ROAD MAP FOR THE LOCAL ADAPTATION PLANS (LAPs)

Life Project

ACT - Adapting to Climate change in Time

No LIFE08 ENV/IT/000436

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PREFACE

The present Road Map for the Local Adaptation Plans represents the main deliverable product of the ***Action 3 – Local Impact Assessment*** of the LIFE Project ACT – *Adapting to Climate Change in Time* (N. LIFE08 ENV/IT/000436). Action 3 was carried out under the responsibility of ISPRA (Italian Institute for Environmental Protection and Research) and with the contribution of the municipalities involved in the project: Ancona (Italy), Bullas (Spain) and Patras (Greece).
The Road Map aims to provide general and city-specific guidelines of the process for the Local Adaptation Plans (LAPs) that will be implemented in the following actions (Actions 4, 5 and 6) by each municipality.
The document builds on the outcomes of Action 2 (Mediterranean basin scenario and State of the art review), which provided relevant scientific evidences on climate change scenarios in the three target areas and drew the basic features for a successful adaptation on the basis of the previous experiences. It represents the linkage between the Local Impact Assessments performed by each municipalities and the concrete Local Adaptation Plans (LAPs).
In this sense, the Road Map is thus specifically addressed to support needs for process start up and consequent development; it defines the most vulnerable sectors to be focused on in the LAPs and identifies challenges, key approaches and strategic addresses to be adopted locally for the coming adaptation process.
For this purpose, the document has been divided into two parts:

- PART A. *Climate change scenarios and outcomes of the impact assessments*, which describes for each municipality the climate framework (observed trends and future scenarios) elaborated by ISPRA in the Action 2, the results of the Local Impact Assessments (current impacts and vulnerabilities, future scenarios where feasible), the gaps and needs identified and points out the main uncertainties that the municipalities will have to manage in the preparation of their Local Adaptation Plans.
- PART B. *The Road Map for the Local Adaptation Plans*, which illustrates the objectives and structure of the Road Map and describes the tasks that municipalities are recommended to implement in order to prepare their LAPs.

The conclusions contain general recommendations, based on commonly shared principles of good adaptation, and specific suggestions for the local administrations in charge of preparing the LAPs.

INTRODUCTION

As summarized in the Fourth Assessment Report of IPCC (IPCC, 2007a), based on climate observations series, global warming is accelerating, most probably as a result of the observed increase in anthropogenic greenhouse gas concentrations. Global average temperature (land and ocean) in 2007 was 0.8 °C above the pre-industrial level (defined as the 1850–1899 average; the increase over land only was 1.0 °C). Eleven of the 12 years between 1996 and 2007 rank among the 12 warmest years, the exception being 1996. The warmest two years on record were 2005 and 1998. The increase of the global average temperature rised from an average of 0.1°C per decade over the past 100 years to 0.2 °C per decade over the past 10 years.
As far as Europe is concerned, the warming is slightly greater than the global average. The annual average temperature for the European land area in 2007 was 1.2 above pre-industrial levels. Seasonally, Europe warmed most in spring and summer. Furthermore, annual precipitation have been showing a general decrease over the 20th century, on average 6-8% between 1901 and 2005. Drying has been observed in the Mediterranean.

Future climate projections for the Mediterranean area indicate a mean temperature increase between 2.2 and 5.1 °C from the period 1980-1999 to 2080-2099 (intermediate scenario). With different emission scenarios, the range of predicted temperature increase is quite larger, going from 3.8 °C (lowest extreme) to about 9-10 °C (highest extreme). Furthermore, precipitation are predicted to decrease even drastically in Southern Europe, from the period 1980-1999 to 2080-2099. The foreseen reduction is more pronounced in summer season. Unlike temperature, precipitation may vary noticeably on small horizontal scales.
Therefore, Europe will not be spared by climate change. Nearly all European regions, in fact, are already negatively affected and are expected to be more and more affected by this rapidly changing climate, with considerable consequences on many physical, biological, economic and social systems. The Mediterranean region, in particular, represents one of the most vulnerable regions in Europe and is considered a hot spot of climate change (Diffenbaugh et al., 2007; Giorgi, 2006). Effects will be severe, in particular, on terrestrial, coastal and marine ecosystems, water resources, health, agriculture, tourism industry, infrastructure but also many other sectors will suffer from climate change (i.e. energy, cultural heritage, fisheries and aquaculture).

