓ For infrastructure developments with a lifetime greater than 50 years, design for staged construction to allow | infrastructure use during extreme events.<br>✓ Study the establishment of planning disaster contingency.<br>✓ Review the inclusion of the plan for infrastructures verification in municipal bylaws.<br>✓ Ensure that infrastructure over a certain number of years are reviewed.<br>✓ Keep encouraging the research of roadway materials that may be utilized in road construction that are more tolerant to quick changes in hot or cold weather in order to decrease repair costs, enhance safety, and increase longevity of road surfaces.<br>✓ Continue the promotion for designs of buildings related to transportation infrastructures (e.g. train station, etc) to allow for ease of future adaptation (e.g. have the ability for significant amounts of shade to be added or removed from a façade). |

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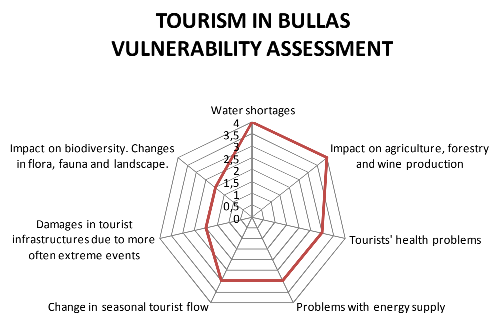
| | future climate change impacts to be taken into account. | ✓ For infrastructure developments with a lifetime greater than 50 years, keep-on with designing for staged construction to allow future climate change impacts to be taken into account. |
| Water shortage → droughts | ✓ Promote water sensitive urban design at the plan-making and development assessment stages of the planning process.<br>✓ Encourage the development of roadsides/utility corridors as native vegetation corridors, in consultation with relevant road authorities to ensure road use safety is protected.<br>✓ Introduction of planning disaster contingency. | ✓ Keep promoting water sensitive urban design at the plan-making and development assessment stages of the planning process.<br>✓ Continue to develop roadsides/utility corridors as native vegetation corridors, in consultation with relevant road authorities to ensure road use safety is protected.<br>✓ Review of existing planning disaster contingency. |

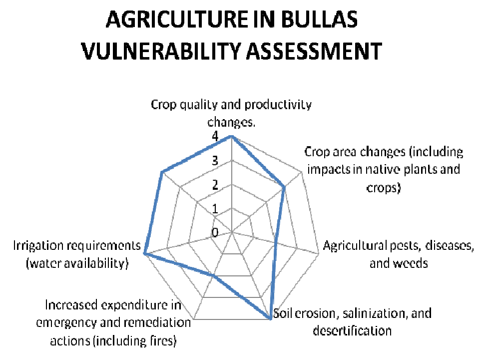
## 5.7 Evaluation and prioritisation of adaptation measures

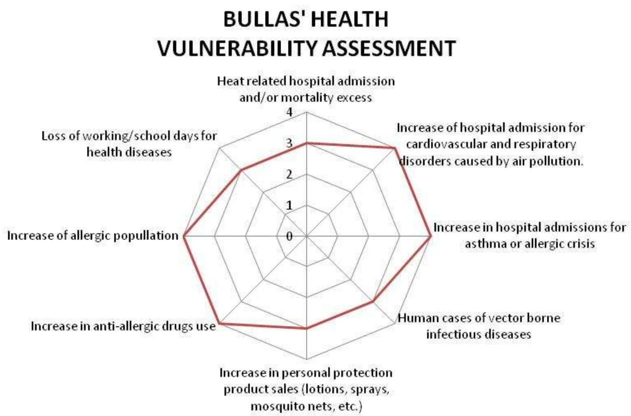
In order to understand this plan and to prioritise the actions proposed is necessary to bear in mind that there are two differenced types of measures, those that pretend to build the adaptative capacity by collecting data from each sector and those specific measures for each impact previouly defined in the vulnerability assessment.

The first type of actions, are considered critical. Having current information about the specific data, trends and models to foresee future impacts will allow stakeholders to act in advance against climate change. Although being consider as "low-cost" measures they are a key point to improve the adaptative capacity of the municipality, so, they are worthwile in terms of cost-effectiveness, and they will be a priority. In order to achieve these measures, Bullas Council should assure that its technicians are correctly formed and trained.

The degree of implementation of the second type of measures will depend on the annual budget available. First of all, priority will be given to those actions responding to the results obtained from the vulnerability assessment performed (see table below) . This means that medium-high vulnerability should be addressed firstly, then the medium vulnerability ones and finally the medium-low ones. But, as said before each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.



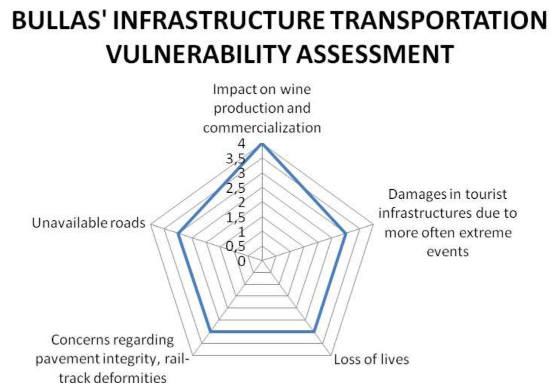




*Table 5.8. Municipality of Bullas – Outcomes from vulnerability assessment*

# IMPLEMENTING THE ADAPTATION PLAN

6


***This chapter describes the implementation tools and responsabilities to achieve the Adaptation Plan, as well as the drivers and constrains for the successful implementation of the different adaptation options, and the financial resources available for it.***

In *Chapter 5* a wide range of adaptation measures was proposed and merely listed, but it is certain that in recession times like the ones we are immersed in right now there is not a single municipality with the means to achieve all of them thus the need of prioritization which is reflected in popular wisdow as *"Don't bite off more than you can chew"*.

As stated in previous chapters, this Adaptation Plan should be considered as an action framework to cope with climate change projected impacts. Therefore, a deeply review must be done each year in order to enclose the specific actions that would be carried out.

According to UNFCCC (United Nations Framework Convention on Climate Change), the adaptation process consists of four key components:

i. Assessment of climate impacts and vulnerability;

ii. Planning for adaptation;

iii. Implementation of adaptation measures;

iv. Monitoring and evaluation of adaptation actions.

Each of these components is associated with, and/or supported by, relevant data and information, methods and tools, and practices, which in the implementation step is "*devising a detailed plan of actions setting out what adaptation measures, how, when and by whom should be implemented, is crucial to achieve action on the ground. These measures will be appraised and endorsed by key actors in order to ensure that they will help to achieve a sustainable future for the area. The evaluation of adaptation options is undertaken at different levels, depending on the policy questions that they are meant to address, and uses a variety of methodologies, including – if needed - computable general equilibrium model analysis, investment and financial flow analysis, and economic appraisal methods*".

## 6.1 Selected adaptation options

### 6.1.1 Measures of first importance

According to the selected fields of study, urgent needs, current municipal budget and availability of staff, a first batch of measures was selected as the ones of first importance, some due to an urgent need and others due to its straightforwardness of implementation.

Agriculture is one of the main pillars – together with tourism- of Bullas economy, therefore the actions concerning those two fields are prioritary ones.

# TOURISM

Climate can influence tourism through a variety of mechanisms. On one hand, it exerts a direct influence by determining weather conditions at places of origin and destination. On the other hand, it affects tourism indirectly, for instance by influencing agriculture, wine production, biodiversity and water supply. HenceTherefore tourism industry depends more strongly on climate than most others.

What links tourism to climate are the preferences of tourists for certain conditions, thus for we have to assure the best possible contions for Bullas within our possibilities to make sure tourist are confortable when visiting out city regardless of climatic conditions.