The need to adapt to climate change is therefore very high, in particular in the vulnerable areas such as the Mediterranean Basin. Adaptation has, in fact, the potential to reduce the vulnerability of natural systems and socio-economic sectors to climate change by reducing the unavoidable impacts that just mitigation cannot remove and/or by enhancing their adaptive capacity. Furthermore, adaptation not only moderates harms but could also lead to exploit beneficial opportunities. Nevertheless, in the Mediterranean area, the exception being Spain, a scarcity of concrete strategies is still remarkable, especially at regional and local level where adaptation needs should be stronger. In general, RAS (Regional Adaptation Strategies) and LAS (Local Adaptation Strategies) have been developed in countries that also have a National Strategy or where adaptation policies are well advanced, suggesting that policy development is evolving between the central and regional government. Within the framework of the White Paper, the European Commission will encourage the further development of National and Regional Adaptation Strategies and will likely consider mandatory adaptation strategies from 2012. In the meanwhile, as adaptation to climate change has predominantly a local dimension, it is critically important to better understand and strengthen the role of local institutions in shaping adaptation and improving capacities of the most vulnerable groups.

PART A. CLIMATE CHANGE SCENARIOS AND OTUCOMES OF THE IMPACT ASSESSMENTS

MUNICIPALITY OF ANCONA

1. CLIMATE FRAMEWORK

1.1 Mean and extreme temperature

Daily mean temperature series for the area of Ancona (meteorological station located at the city airport) are available with regular update since 1973/4, whereas the daily precipitation values are available since 1979.
Mean temperature series show a positive significant trend in all seasons except winter. The summer series show the highest increase, with a rate equal to 0.06 ± 0.011 °C/year. These results agree with the estimates for Italy by Toreti et al. (2010).
Three indices are useful to evaluate the temporal evolution of temperature extreme events[1]: HWII[2], LWII[3], NWII[4]. In the area of Ancona a great occurrence of heatwaves was registered over the last decade, with a maximum value in correspondence of the severe heatwaves of 2003.
Over the last 30 years, an increasing occurrence of both tropical nights[5] and summer days[6] has been observed. Warm nights amplify health effects by inhibiting the recovery from the daytime and exacerbating the impact through sleep deprivation (Desiato et al., 2010).

Temperature projections for 2100 (compared to the period 1961-1990) in the area of Ancona 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 projections (2046-2065, 2081-2100 with respect to the climatological values of the period 1961-1990) were estimated through the statistical downscaling[7], which has been developed to estimate the local-scale information (50 km or less).
Tables 1 and 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.

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[1] A heatwave is defined as a prolonged period whose maximum temperature is greater than a particular threshold. In the present work, a heatwave is a period of at least three days whose maximum temperature exceeds the thirty year 95th percentile (Kuglitsch et al., 2010).

[2] HWII is the average intensity of a heat wave (in °C), namely the average of the temperature exceeds with respect to the reference threshold during the heatwave event.

[3] LWII indicates the average number of days of each heatwave event.

[4] NWII is the average number of heatwaves.

[5] A tropical night is defined as one night with a minimum temperature greater than 20 °C.

[6] A summer day is one with a maximum temperature greater than 25 °C.

[7] This approach is based on the development of a statistical relationship between large scale variables (predictors) and observed time series (predictands, e.g. temperature), by means of which to simulate future local climate characteristics.

CLIMATE SCENARIOS (2100) – MEAN TEMPERATURE (°C)									
	Winter		Spring		Summer		Autumn		Annual
GCMs	+1.5,+3.0		+1.9,+4.8		+3.2,+6.3		+1.8,+4.6		+2.1,+4.7
RCMs	+2.8,+3.4		+2.4,+2.9		+3.9,+5.7		+3.4,+4.0		+3.4,+3.7
Downscaling	I	II	I	II	I	II	I	II	
	+1.2,+2	+1.5,+3.2	+1.2,+1.8	+1.9,+3.1	+1.7,+2.7	+2.4,+4	+0.9,+1.3	+1.5,+1.8	

Table 1. Municipality of Ancona – Projections for seasonal and annual mean temperature. I = 2046-2065; II = 2081-2100.

Two opposite scenarios A2 and B1 introduce an uncertainty in the variation of the mean temperature of about 2.5 °C, which is likely to be wider when more GCMs are considered.
The maximum increase for the mean temperature (6.3 °C) is predicted in the pessimistic scenario for the summer season, while the weaker increase (1.5 °C) is predicted for the winter season both in the intermediate scenario and in the optimistic scenario.
The three RCMs predict an increase of the mean air temperature at the end of the century between 3.4 °C and 3.7 °C. The warming is more pronounced in summer (between 3.9 °C and 5.7 °C) and less in spring (between 2.4 °C and 2.9 °C).
Also for temperature projections derived from the statistical downscaling, summer is the season with the highest mean, minimum and maximum temperature increase.

CLIMATE SCENARIOS (2046-2065, 2081-2100) – HEATWAVES						
	HWII		LWII		NWII	
Downscaling	I	II	I	II	I	II
	+2.8,+55.6	+16.7,132.7	+3,+30.1	+12.3,+54.3	+0.4,+1.6	+1.6,+3
	SU		TR		FD	
	I	II	I	II	I	II
	+5.4, +93	+12.3, +103.6	+11.9, 53.9	17.5,99.6	-21.4,-24.7	-25.3,-26.7

Table 2. Municipality of Ancona – 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 16.7 and 132.7, while the average length increase is projected to range between 12.3 and 54.3. 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).

1.2 Cumulated precipitation and dry days

The analysis of the seasonal precipitation series did not highlight significant trend in any season except winter, when a significant weak decrease was identified. A weak but statistically significant decrease (10.43 ± 3.41 mm/year) characterises the annual series as well. However, a confirmation of these results and more reliable trend estimates would require longer time series.

Temporal evolution of Consecutive Dry Days (CDD) Index[8] and Simple Daily Intensity Index[9] (SDII) do not show any specific trend, but data series are not sufficiently continuous and complete in order to calculate appropriately the two indexes.

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 table 3 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	-21.9,+2.4	-47.4,-28.2	-46.9,-5.2	-34.1,-12.4	-33.6,-12.3
RCMs	-14.4,+8.8	-20.2,-1.5	-55.6,-41.0	-14.2,+42.9	-17.0,-1.8

Table 3. Municipality of Ancona – Projections for seasonal and annual cumulated precipitation (2100).

With regards to the GCMs projections, the drop of annual precipitation is predicted to range between -27,5% and -33.6% (pessimistic scenario), while in the optimistic scenario the global CNRM model predicts a - 12.3% reduction.
The RCMs predict a reduction of the annual cumulated precipitation for the last decade of the century, ranging between - 1.8% and - 17.0%. Two models out of three predict a relative maximum of precipitation (higher than present) in the middle of the century.
Summer is the only season whose precipitation has a quite regular decreasing tendency over the century, with a reduction of the seasonal cumulated precipitation in the last 10 years, ranging between - 41.0% and - 55.6%. Finally, two models out of three predict an increase of seasonal precipitations (in autumn: + 17.0% and + 42.9%; in winter: + 6.0% and + 8.8%) (Desiato et al, 2010).

1.3 Sea level variations

Sea level variations along the coasts are the sum of various components: eustasy, glacio-hydro-isostasy, and vertical movements. The contribution of each of these components to the Relative Sea Level Rise (RSLR) has been analysed in order to formulate local parameters of expected sea level rise for 2050 and 2100.
Predicted values for RSLR for the site of Ancona indicate a range between 116,5 mm and 444,5 mm for 2050 and between 231 mm and 1449 mm for 2100 (table 4). In the case of Ancona, tectonic and isostatic components contribute to increase forecast relative sea level. Anyway, if the

[8] CDD counts the largest number of consecutive days with no precipitation (i.e. daily precipitation amount less than 1mm).
[9] SDII represents the mean intensity of wet days (i.e. days whose daily precipitation amount is greater than 1 mm).

most pessimistic conditions should occur, the isostatic and tectonic components will be quite marginal. On the other hand these factors will have a more significant role in the future outline of the coast if sea level rise due to global climate change stays within the lowest values among those provided for by various models currently available in the Mediterranean (Silenzi, 2010).