Therefore the selected adaptation measures for tourism are developped below:

1. Enable the adaptation of tourist and commercial schedules at times with greater influx of visitors.

   Nowadays businesses have to follow some national, regional and local laws concerning commercial schedules, so they are not allow to open whenever they see fit. Changing local laws to allow it will give MSE (small and medium-sized enterprises) a wider timeframe for business.

   Like this, business that are tourist related could be open on Sundays if there is an obvius trend of tourist influx during those days.

2. Awareness campaigns (health, water, energy, etc.), including autoprotection measures.

   Those campaigns could be done using local media (radio, TV, etc.), as well as leaflets or billboard situated within the urban center.

3. Provide accessible air conditioned in public facilities and in those with a higer influx of tourist, to avoid thermal stress.

   Most of tourist facilities already have a climate control system (air conditioner and heating system) like the wine museum, and others like the wineries owing to theirs specific needs and particular characteristics (such as need for wine preservation) are in no need of them.

4. Extension of the shaded areas in public spaces with awnings and indigenous trees (where awnings cannot be placed).

   Following the initiative started with local market El Zacatín, more awnings are going to be situated in some centric streets and squares, and a variety of indigenous trees that will provide shade in places where is not feasible the positioning of awnings.

*Figure 6.1: Awanings in Zacatín Market*


5. Manage additional awareness campaigns for sustainable water consumption among tourists,

since they typically use relatively more water than local inhabitants (in part because of additional water uses such as garden irrigation, cleaning, swimming pools, etc.). This is already a measure imposed to establishments adhered to the Wine Route to b able to obtain the Quality Certification.

It is already stated in regional law 6/2006 that a notice stating the need for water saving must be placed in every water source that is public open, such as restaurants, museums, enterprises, etc…[137]

6. Increase the application of mulches in more parks than already have, to avoid evapotranspiration as well as weds. Right now pine bark is being used in some local parks, and it will be used in other green areas within the city limits.

7. Inquiry and advertise new ways to save, reuse, and manage water efficiently. Within local media range of distribution. This adaptation option will try to have the contribution of local association of irrigators.

8. As a consequency of the adhesion to the Covenant of Mayors, the following measures must be adopted:

    - Reduce local energy comsuption.
    - Improvement of energy efficiency in public buildings.
    - Work towards resilience increasing of energy systems.

- Promotion of renewable energy sources and saving, reuse and efficient energy management.

To achieve this, a Local Plan of Action for Sustainable Energy, including the development of an inventory of emissions reference that summarizes how the objectives will be met, is being made by municipal energy department (see Annex III).

9. Make a more comprehensive and systematic record of tourist indicators that complements the previous one and includes indicators of sustainable tourism, such as: average stay, tourism spending, level of satisfaction and preferences of tourists, etc.

   Currently a compilation of tourist indicators is being made within the visitors of wine museum, and it will be improved with a short questionnaire that tourist can fill whenever they visit the museum or any of the wineries.

10. Include practical information on adaptation measures in municipal tourism web pages. Such as Bullas ACT blog (http://www.proyectoactbullas.blogspot.com.es/), and Bullas town hall (http://www.bullas.es/).

## AGRICULTURE AND SOIL

Bullas is a rural area characterized by agricultural and tourist activities that may be very vulnerable to climate change. In particular, grapevine (for wine) and olive are two of the main agricultural crops in Bullas. The former is very important for the economic role that wine producers' play at national and international levels, whilst, the latter is important not only for the income that it generates but also for its contribution to landscape.

Both crops are perennial, which makes them more vulnerable to climate change due to their growing season being carried out mostly during the spring/summer, in which major climatic anomalies are found; so the selection of the most appropriate crop management techniques is fundamental and may be considerably affected by expected changes in climate.

Thus for, the measures of first importance for agriculture are the ones orientated to increase the awareness of local farmers as well as creating a database to analize trends that will allow farmers to be more prepared for future climate change impacts. Therefore the selected adaptation measures are:

1. Create a **knowledge-sharing platform** where all concerned parties can exchange practical information regarding energy efficiency, irrigation, farm-level adaptation options, new technology, other innovations, etc.

   Regarding this adaptation measure, Bullas is creating a draft to submit its candidature for another LIFE+ project concerning the developing of this knowledge-sharing platform.

   This knowledge-sharing platform will be created and managed by the same municipal workers that are managing Bullas ACT blog (http://www.proyectoactbullas.blogspot.com.es/). This platform will be password protected so members can be assured of the privacy of the data about their crops that they are introducing.

   The required data should be filled using a simple check list to state when crops did started buddeing, flowering, ripening, etc. As well as irrigation needs or any new technology used.

2. Attempt to provide a **local early climate warning system** for daily weather predictions, seasonal forecasts and weather alerts, within the limits of the knowledge-sharing platform.

   This local early climate warning system will be included within the framework of the knowledge-sharing platform as a section of it, where members of the platform can control weather projections.

   This system will be managed by municipal workers in collaboration with a local collective meteorology-related. This collective is already recording climatic data and trends.

   With this system farmers will have updated weather forecast and use it as a way to schedule crop managing such as harvest, seeding, etc.

3. Develop an **early alert system** with consultation forums regarding weeds and pests so that farmers are informed in time of new pests, action protocols, new methods of prevention, etc, within the limits of the knowledge-sharing platform. Bullas municipality should assure that municipal technicians identify and control pest arrival and proliferation by asking farmers regularly.

   The system will be included within the framework of the knowledge-sharing platform as a section of it, where members of the platform can be informed of the appearance of weeds and pests in neighbours' farms so they can prevent its spread through a wider area.

   This system will be managed by municipal workers in collaboration with regional government.

# HEALTH

In Spain health competences are owned by regional administrations and local governments has little to non real competences in the developing and managing day-to-day actions regarding health, therefore the selected adaptation option for Bullas concerning health is aim to **improving the awareness of citizens about climate change associated risks**, at making the information provided at the regional, national and European level more accessible, as well as delivering behavior advices and recommendations in case of extreme events situations.

# TRANSPORTATION INFRASTRUCTURE

Due to the lack of real competence of Spanish municipalities in the development and day-to-day actions concerning transportation infrastructures, the available actions are along the lines of increasing citizens' awareness for transportation infrastructure use during extreme events. Thus for the implementation of the Adaptation Plan the selected option was the **update and approval of the Municipal Emergency Plan** including a section for awareness rising and review and verification of transportation infrastructures against extreme events through the years.

## 6.1.2 SECONDARY MEASURES

It is in the nature of any successful Adaptation Plan the need for a periodical review that assures the Plan is updated up to current conditions in the municipality – weather, economy, social structure, etc.

Therefore each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

For this timely review the following provisional selection for measures that can be implemented in the future was made:

| TOURISM |
|---|

- ✓ Develop an ecotourism website with practical information on adaptation measures, including the actions (among the proposed ones) that Bullas Council considers appropriate each year.
- ✓ Promote sustainable tourism as Bullas Natural winery giving value to climate change mitigation and adaptation measures that Bullas Council is carrying-out. To achieve this goal a **green or natural passport** can be designed.

# AGRICULTURE AND SOIL

- ✓ Encourage the diversification of crop types and varieties, including crop substitution, to address the environmental variations and economic risks associated with climate change.
- ✓ Promote the development of private insurances to reduce climate-related risks at farm-level production.
- ✓ Check old drainage systems and study the possibility of investing in water transfer infrastructure improvement for a greater efficiency in distribution that will entail leakage reduction.
- ✓ Encourage the Regulation Council of Bullas Denomination of Origin to continue with its guidance work and promote the inclusion of hazards climate change related.

# HEALTH

- ✓ Try to gather local daily and nightly pollution indicators in collaboration with competent authorities and research centers (i.e. air quality, noise, etc.).
- ✓ Increase public awareness and educate citizens about health implications of air pollution, including risks and the need for emergency preparedness

# TRANSPORTATION INFRASTRUCTURE

- ✓ Identify alternate routes and modes for goods transport and evacuation efforts during emergency situations.
- ✓ Explore the use of traditional and alternative building materials for added strength and durability of construction to improve the longevity of buildings and then incorporate these materials into building code requirements.
- ✓ Update City code to include green building standards for all major renovations.
- ✓ Awareness rising for transportation infrastructure use during extreme events.

## 6.2 Financial resources for the implementation phase

Within the municipal budget for the year 2013 the following items are available, if appropriate, for the adoption of adaption measures:

- Parks and gardens:
  - Maintenance and upkeep of parks and gardens ... 2.000,00 €
  - Supplies of products and plants for parks and gardens ... 6.000,00 €
  - Other various expenses for parks and gardens ... 1.000,00 €
- Environment:
  - Various environment expenses ... 4.000,00 €
- Territory management and tourism promotion:
  - Various territory management and tourist promotion expenses ... 4.000,00 €

In addition to the municipal budget, Bullas has funding subsidies and grants from European projects.

In this way, and on the basis of a previous and already conceded grant from EAFRD (European Agricultural Fund for Rural Development), Bullas is going to install a biomass boiler in the municipal pool, at a total cost of 135.000,00 €, with the objective of reducing $CO_2$ emissions and improve energy efficiency.

Bullas is also currently in the phase of drafting three new European projects, one whiting the framework of the LIFE+ program, which aims at the creation of the knowledge-sharing platform proposed as an adaptation measure for agriculture and soil, and two other projects as part of the announcement for Intelligent Energy, with and aim in energy efficiency in public buildings and the reduction of the municipal energy bill.

## 6.3 Implementation tools and responsibilities

It is clear that the transverse framework of most of the measures proposed makes it necessary for the Environment Department to be the one responsible of policy implementation, advised by the Department of Local Development and Tourism, through the Local Development Agency, and the Department of Urban Planning and Public Services, through the Municipal Technical Office and Public Services.

In this sense and for the time being, is it clear that Bullas town hall will continue with the Local Working Group (adaptation team) created on the occasion of this project and that integrate the municipal technicians in charge of the subjects relating to the implementation of the measures (see Annex IX).

Being small town hall coordination between the various services involved is it possible, so each department will contribute depending on their competencies to deal with their share. The organization chart is show below:

**BULLAS TOWN HALL**

Area of health, consumption and sports

Health department

↓

In collaboration with Murcian Health Service

↓

Measures to execute:
- Raise public awareness and educate on health implications of climate change.

**BULLAS TOWN HALL**

Area of Local Development and Tourism

Department for Local Development and Tourism

Headquarters of the Area of Local Development and Tourism

**Local Development Agency**

Pedro García Moreno (Development agent of local affaires)
Gregorio Egea Jiménez (administrative)
Measures to execute:
- Include practical information on adaptation measures on websites of tourism promotion.
- Facilitate the adaptation of tourist and commercial schedules.
- Awareness raising campaigns including measures of self-protection.
- Knowledge-sharing platform.
- Local weather alerts, in collaboration with the meteorological Association of Southeast.
- Local alert system of pests, in collaboration with IMIDA (Murcia Institute of agricultural research and development).

**Wine Museum**

Salvador Martínez Sánchez (Wine museum director and Wine route manager
Measures to execute:
- Improving the register of tourism indicators.
- To facilitate the adaptation of tourist schedules.
- Awareness for responsible consumption of water among tourists.

**Tourist Office**

Josefa García Toledo (Tourism development agent):
Measures to execute:
- Improving the register of tourism indicators.
- Awareness raising campaigns including measures of self-protection.

## BULLAS TOWN HALL

Area of urban planning, construction and public services

Department of Urban Planning, Construction and Public Services

Headquarters of the Area of Local Development and Tourism

Urban Planning headquarters

Municipal Technical Office

Juan Miguel Burruezo Sánchez (Responsible of energy efficiency and environment)

Measures to execute:

- Disclose new ways of saving, reuse and efficient management of water.
- Reduce energy consumption.
- Improvement of energy efficiency.
- Building the resilience of energy emergency systems.
- To promote renewable energy sources and saving, reuse and efficient energy management.
- Updating Municipal Emergency Plan.

Municipal Services headquarters

Masonry and electricity service

Measures to execute:

- Extension of the areas of shadow in public spaces (awnings).
- Installation of air conditioning in public facilities.

Gardening services

Measures to execute:

- Extension of the areas of shadow in public spaces (tree planting).
- Reduce evapotranspiration in municipal parks.

As proposed in the Adaptation Plan, a timely review each year is need in order to assure that the Plan is updated up to to current conditions in the municipality – weather, economy, social structure, etc.

Therefore each year, after timely considerations, the local government will come to a decision on which measures are applicable according to the availability of personnel and budget.

Since in local governments deadlines are tied up with term in office of each selected political parties, which is four years between local elections, the deadline for the proposed measures is four years.

## 6.5 Drivers and constraints for the implementation

The driver of this Local Adaptation Plan and the measures that it tries to define and implement is **making Bullas climate resilient**. Those actions shall bring benefits to those affected by climate change through appropriate and tailored responses, while respecting at the same time general aspects for good adaptation. However, determining that a specific measure is appropriate is not so easy, as the desired outcome is often delayed or invisible.

Some of the constraints for the implementation of this Local Adaptation Plan are studied in chapter 5. Also, more knowledge is needed on climate science, vulnerability and impacts of climate change so that appropriate policy responses can be developed. In fact, enhancing and developing the knowledge base, thus bridging as much as possible the gaps and reducing the uncertainties, will mean to empower decision-makers to formulate more scientifically-sound policies and to better address the challenges posed by climate change. However, bridging the knowledge gaps represents a very challenging issue. Research on this issue is already considerable, but results are not always downscaled at local level and shared among the local decision-makers.

Concerning the implementation constrains, it was also found that main limitations came in one or other of the following ones:

- Reduced budget
- The lack of qualified personnel to tackle the challenges raised by climate change
- Political involvement: Even if the local government is actually totally immersed in this Adaptation Plan, a political change may occur, with an uncertain future for the Plan implementation, even if it is already approved by the current local government.
- Lack of citizens and decision makers' awareness.

# MONITORING AND REPORTING THE ADAPTATION PLAN

# 7

**This chapter study the monitoring and reporting system that it is a key point for any successful plan.**

**Key indicators and target are also selected.**

The purpose of monitoring, evaluating and reviewing the strategy is to determine whether the project delivers the intended benefits and/or creates negative impacts. Evaluation and monitoring should be conducted to verify the effectiveness of measures taken and make adjustments, if needed. In addition it allows keeping up to date with climatic, scientific and technological developments (UNFCCC).

## 7.1 Monitoring and evaluation

The success of the Adaptation Plan is strongly related to the implementation of the proposed and selected measures as well as its monitoring and evaluation. There is an imperative need to select someone as a reference for the monitoring and evaluation.

Therefore there will be a designated municipal worker that will assume the role of person in charge of Monitoring and Evaluation (M&E) to undertake the monitoring and evaluation of implemented actions within the framework of this Local Adaptation Plan. This designated worker will most likely be the development agent of local affaires.

Broadly, monitoring will cover the following:

a) Physical progress of implementation of the Strategy within time and cost schedules.

b) Quantitative and qualitative progress of implementation of programmes and projects where targets are set.

c) Maintenance of capital assets created to be monitored selectively so that the expenditure earmarked for the purpose in the national and district budgets is in fact utilized for the purpose.

d) Plan expenditure—to ensure that sectoral outlays are not disturbed and outlays earmarked for specific projects are not diverted for other purposes without compelling reasons.

While the limited purpose of monitoring is to ensure timely completion of stipulated tasks for which resources will be allocated to the Strategy, its evaluation will aim at assessing the impact of the Strategy and determining the success or failure in its formulation and implementation. Evaluation will be undertaken periodically, first during the mid-term and later after the completion of the Strategy life-time preferably by external consultants.