CLIMATE SCENARIOS (2050 and 2100) – SEA LEVEL VARIATIONS (mm)			
2050		2100	
Min	Max	Min	Max
116.5	444.5	231	1449

Table 4. Municipality of Ancona – Projections for Relative Sea Level Rise.

2. AUDIT AND LOCAL IMPACT ASSESSMENT RESULTS

2.1 Impacts, vulnerabilities and adaptive capacity

A great number of observations and evidences shows that climate change is already affecting natural systems and social and economic sectors in the area of Ancona.
Many of the consequences arising from gradual change cannot be attributed just to climate change, since they are affected by other 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 Ancona experienced an intensification of summer heatwaves, landslide and flooding phenomena, exacerbated by extreme precipitation events, and also periods of prolonged dry summer. As a consequence, the municipality of Ancona is already making efforts in order to face the climatic effects particularly relevant on the infrastructure system as well as the degradation level of its cultural heritage due to the joined action of climate change and air pollution.
Furthermore, coastal erosion, with the loss of beaches and changes of habitats, is among the most critical issues to be faced in planning coastal areas like Ancona. Sea level rise alone may potentially entail, for each millimetre of rise in sea level along a sandy shore, a recession of 10 cm in the shoreline (Douglas et al., 2001). In Ancona, coastal erosion cause already economic impacts such as the annual beach-nourishment in areas of high naturalistic interest.
As regards landslide, the city of Ancona is currently one of the most critical areas in our Italy. Landslides represent for the municipality already a big challenge to face and one of the most important case study in Italy, and even in Europe. The vulnerability of Ancona to the current landslide risk has been already reduced thanks to a comprehensive early-warning system which guarantees the population safety. Living with landslide is therefore a reality in Ancona and a clear example of adaptation to this threat (Municipality of Ancona - Questionnaire on past, current, future impacts, vulnerability, policies related to climate risk, 2010).

Future climate change poses a further challenge to the municipality due to the projected change in the climate variables.
In fact, projections of temperature rise, increasing intensity, length and occurrence of extreme temperature events, variation in the precipitation patterns and sea level rise give reason to expect further climatic effects in the coming decades in the area of Ancona. The greater the magnitude of global climate change, the stronger these effects will be. In fact, the magnitude and timing of impacts will vary with the amount and timing of climate change and also the capacity to adapt. Problems that are currently experienced, will be likely accelerated and exacerbated by climatic factors.
The table 5 lists the main results of the Local Impact Assessment for Ancona.

MAIN POTENTIAL IMPACTS, VULNERABILITIES and ADAPTIVE CAPACITY			
	Potential impacts/opportunities	**Main vulnerabilities**	**Adaptive capacity**
Cultural heritage	Surface calcareous erosion due to the joined action of air pollution and climate change is predicted to keep constant values	Medium-high vulnerability of cultural heritage of Ancona compared to vulnerability of Italian cultural properties. In particular among 25 architectural monuments: - 9 monuments show vulnerability values between -1.65 and -1 u.a. (medium –low vulnerability) - 11 monuments show vulnerability values between -1 and 0 u.a. (medium–high vulnerability) - 5 monuments show vulnerability values > 0 u.a. (high vulnerability). The two archaeological sites show vulnerability values > 0 u.a. (high vulnerability).	
Landslide	Landslide increase due to the increase in seasonal (winter, autumn) precipitation	Increase in landslide risk from 21.6% (2011) to 30.3% (2100)	A whole district of the city have been moved after the intense landslide occurred in 1982. An early-warning system currently guarantees population safety in the area at risk. Information and education policies concerning the risk associated to landslides.
		Increase in population at risk from about 10% (2011) to 15% (2100)	
		Increase in rail tracks at risk from about 12% (2011) to 19% (2100)	
		Increase in nurseries and primary schools at risk	
Infrastructure	- Increase of concerns due to sea level rise, to the increase in frequency and intensity of weather extreme events (heat waves, flooding, drought), to increase of landslide	- Increase of risk of damages to physical infrastructure in critical areas, negative impacts on operational aspects, higher maintenance costs, influence on new infrastructure planning	
Coastal environment	- Increase of coastal erosion due to sea level rise and increasing frequency and intensity of coastal flooding	- RICE area (Radius of Influence of Coastal Erosion) around 1100 ha in the next 100 years	
		- 15 km of low-lying coastal areas (6.5 km are currently affected by coastal erosion)	
		- Intensive use of coastal areas	
		- Medium-high risk identified in the area of the floodplain, in the northern part of the city	
		High Coastal Sensitivity Index identified in the area of the promontory of the Mount Conero (5) and the floodplain (6) due to	