## 7.2 Monitoring indicators

Monitoring indicators are needed to follow through time the development of a plan in order to see its success or failure.

For Bullas' Adaptation Plan, and accordingly with the selected adaptation measures, the following indicators were selected:

TOURISM:

- Number of updates of the tourist register
- Number of updates of Bullas' website
- Number of website visits
- Number of installations with air conditioner
- Number of awareness campaigns
- Percentage of streets with awnings or trees providing shadow
- Amount water consumption
- Follow-up of the pacts involving the Covenant of Mayors

AGRICULTURE & SOIL:

- Number of updates of the standardized record
- Number of updates knowledge-sharing platform
- Number of updates of the local early climate warning system
- Number of website visits

HEALTH:

- Number of awareness campaigns (local, regional and national promoted ones)

TRANSPORTATION INFRASTRUCTURE:

- Degree of integration of the measures in local urbanization plan

## 7.3 Monitoring actions

Some of the main actions for monitoring and reporting the success of the Local Adaptation Plan are:

- Explore a wide spectrum of adaptation options.
- Avoid mal-adaptation.
- Effective coordination.
- Assure the implication of local government.
- Review and updating of the Local Adaptation Plan.

## 7.4 Monitoring and evaluation of the plan

### *7.4.1. Programme monitoring and evaluation*

The success of the Adaptation Plan is strongly related to the implementation of the proposed and selected measures as well as its monitoring and evaluation. Thus, for the later one the following check-list was created:

| **Information Requirement** | | | | | |
|---|---|---|---|---|---|
| **TOURISM** | | | | | |
| **Specific objective** | **Milestone** | **Data Source** | **Frequency** | **Responsibility** | **Means of Verification** |
| **1. Enable the adaptation of tourist and commercial schedules at times with** | Change local laws<br><br>Dissemination | Community participation (business owners) | Once, but to be reviewed if the tourist flux changes | Local government and business owners | Citizens assessment<br><br>Monitoring |

| | | | | | |
|---|---|---|---|---|---|
| **greater influx of visitors.** | and information to business owners and clients | Local government | | Tourist office | and Evaluation reports. |
| **2. Awareness campaigns** | Dissemination and Communication Strategy | Community participation<br><br>Local government<br><br>Relevant institutions | Yearly | Local Development Agency<br><br>Tourist office | Citizens assessment<br><br>Monitoring and Evaluation reports. |
| **3. Provide accessible air conditioned in public facilities** | Installation of air conditioned devices in public facilities open to citizens and tourists | Community participation<br><br>Local government | Yearly | Local government | Citizens assessment<br><br>Monitoring and Evaluation reports. |
| **4. Extension of the shaded areas in public spaces with awnings and indigenous trees** | Installation of awnings and indigenous trees in order to provide shade in the main streets | Community participation<br><br>Local government | Yearly | Municipal services<br><br>Local government | Citizens assessment<br><br>Monitoring and Evaluation reports. |
| **5. Additional awareness campaigns for** | Dissemination and Communication Strategy | Community participation | Yearly | Tourist office | Hotel managers |

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| **sustainable water consumption among tourists; 10. Include practical information on adaptation measures in municipal tourism web pages** | Update of Bullas' tourist website | Local government<br>Community participation (business owners)<br>Relevant institutions<br>Tourists | Monthly | Local Development Agency<br>Tourist office<br>Local government | Tourist office operators<br>Monitoring and Evaluation reports<br>Monitoring and Evaluation reports. |
| **6. Increase the application of mulches in more parks than already have** | Installation of mulches in order to prevent evapotranspiration | Municipal services<br>Local government<br>Community participation | Quarterly | Municipal services<br>Local government | Citizens assessment<br>Monitoring and Evaluation reports. |
| **7. Inquiry and advertise new ways to save, reuse, and manage water efficiently.** | Dissemination and Communication Strategy | Community participation<br>Local government<br>Relevant institutions | Yearly | Local Development Agency<br>Tourist office | Citizens assessment<br>Monitoring and Evaluation reports. |
| **8. Local Plan of Action for sustainable energy** | Follow-up of the pacts involving the Covenant of Mayors | Local government<br>Relevant institutions | Yearly | Urban Planning headquarters<br>Local government | Monitoring and Evaluation reports. |
| **9. Comprehensive and systematic record of tourist indicators** | Update of the existing record | Tourist office | Quarterly | Tourist office | Tourist office<br>Monitoring and Evaluation reports. |

| Information Requirement | | | | | |
|---|---|---|---|---|---|
| **AGRICULTURE AND SOIL** | | | | | |
| **Specific objective** | **Milestone** | **Data Source** | **Frequency** | **Responsibility** | **Means of Verification** |
| **1. Create a knowledge-sharing platform** | Creation and update of the platform | Local Development Agency<br><br>Farmers | Quarterly | Local Development Agency | Stakeholders assessment<br><br>Monitoring and Evaluation reports. |
| **2. Attempt to provide a local early climate warning system for daily weather predictions, seasonal forecasts and weather alerts** | Creation and update of the platform | Relevant institutions<br><br>Local Development Agency<br><br>Farmers | Weekly | Local Development Agency | Monitoring and evaluation reports<br><br>Farmers assessment |
| **3. Develop an early alert system regarding weeds and pests** | Creation and update of the platform | Relevant institutions<br><br>Local Development Agency<br><br>Farmers | Monthly or whenever pests are detected | Local Development Agency | Monitoring and evaluation reports.<br><br>Farmers |

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| | | | | | assessments |

| Information Requirement | | | | | |
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| **HEALTH** | | | | | |
| **Specific objective** | **Milestone** | **Data Source** | **Frequency** | **Responsibility** | **Means of Verification** |
| **Improvement the awareness of citizens about climate change associated risks** | Dissemination and Communication Strategy | Relevant health institutions (local, regional, national and international promoted ones) | Monthly or whenever health threads are detected | Health headquarters<br><br>Local government | Citizens assessment<br><br>Monitoring and Evaluation reports. |

| Information Requirement | | | | | |
|---|---|---|---|---|---|
| **TRANSPORTATIONINFRASTRUCTURE** | | | | | |
| **Specific objective** | **Milestone** | **Data Source** | **Frequency** | **Responsibility** | **Means of Verification** |
| **Update and approval of the Municipal Emergency Plan** | Integration of the measures in local urbanization plan | Urban planning headquarters | Yearly | Urban Planning headquarters<br><br>Local government | Urban Planning headquarters assessment |

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| | | | | | Monitoring and Evaluation reports. |

# ANNEX I: STAKEHOLDERS INVOLVEMENT

Stakeholders are central to the adaptation process and each phase of the adaptation process involves different stakeholders in a number of ways. Stakeholder engagement is thus essential throughout the whole adaptation process.

Why to engage stakeholders? Because they have knowledge and ideas that are relevant to the process, decisions made will affect them, and they are more likely to consent to such decisions if they feel they have contributed to define them. Adaptation strategies will not be successfully enforced unless there is a willingness to adapt among those affected, as well as a degree of consensus regarding what types of actions are appropriate.

For this purpose, relevant stakeholders have a representation within the Adaptation Team, the body in charge of defining this Local Adaptation Plan.


# ANNEX II: MAINSTREAMING ADAPTATION INTO THE SECTORAL POLICIES

Mainstreaming refers to the integration of adaptation objectives, principles, strategies, policies and measures so that they become a critical component of existing policies, processes, planning, policy-making, and investment decisions at all levels and stages. As such, mainstreaming is considered to be a fundamental step in the adaptation process. In this sense, adaptation to climate change impacts will not be regarded as a separate topic but an integral part of sectoral policies and planning (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UNDP, 2004).

# ANNEX III: ENERGY

**STEP 1: Identification of current adaptation options/policies**

**Carried out actions for the reduction of energy consumption in municipal facilities.**

1.- Accession to the Mayors Pact to reduce $CO_2$ emissions by at least 20 % by 2020, implying the following measures:

- Development of a Plan of action for sustainable energy, including the development of an inventory of emissions reference that summarizes how the objectives will be met.
- Presentation of an implementation report at least every two years since the submission of the Plan of action for evaluation purposes, follow-up and control.

2.- Organizing informative sessions on efficiency and energy saving. On 13/7/2011 one was carried out in collaboration with ARGEM and an energy consulting company and also an information day on efficiency and savings inviting the winemakers and the industrial sector of the area, issued by media such as the Local TV.

3.- Signature of the Protocol of Action for the reduction of energy consumption in the municipality of Bullas, between ARGEM (Agency for the management of energy of the Region of Murcia) and the municipality of Bullas.

4.- Procurement of collaboration between public and private sector for the provision of energy services in the municipality of Bullas exterior lighting systems.

5.- Maintenance program for electrical installations, heating and air conditioning, for improvement of performance of installations, review and replacement of insulation pipes, adjustments of schedules of heating and pumping of irrigation, etc.

6.- Awareness campaign of municipal staff of the need to use the facilities efficiently, using information on simple cost-saving measures that everyone can apply.

7.- Reduction of power consumption in street lighting through the decrease of the number of hours of operation and selective shutdown of streetlights.

**Selected actions for the reduction of energy consumption at the local level.**

1.- Procurement of collaboration between public and private sector for the provision of energy services in the municipality of Bullas exterior lighting systems.

2.- Organize "Energy day" in cooperation with the European Commission, ARGEM and other interested parties.

**STEP 2: How these policies/options must be improved to cope with the current climate?**

Supporting measures defined in the Plan of action for sustainable energy with a consequent reduction of $CO_2$ emissions, looking for funding to carry out projects and optimizing the dissemination of information at the local level of the proposals at all levels, domestic, industrial and commercial.

**Do they reduce the vulnerability?**

Taking into account that most of the energy consumed in Bullas is produced or transported from outside the region, the reduction of $CO_2$ emissions equivalent to the consumption of energy not consumed at the level of the municipality of Bullas, is not significant at the global level, however, in case of performing several municipalities joint action it could be considered substantial in reducing $CO_2$ equivalent emissions.

**Are additional strategies identified?**

No

**STEP 3: How should these options be enhanced to address future climate variations? Do they reduce future vulnerability? Are additional strategies identified?**

Adapting facilities and periods of consumption to the new climatic conditions.

Betting on renewable energies.

Adapt the habits of consumption of energy and natural resources to the climatic conditions.

**STEP 4: How to prioritize these options and policies of adaptation?**

Since most energy saving measures represent an economic cost in investment, priorities will be

1st-saving measures not involving economic costs.

2nd cost-saving measures that obtain greater energy and economic savings with minimum cost in investment.

How are they integrated into the existing policies?

Carrying out public procurement with energy service companies that make the investment to the produced energy savings account.

Including energy saving measures in urban planning.

**Are they feasible?**

Yes

**Are they effective?**

Only future will tell

**STEP 5: Best options for Bullas**

From the point of view of public infrastructure, it is considered that the best choice is to conduct public competitions with energy service companies that carry out investment in improving the energy efficiency of buildings, installations and equipment, to the produced energy savings account.

For the private sector, given the economic situation in which we find ourselves, probably the greatest difficulty in implementing cost-saving measures is financing them, therefore, the figure of the energy service companies can be an interesting alternative for the Industrial sector, not so much for the commercial and domestic sector that they would have to seek self-financing.

# ANNEX IV: BULLAS 2020: GOOD PRACTICES FOR WATER SAVING

Water is essential for life and an important part of a country wealth; that is why we must learn to not squander it. Safe drinking water is essential for human life, but it is scarce as the population increases and due to poor management, bad use and exploitation and waste.

Society is increasingly more concerned of the need to save water. The decrease in rainfall or increased pollution and the associated costs of the treatments of water purification are being taken into account by the citizens.

Given that general measures of saving water in homes are well known by the general public and by the inhabitants of the region of Murcia in particular, due to the scarcity of water in the region, these were not addressed during the round table on ACT day.

Thus good water saving practices proposed during the round table have been divided into different categories, although many overlap depending on its level of implementation: domestic, local, regional.

**A. Domestic:**

- To recirculate the domestic hot water (DHW) within the system only leaving it when the desired temperature is reached.
- To popularize cold water saving while in the shower, etc.
- Install mini treatment plants in every house or building.
- Install osmosis filters in each house or other systems for purification – filtration.
- Redirect the gutters to water tanks for the collection of precipitations.

- Use of decalcification equipments since that will mean less, less bottled water, less skin problems, less damages appliances, less use of fuel (it would take less time to cook something, etc.).
- Promote the collection and reuse of cold water (e.g.: of the shower for use of toilets, watering plants, cleaning, etc.).
- Promote the use of the grey-water (laundry, shower, etc.) for its use in tanks.
- Directing water through a rolled black hose situated on the rooftop or the sidewalk to heat up the water by solar radiation, especially in the summer and for some isolated buildings.
- Use of water tanks in isolated cottages isolated without debugging or water drinking network.
- Use of biological purification in houses with garden.

**B. Local:**

- To generalize water-saving measures and force the binding of Municipality Laws.
- Promote drip irrigation and rain-fed crops. Know exactly the water needs of each type of cultivation in order to make more efficient its irrigation.
- Awareness.
- Invest in water transfer infrastructure improvement → greater efficiency in distribution.
- Teach companies the available different methods for water-saving that are available on the market and that they can implement.
- Encourage businesses for recovery of rainwater → tax rebates in the real state and for obtaining licenses, etc.

– Control the emptying and filling of swimming pools.

– Enhance the development with aids and awareness.

– Promotion of organic farming since the fewer the use of pesticides is, the less the water that will be have to be spend trying to eliminate them of the final products.

– Control water theft → seal water meters; have divisional and general water meters, and give the control to a neutral body to which everyone will have to report in a compulsory way.

– To control water consumption to detect leaks and repair them in the shortest possible time.

– Improve circulation and discharge water systems so there is a differentiation between sewage, industrial and waste water, so the subsequent treatment is more effective and less expensive, as well as to determine the use that is going to be given to each water and control its quality based on it.

– Control water quality through more frequent analysis.

– Use of the existing irrigation canals as a mean of channelling the water.

– Subsidies for the reuse of some types of waters.

– Control by the Town Council of water distribution networks outside the urban area.

– Municipal regulations that encourages the use of biological sewage treatment plants or green filters.

– Incentive for the use of tanks in homes without depuration or drinking water network.

**C. Regional:**

- Increase water price because their wallet is what moves the citizenship to act.
- To install floating roofs in water reservoirs, favoring those which are solar panels with modular assembly.
- To recover water from condensation through the coverage of reservoirs.
- Build more dams.
- Drain water from underground to prevent landslides and use that water in the industry.
- To force industries to comply with water legislation and to set out their own sewage treatment plants.
- Reduce the consumption of transferred water.
- To reduce the overexploitation of water resources.

**CONCLUSION:**

While all the proposed options would contribute to a greater or lesser extent to water saving, the following one is considered as the one that would be more useful:

*“Improve circulation and discharge water systems so there is a differentiation between sewage, industrial and waste water, so the subsequent treatment is more effective and less expensive, as well as to determine the use that is going to be given to each water and control its quality based on it”*

# ANNEX V: AT HOME AND HEALTH, WHAT CAN I DO?

**AT HOME:**

***Actions to mitigate the negative effects of climate change:***

1) The main thing is to educate and make people aware concerning saving in general, and particularly in water, gas and light consumption, especially with infants and adult population.