		morphological characteristic.	
		The highest Coastal Vulnerability Index (4) has been found both for the promontory of the Mount Conero due to high ecologic value of the areas and the floodplain due to the high level of urbanization (URice).	
		The Coastal Vulnerability Index is equal to 3 for the area for the harbour due to port infrastructure.	
Other sectors	Potential impact of temperature increase, increase in frequency and intensity of weather extreme events (heat waves, flooding, drought), precipitation regimes variation, sea level rise, sea surface temperature increase		

Table 5. Municipality of Ancona – 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.

The assessment of the future superficial erosion of calcareous materials of a number of monuments and archaeological sites analysed in the area of Ancona seems to predict insignificant changes in the coming decades (2030). However, some approximations have been adopted due to incomplete series of observed data (both for climate trend and pollution), but also to the lack of appropriate future projections of some relevant parameters such as relative humidity and pollutants. For these reasons these results should be considered partial as it will be important to further perform the assessment if more appropriate data set is available in the next future. Furthermore, the investigation of further degradation processes such as thermoclastism, crystallization and salt dissolution would be worth, since they have not been included up to now because of the lack of future projections of some climatic data (as again, relative humidity and daily maximum and minimum air temperatures) (Local Impact Assessment on cultural heritage, 2011).

As regards landslide, a possible future seasonal increase of precipitation, estimated by two out of three models for winter (about 10%) and autumn (about 40%), gives reason to expect a change in the landslide risk.

As regards the large landslide of Ancona, it was not possible to develop an impact analysis for these scenarios, as the lack of data (in particular concerning triggering thresholds for the landslide displacement) is going to be filled through a special agreement between the municipality of Ancona and the University with the specific aim to identify specific thresholds and a stability model for predictive purposes.

The current situation concerning the hydraulic risk does not show particular critical points, as it is mapped by the Basin Authority.

The increase of distributed landslide risk for the whole municipal area was estimated between 22% and 30% in 2100 with an average increase of 30% for each land use category except for industrial and commercial for which the percentage of area under landslide risk will increase more than 50%. Population living in potential unstable areas is estimated to increase from about 10% to 15% in 2100 in the worst case scenario, while the exposed rail tracks will increase from about 12% to 19%. Nurseries and primary schools are among the most vulnerable schools (Local Impact Assessment on landslide, 2011).

The risk analysis performed for the coastal environment identified a RICE area (Radius of Influence of Coastal Erosion) of around 1090 ha in the next 100 years. In particular, a medium-high risk was identified in the floodplain in the northern part of the city. This area, in fact, shows a high Coastal Sensitivity Index (equal to 6) mainly due to its morphological characteristics and to a considerable presence of coastal protection and defence works systems. The use of coastal defence systems, in fact, is associated to the high level of instability and fragility of these areas which are already affected by an intense erosion rate. A high Coastal Sensitivity Index (equal to 5) was identified also for the promontory of Mount Conero. The highest Coastal Vulnerability Index has been found for both areas (4), respectively due to the presence of high ecological value (Mount Conero) and to the high urbanization level (floodplain) (Local Impact Assessment on coastal environment, 2011).

Regarding the infrastructure, and the potential effects of sea level rise, extreme events, extreme temperatures and increase in the flooding and landslide risk, the qualitative analysis of vulnerability has shown three major vulnerable elements to put under attention:

- the north section, including connection to the national highway system and to airport, the only accessible port available for heavy vehicles, strategic structures as the regional Hospital;
- the south section, that provides connection to commercial and industrial area, and the access to the southern urban area;
- the port, as strategic economic asset for the region.

A medium level of vulnerability characterizes both physical infrastructure and local development aspects (i.e. population, economic activity, development), showing that a more efficient management of the problem could reduce vulnerability and make it possible to identify “in progress” adaptation measures.