2) Reinforcement and isolation of houses:

- Double glazing in doors and windows.
- Reuse of grey-waters: storing precipitation in water tanks, collecting water from washing machines and sinks for its use on the toilet, etc.
- Promote more rental housing because there are many houses sitting empty by their owners with the consequent harmful effects of humidity, pests, as well as the costs invested in construction that are not depreciated.

3) Advertising and awareness campaigns:

- Campaigns to promote the use of how and why recycle with emphasis in making them visual and graphic since there is a population sample between the age of 50 to 70 that still struggle with waste separation.
- Campaign advice to construction companies and related ones such as plumbers, electricians, etc., concerning reinforcements, isolation, and use of quality materials, as well as home energy such as biomass.
- Consultants that teach and advice for this type of business.
- Promote solar home panels since the cost savings is very important and the benefits to the environment are enormous.

4) Usages and customs:

- Promote recycle, reuse, reduce, return (packaging), recharge, reconvert as a general way to redirect our habits to healthier and friendly environmental attitudes.

- Promote the use of express pots while cooking as well as avoid leaving things boiling more than necessary because it takes up a lot of energy. Promote also the use of induction cooker and bithermic appliances since they use the hot water collected from solar panels.
- Avoid fast food restaurants and take-away because their use of plastic containers.
- Promote the purchase of low consumption appliances.
- Disconnection of the appliances plug (avoid leaving the red led on).
- Water timers to avoid that the taps are left open by the manipulation of children or elderly.
- Promote the installation of light movement sensors not only to save but also for safety.

***Actions to adapt to climate change:***

- New approaches in house construction with a commitment from the local administration to municipal enterprises, redirecting them towards a greater reinforcement and protection in buildings and largest and best insulators.
- Development of "Local energy vouchers" for those citizens who carried directly their waste to garbage collections points, receiving an stamp each time they do so and once the voucher is completed they could present it at the Town Hall for a tax reduction in water and garbage bills.
- Promote more direct advertising campaigns for the population sector between 50 to 70 years, and try to eliminate the destructive campaign that some television programs made on plants of waste recycling that transmitted the idea "why recycle at home if the plants are gonna mix it all?"
- Implement at a local level a greater number of recycling spots since there are few and far apart, in general just make it easier the access to them.

- Organize open courses such as "remains cooking classes" to recycle the remains of some foods to create new dishes or products such as jam, juices, etc.
- Separate the organic garbage from the rest and use it as a field fertilizer.
- Promote the introduction of thermal solar plants for salt storage.
- Solar kitchens.

**FOR MY HEALTH**:

- Promotion of consumption of ecological and local products.
- Influence from administrations for traditional work, more plantations, planting more products that we are going to consume.
- Health, security and sport education, such as more walking, less use of the car, and encourage the use of bicycles.
- Promote awareness since primary school together with the City Council, with campaigns, educational programs showing the best practices for the environment and to avoid its harmful effects, and their impact on our health.
- Create a school bus service, that tour the city from 8:00 to 9:00 and from 14:00 to 15:00 to avoid car jam, producing less $CO_2$ and saving fuel.
- Design routes for children to go to school by bicycle rewarding them for their use by teachers with better grades on environmental subjects or similar to incite them.
- Avoid car traffic during a few hours a day in some areas and support it with public transportation (school bus) at certain times of the day.

To know things origin is the key to better value them and avoid their waste and disregard because what doesn't cost us anything is never appreciated.

# ANNEX VI: OUR LAND. AGRICULTURE, LANDSCAPE AND SOIL. HOW TO LIVE AND WORK WITH CLIMATE CHANGE.

**15:00 GROUP:**

- Increase research to find alternative methods to those used at present time, such as pheromones avoiding when possible the use of pesticides and the proliferation of pests, also allowing the permanence of the beneficial fauna.
- Farmers' awareness.
- Return to past habits recovering our ancestors' behaviors, reusing objects for new uses and recycling. Optimize resources and decrease consumerism.
- Search for a balance of the ecosystem.
- Correct flawed policies of vineyard aids. Subsidize the sustainable vineyards. Require policies that guided the maintenance of the vineyard as part of the territory to preserve nature and wine tourism and if possible to increase it.
- Try to convince the wineries to use alternative energy sources even with the high price barrier. Facilitate it by removing obstacles and encourage their use.
- Eliminate electricity pylons in landscapes and other elements that spoil the areas susceptible to be visited within tourism routes.

**15:30 GROUP:**

- Protect what we have. In terms of vineyards allow the necessary measures for the farmers to switch to ecologic farming and for it to be profitable. To restrict landscape interventions and to preserve native or long time cultivated crop varieties.

- Maintaining biodiversity and protecting local producers and products. Gene plants banks. Recovery of varieties in the area.
- To maintain grape and wine quality and to provide the means for their commercialization. Search for these products profits and protect them.
- Search for stable prices in productions and enable producers to survive. Provide grants to whoever takes the right actions.
- Reforestation programs. Comprehensive control of aquifers.
- No to genetic modified food (GM). Whoever work with GM and mess it up should be held economically liable for the damage caused. Fines on malpractice in agriculture.
- Promotion of organic farming also informing of differences and benefits from the intensive and traditional agriculture.
- The terrain determines differences of agricultural and livestock products, and developments are different according to the areas: protect those differences and keep them to take advantage of these differences as a hallmark of quality.
- Commercial development of local products. Defense and promotion of our products.
- CEAMA (Center for agro-ecology and environment): Application to this Centre to research and recovery crop varieties adapted to the area, such as almonds and vineyards.
- Soil protection: training course for farmers on how to till following the ground curves. Planting of hedgerows, vegetation next to dry riverbeds. Conservation of shrubs in these areas is very important for the useful fauna to remain near the crops. Leave vegetation between plots as an space for life (insects, animals, etc.). Leave the wider boundaries between plots and respect them.
- Awareness campaigns and later control through regulations and sanctions at a local level. Difficulty: The land is in the hands of many owners so the work of awareness is difficult since there is a very large number of a person to form and to report to.

- Find out what performances are being done elsewhere and import ideas that work.
- Use of agricultural byproducts for energy: almond shell, grape cuts, biomass. Production of gas to obtain electricity.
- Sustainability: help the farmers get a benefit from the use of their agricultural byproducts as raw materials to obtain energy.

**<u>16:00 GROUP:</u>**

- Make the crops such as vineyards and almond ones profitable because currently they not are.
- There is also the social problem that farmers have little weight in society, despite the fact that his work is very important. The territory in general belongs to them.
- 85 % of farmers are small farmers with zero power, and the little they have they lose it in the distribution chain, with their products not providing them any benefits.
- How to make sustainable agriculture? It is necessary for the farmers that their products are being consumed and that they profit from them. Remove some of the intermediaries shortening the supply chain.
- Manage a more direct relationship between consumers and farmers.
- Comprehensive monitoring of products, from its production to its consumption.
- Use of alternative crops.
- A good water management.
- What reports to buy a bottle of wine in Bullas or another one from a more distant place outside the production area?
- Promote reforestation with grants and other kind of aids. Encourage the planting of native species such as oaks or olive trees amongst others that provide a settlement for local animals to live, which also help with soil regeneration.
- Develop mycology and forestry.

- Plantation of aromatic plants since they have a great adaptability to the area.