On the contrary, the analysis showed a wide gap of knowledge on operational and financial aspects concerning the management of infrastructure, in addition to a scarce consideration for the “network” aspects, i.e. regional effects of local malfunctioning, relocation concerns, resource distribution, etc. This is primarily due to a scarce discussion between stakeholders and public authorities, absence of an integrated intermodal planning and operational management, to the lack of parameters to ordinary system to measure efficiency, malfunctioning and financial impacts but also the lack of instruments connecting transportation policy (including port development), land evolution and adaptation to climate change. The absence of evaluation for the rail sector in this study is due to scarce literature and a low attention in general studies about climate change but also to a scale factor, related to difficulty in taking account of national/international networks at the local level (Local Impact Assessment on infrastructure, 2011).

The results of climate projections give reason to expect further impacts which may concern other important sectors of the municipality of Ancona. In fact, natural resources, such as marine and terrestrial biodiversity and water resources, and socio-economic sectors such as tourism, health, fisheries which are currently considered to be less vulnerable to climate change, in the coming decades may rapidly start to suffer from its negative effects.

2.2 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 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 Ancona 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 knowledge deficit on local issues.

Table 6 lists the main gaps and needs on the way towards the adaptation process of the municipality of Ancona.

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	- Advances in research
IMPACTS, VULNERABILITIES, ADAPTATION	
- Scarce availability of expertise on climate change impacts, vulnerability and adaptation 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 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
	- Strengthening the link with universities and research community
- Scarce availability of models for the estimate of future impacts	- Advances in research

	GAPS	**NEEDS**
Cultural heritage	- Further degradation processes still have to be investigated in addition to surface erosion of calcareous materials	- Enlarging the study on degradation processes of cultural heritage to climate change
	- Limited number of monuments analysed for the evaluation of their conservation status	- Enlarging the study on vulnerability of cultural sites to climate change
	- Incomplete data series for pollution	- Strengthening the monitoring pollution data by diffusive samples or mobile air monitoring units
Landslide	- Lack of data concerning the triggering thresholds for the displacement of the large landslide of Ancona	- Advances in research - Specific agreement between the municipality of Ancona and research institutes (i.e. University)

		- Sector specific study
	- Lack of in depth analysis on the impact of current and future landslide on infrastructure, as well as the exposed elements to high risk	
Flooding	- Lack of specific studies of hydraulic risk at urban level associated to flash flood	- Advances in research
Infrastructure	- Scarce level of intermodal management - Scarce availability of operational plans and programmes - Scarce availability of evaluation at the network level (level of concern at the network level, default scenarios, policy aspects, etc) - Scarce availability of information about financial management	- Involvement of the rail sector - Promotion of intermodal discussion - Instruments to mainstream local adaptation issues in transport management programs - Promotion of the integration between transport management and land planning - Promotion of specific studies at the network level for each transport mode - Promotion of specific studies to assess the impacts on port - Agreement for the definition of set of financial data, both public and private, on transportation management and planning
Coastal environment	- Lack of models at local scale for the assessment of coastal erosion in the next 50 and 100 years	- Collection of data on future scenarios from validated models in order to estimate appropriately the evolution of the shoreline on the basis of the climate scenario presented.
Other sectors	- Lack of quantitative analysis of other potential impacts and vulnerabilities to climate change.	
- Marine and terrestrial biodiversity	- Scarce availability of analysis at local level	- Specific studies on local biodiversity
- Fisheries	- Scarce availability of analysis at local level	- Specific studies on local fisheries and fish farming (i.e. diffusion of alien thermophilic species, distribution of size/age in fish and shellfish samples, decrease of average size of first reproduction, adult/young ratio, decrease of catches per unit of fishing effort (CPUE) in scientific fishing surveys; increase of temperature in sea water at various depths; increase of hypoxia and anoxia episodes in coastal areas; "explosions" of undesired species)
- Water resources	- Lack of analysis at local level	
- Health	- Lack of analysis at local level	
- Tourism	- Lack of analysis at local level	

Table 6. Municipality of Ancona – Main knowledge gaps and needs.

2.3 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 Ancona 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 Ancona will have to deal with uncertainties at different levels (table 7).