**<u>16:30 GROUP:</u>**

- There are very notable changes with almost no time to adapt. We have to act from a collective sense of awareness. Demonstrations must be made so that everyone understands it perfectly.
- Intensive crops with a high water demand should be reduced and replaced them by others with fewer needs.
- Organic farming should be sought without it being inconsistent. Organic farming should be produced to consume in nearby areas because consuming organic products coming from far away it is just absurd since the transport needed to bring them to our tables' increases $CO_2$ production in a monumental way.
- In wine industry the added value of having a Denomination of Origin should be exploited for example by using the marketing to be able to sell products from agriculture and livestock, to wine, oil, cheese, almond, etc.). For example there is a high almond production in the area and yet on the premises of fancy cooking almonds offered are from abroad, from other continents normally, which is absurd.
- Awareness campaigns. Use of local plants to offset $CO_2$ emissions. These plants also provide shade and save water.
- Vineyards: Try to adapt crops to new forms. For example leaving grass between some rows of vines which also helps against soil erosion.
- Wine: It is very difficult to increase the consumption since income per capita falls every year. We could import consumers: search for tourism that consumes wine here, and who buy them to consume them in their place of origin.
- Raise awareness among residents of the area of the consumption of local products, consumption of wines and other quality products produced and processed in the area.
- Try to open a distribution chain of local organic products to be consumed in the area.

- Large scale projects.
- Farmers: Younger farmers tend to be more educated. Training and information is very important for farmers to upholding the environment, the soil, and to make the environment attractive and to be able to remain like that, to not pollute aquifers and to try to avoid residues being present in final agricultural products.
- Policies activation, incentives, tourism development.
- Aid to enhance the cultivation of the vineyard.
- Population awareness, advertising, etc.
- Perform many festivals and events with the wine being the main product to entice the consumer and to let young population know about wine culture, always providing public transport so people don't have to drink and drive.
- Also take into account other parallel to the wine products such as cheeses, almonds, olives, etc.

**17:00 GROUP:**

- Development of sustainable buildings that do not break with the environment.
- Forbid the construction of private houses in non-urban areas unless it is for residence of farmers that works near that area. Many second homes are unnecessary and hardly used.
- Built houses only in urban areas and around them to concentrate people. These will be more efficient.
- Do not allow buildings that make a clear contrast with their surrounding landscape. Housing adapted to the natural landscape. More green landscapes attract more tourism and that should be maximized by relating it to wine tourism and visits to vineyards.
- A beautiful landscape is a valuable asset in itself.

- Improve the management of water in agriculture. Repair ditches and pipes to prevent loss of water. Improve infrastructure to avoid losses and water theft.
- Landscape it is able to adapt itself, we just need to manage it properly without aggravating its situation.
- Fewer roads and paths. No need to reach all sites in four-wheeled vehicles.
- Less aggressive ground crops. Adapt to the climate by using already adapted plants varieties.
- Soil conservation.
- Promote the use of local products.
- Forbid the use of wood from forest fires.
- Carry out a fine-tuning architecture.
- Private property: are very small plots (very difficult to agree upon so many owners), management much difficult as if the land was in the hands of large landowners.
- Efficient management of soil to prevent irregularities.

# ANNEX VII: COMPANIES AND INFRASTRUCTURES: WHAT OPPORTUNITIES AND CHANGES ARE NEEDED FOR A PRODUCTION CLEANER AND SUSTAINABLE GROWTH IN BULLAS?

Different sessions that have been held of Table E have been counting on a high level of participation. Even though it has focused on two main lines: how to improve infrastructure to adapt them to the needs that arise us, and they should do the enterprises to be competitive and survive in an environment as adverse as the current one.

In this way, we structured this summary in two key areas: business and infrastructure. We enumerate here the main contributions of people who took part in it.

**D. Enterprises:**

a. Promotion of ecotourism, taking advantage of the synergies generated by the landscape with the local productive fabric (agriculture, food industry, services, etc...).

b. Enhance energy production systems that need the companies and individuals, through use of the by-products of biomass. (Use of the pruning waste from agriculture).

c. Get the appropriate technology that will allow us to comply with the previous point, while maintaining current levels of comfort.

d. In the case of agriculture, economic incentive policies should think more in the maintenance of the landscape in the amount of production.

e. An interesting question which arises is that of the possibility of creating an energy bonus that could result in a

    i. Tax breaks for being environmentally responsible.

    ii. Fiscal savings for the industry or activity which take advantage of renewable energy in its production line.

f. Develop complementary tourism activities (horse riding, sports, leisure, agroactividades, etc.).

g. Promote the professionalism and stewardship in all fields and levels, as a tool that can allow us to achieve greater competitiveness and adaptation to environmental issues.

h. Use of endogenous resources (raw materials, people, etc..).

i. Promotion of the recycling of organic waste for its subsequent use in agriculture.

j. Promote enterprises social responsibility.

k. Fighting for energy self-sufficiency without relying on large electrical companies.

l. During the different sessions several references have been made to the campsite of the Rafa as a center of activity that must undergo various modifications in its use. Thus, here we collect some of the contributions with respect to the same:

    i. conversion into certified eco-friendly Camping.

    ii. Conversion into a quality tourist and ecological residential complex that would be more profitable for the municipality to a simple parking of caravans.

iii. Everyone talks about new ways to exploit the Rafa's campsite.

m. At the functional level promotes the elimination of bureaucratic obstacles and the principle of proportionality, depending on the size of the company or the purpose of the same.

n. In particular, in the wine sector they are committed by a younger generation of waste and natural production. By a change in the mode of cultivation and the trial of new tillage techniques that allow an adaptation to changes are logged.

o. To achieve the creation of an office of sustainable business development that provide the following services:

   i. Technical support to provide guidance to companies and entrepreneurs in fields as innovative as those of the restoration and rehabilitation as well as renewable energies. Guide to know what to do and how to do it.

   ii. Business advice.

   iii. Aid and stimulus.

**E. Infrastructures:**

a. We must return to the subject of public transport, taking a more serious perspective. In this regard the promotion of railway building on ancient has a fundamental role.

b. Conversion of the municipal vehicle fleet to electric vehicles or use of other fuels.

c. Empowerment of bike lanes, along with the development of awareness-raising campaigns by environmental education and clean transport.

d. The Urban Plan of Bullas should tend to a concentrated model to be more effective from the point of view of saving, and not opt for a diffuse or shading model.

e. Adaptation of urban infrastructure such as sewer rainfall maxima that currently occur. In this way, ending the problems of flooding in certain sensitive points.

f. Adaptation of urban infrastructure for collecting water that are not mixed with the dirty rain water, and thus be able to make use of the first, through the construction of areas of storage in the urban environment.

g. Promote the reuse of rainwater by citizens.

**CONCLUSION:**

To summarize, all raised the following concerns:

- Seek new ways of work, new technologies,... we all have the idea and the awareness of change, but how can this objective be met without a clear economic support?.
- We must continue on the path of sustainable development, but not only at a general level, but as individuals' citizens.
- The negative issues should be penalized. It must be run to criminalize what is bad for the whole of society, rather than subsidizing the positive productive activity.
- To sum up, we must seek a change of mentality of people that allows us to consider a future with prospects.

# GLOSSARY [138]

**Adaptation:** Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.

**Adaptive capacity:** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

**Climate:** Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands of years. The classical period is 3 decades, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

**Climate model:** A quantitative way of representing the interactions of the atmosphere, oceans, land surface, and ice. Models can range from relatively simple to quite comprehensive.

**Climate change:** Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.

**Climate sensitivity:** In Intergovernmental Panel on Climate Change (IPCC) reports, equilibrium climate sensitivity refers to the equilibrium change in global mean surface temperature following a doubling of the atmospheric (equivalent) $CO_2$ concentration. More generally, equilibrium climate sensitivity refers to the equilibrium change in surface air temperature following a unit change in radiative forcing (degrees Celsius, per watts per square meter, °C/Wm-2). One method of evaluating the equilibrium climate sensitivity requires very long simulations with Coupled General Circulation Models (Climate model). The effective climate sensitivity is a related measure that circumvents this requirement. It is evaluated from model output for evolving non-equilibrium conditions. It is a measure of the strengths of the feedbacks at a particular time and may vary with forcing history and climate state.

**Desertification:** Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Further, the UNCCD (The United Nations Convention to Combat Desertification) defines land degradation as a reduction or loss, in arid, semi-arid, and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation. Conversion of forest to non-forest.

**Ecosystem:** Any natural unit or entity including living and non-living parts that interact to produce a stable system through cyclic exchange of materials.

**Emissions:** The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere.

**Evapotranspiration (ET):** The sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves.

**General circulation model (GCM):** A global, three-dimensional computer model of the climate system which can be used to simulate human-induced climate change. GCMs are highly complex and they represent the effects of such factors as reflective and absorptive properties of atmospheric water vapor, greenhouse gas concentrations, clouds, annual and daily solar heating, ocean temperatures and ice boundaries. The most recent GCMs include global representations of the atmosphere, oceans, and land surface.

**Global warming:** The recent and ongoing global average increase in temperature near the Earth surface.

**Greenhouse effect:** Trapping and build-up of heat in the atmosphere (troposphere) near the Earth surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the Earth surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase.

**Greenhouse gas (GHG):** Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.

**Habitat fragmentation:** A process during which larger areas of habitat are broken into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original habitat.

**Heat island:** An urban area characterized by temperatures higher than those of the surrounding non-urban area. As urban areas develop, buildings, roads, and other infrastructure replace open land and vegetation. These surfaces absorb more solar energy, which can create higher temperatures in urban areas.

**Heat waves:** A prolonged period of excessive heat, often combined with excessive humidity.

**Hydrologic cycle:** The process of evaporation, vertical and horizontal transport of vapor, condensation, precipitation, and the flow of water from continents to oceans. It is a major factor in determining climate through its influence on surface vegetation, the clouds, snow and ice, and soil moisture. The hydrologic cycle is responsible for 25 to 30 percent of the mid-latitudes' heat transport from the equatorial to polar regions.

**Indirect emissions:** Indirect emissions from a building, home or business are those emissions of greenhouse gases that occur as a result of the generation of electricity used in that building. These emissions are called "indirect" because the actual emissions occur at the power plant which generates the electricity, not at the building using the electricity.

**Intergovernmental Panel on climate Change (IPCC):** The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories.

**Mitigation**: A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

**Ozone:** Ozone, the triatomic form of oxygen ($O_3$), is a gaseous atmospheric constituent. In the troposphere, it is created by photochemical reactions involving gases resulting both from natural sources and from human activities (photochemical smog). In high concentrations, tropospheric ozone can be harmful to a wide range of living organisms. Tropospheric ozone acts as a greenhouse gas. In the stratosphere, ozone is created by the interaction between solar ultraviolet radiation and molecular oxygen (O2). Stratospheric ozone plays a decisive role in the stratospheric radiative balance. Depletion of stratospheric ozone, due to chemical reactions that may be enhanced by climate change, results in an increased ground-level flux of ultraviolet (UV-) B radiation.

**Ozone depleting substance (ODS):** A family of man-made compounds that includes, but are not limited to, chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODSs.

**Ozone layer:** The layer of ozone that begins approximately 15 km above Earth and thins to an almost negligible amount at about 50 km, shields the Earth from harmful ultraviolet radiation from the sun. The highest natural concentration of ozone (approximately 10 parts per million by volume) occurs in the stratosphere at approximately 25 km above Earth. The stratospheric ozone concentration changes throughout the year as stratospheric circulation changes with the seasons. Natural events such as volcanoes and solar flares can produce changes in ozone concentration, but man-made changes are of the greatest concern.

**Ozone precursors:** Chemical compounds, such as carbon monoxide, methane, non-methane hydrocarbons, and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone, mainly in the troposphere.

**Phenological growth stages of grapes:**

| Growth stage | Description |
|---|---|
| Sprouting /<br>Bud development | Dormancy: winter buds pointed to rounded, light or dark brown according to cultivar; bud scales more or less closed according to cultivar |
| | Beginning of bud swelling: buds begin to expand inside the bud scales |
| | End of bud swelling: buds swollen, but not green |
| | “Wool stage”: brown wool clearly visible |
| | Beginning of bud burst: green shoot tips just visible |
| | Bud burst: green shoot tips clearly visible |
| Leaf development | First leaf unfolded and spread away from shoot |
| | 2nd leaves unfolded |
| | 3rd leaves unfolded |
| | Stages continuous till . . . |
| | 9 or more leaves unfolded |

| | |
|---|---|
| Inflorescence emerge | Inflorescences clearly visible |
| | Inflorescences swelling, flowers closely pressed together |
| | Inflorescences fully developed; flowers separating |
| Flowering | First flowerhoods detached from the receptacle |
| | Beginning of flowering: 10% of flowerhoods fallen |
| | 20% of flowerhoods fallen |
| | Early flowering: 30% of flowerhoods fallen |
| | 40% of flowerhoods fallen |
| | Full flowering: 50% of flowerhoods fallen |
| | 60% of flowerhoods fallen |
| | 70% of flowerhoods fallen |
| | 80% of flowerhoods fallen |
| | End of flowering |
| Development of fruits | Fruit set: young fruits begin to swell, remains of flowers lost |
| | Berries groat-sized, bunches begin to hang |
| | Berries pea-sized, bunches hang |
| | Berries beginning to touch |

| | |
|---|---|
| | Majority of berries touching |
| Ripening of berries | Beginning of ripening: berries begin to develop variety-specific colour |
| | Berries developing colour |
| | Softening of berries |
| | Berries ripe for harvest |
| Senescence | After harvest; end of wood maturation |
| | Beginning of leaf discolouration |
| | Beginning of leaf-fall |
| | 50% of leaves fallen |
| | End of leaf-fall |
| | Harvested product |

**Phenology:** Is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate, as well as habitat factors (such as elevation).

**Resilience:** A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

**Scenarios:** A plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships.

**Sensitivity:** The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).

**Tourism Climate Index (TCI):** Is the most common index used to analyze the potential impacts of climate change on the number of tourists visiting a specific region. This index is based on the notion of "human comfort" and consists of five sub-indices, each represented by one or two monthly climate variables.

**United Nations Framework Convention on Climate Change (UNFCCC):** The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The Convention entered into force on 21 March 1994. The Convention enjoys near universal membership, with 189 countries having ratified. Under the Convention, governments:

- gather and share information on greenhouse gas emissions, national policies and best practices
- launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries
- cooperate in preparing for adaptation to the impacts of climate change

**Vector borne disease:** A vector-borne disease is one in which the pathogenic microorganism is transmitted from an infected individual to another individual by an arthropod or other agent, sometimes with other animals serving as intermediary hosts. The transmission depends upon the attributes and requirements of at least three different living organisms: the pathologic agent, either a virus, protozoa, bacteria, or helminth (worm); the vector, which are commonly arthropods such as ticks or mosquitoes; and the human host. In addition, intermediary hosts such as domesticated and/or wild animals often serve as a reservoir for the pathogen until susceptible human populations are exposed.

**Vulnerability:** The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed; its sensitivity; and its adaptive capacity.

**Weather:** Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. A simple way of remembering the difference is that climate is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard).

# CONCLUSIONS

As stated in previous chapters, this Adaptation Plan should be considered as an action framework to cope with climate change projected impacts. Therefore, a deeply review must be done each year in order to enclose the specific actions that would be carried out.

In conclusion, to know the impacts of climate change and to create a strategy to overcome them is the first milestone to make Bullas a climate resilient community.

Besides, this plan is a useful tool to build Bullas adaptive capacity and delivering adaptation actions in order to transform risks and vulnerabilities from climate change into medium- and long-term business opportunities for agriculture, wine industry and tourism, among others.

Being conscious of this, the local government is supporting this plan and will provide the incentives to take advantages of climate change implementing cost-effective measures than can positively influence the role of Bullas economy showing that adaptation is essential to ensure the sustainable development of the Municipality.

Nevertheless, this Adaptation Plan should be considered as an action framework to cope with climate change projected impacts. Therefore, a deeply review must be done each year in order to enclose the specific actions that would be carried out.

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