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	
Cultural heritage	- Projections of relative humidity - Projections of pollutants (2030) - Projections of climate change impacts on cultural heritage
Landslide	- Projections of climate change impacts on landslide risk - Capacity of the early-warning system to cope with the future climate change
Infrastructure	- Projections of sea level rise, temperature and precipitation extremes
	- Projections of frequency and intensity of flooding and landslides
	- Projections of effects on building materials
Coastal environment	- Projections of climate change impact s on coastal environment
Other sectors	- Projections of climate change impact on other relevant sectors (i.e. marine and terrestrial biodiversity, fisheries, water resources, health, tourism)

Table 7. Municipality of Ancona – Main uncertainties to manage.

MUNICIPALITY OF BULLAS

3. CLIMATE FRAMEWORK

3.1 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 (Desiato et al, 2010).

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 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 8 and 9 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) – 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 8. Municipality of Bullas – Projections for seasonal and annual mean temperature. 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 9. 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).

3.2 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 table 10 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 10. 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 (Desiato et al., 2010).

4. AUDIT AND LOCAL IMPACT ASSESSMENT RESULTS

4.1 Impacts, vulnerabilities and adaptive capacity

A great number of observations and evidences shows that climate change is already affecting natural systems and social and economic sectors in the area of Bullas.

Many of the consequences arising from gradual change cannot be attributed just to climate change, since they are affected by other 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 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 (Municipality of Bullas - Questionnaire on past, current, future impacts, vulnerability, policies related to climate risk, 2010).

The table 11 lists the main results of the Local Impact Assessment for Bullas.

MAIN POTENTIAL IMPACTS, VULNERABILITIES and ADAPTIVE CAPACITY			
	Potential impacts/opportunities	**Main vulnerabilities**	**Adaptive capacity**
Agriculture	- Crop quality and productivity changes (in particular grapevine and olive)	High vulnerability, based on qualitative assessment	- The Regulating Council of the Bullas Origin Denomination is in charge of advising farmers in cultivar development and helping them to adapt to new situation - Crop insurance - Clean Agriculture Program - Agro-climatic Information System for Irrigation (SIAR)
	- Change in crop phenology (grapevine)		
	- Increase of soil erosion and desertification risk (Murcia)		
	- Land use change		
	- Increase in irrigation requirements (Murcia)		
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 - Tourism industry	
	- Effects on grapevine phenology, quality and yield	- Wine industry, rural housing, hotel and restaurant business, museums	
Soil degradation and desertification	- Increase of desertification risk	- High erosion risk area	

Table 11. 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 (Local Impact Assessment on agriculture, 2011).

The TCI (Tourism Climate Index) has been calculated for different scenarios 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 worse between June and September, showing 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.
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 (Local Impact Assessment on tourism, 2011).

Furthermore, projected climate change may exacerbate the problem of desertification, drought and soil degradation (Local Impact Assessment on soil, 2011).

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.

4.2 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 12 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	
- 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

	GAPS	**NEEDS**
Agriculture	- Lack of data at local level	- 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	- 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) - 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	- Advances in research - Enhance transfer of knowledge from research communities to local decisions makers - Data collection at local level
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 12. Municipality of Bullas – Main knowledge gaps and needs.

4.3 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 13).

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 13. Municipality of Bullas – Main uncertainties to manage.

MUNICIPALITY OF PATRAS

5. CLIMATE FRAMEWORK

5.1 Mean and extreme temperature

The trend assessment for Patras was performed for the temperature series alone, as no precipitation time series was available to us. The temperature time series covers a period ranging between 1960 and 2003, long enough for a proper estimation of the annual and seasonal trends. However, the validity of results is partially limited by the lack of data for the period 2004-2009. Such a piece of information is relevant for a proper trend assessment, since over the last six years of the last decade the temperature exhibits a signal which resembles the temperature projections of the GCMs. Neither the annual nor the seasonal series exhibit a significant trend. However, a weak positive signal characterizes the summer series. It is likely that the information for the 2004-2009 period would modify this result (Desiato et al., 2010).

Temperature projections for 2100 (compared to the period 1961-1990) in the area of Patras 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 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 14 and 15 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) – MEAN TEMPERATURE (°C)									
	Winter		Spring		Summer		Autumn		Annual
GCMs	+0.5,+2.6		+1.2,+3.7		+2.0,+4.7		+1.5,+3.3		+1.4,+3.6
RCMs	+2.6,+3.6		+2.4,+3.0		+4.5,+5.1		+3.4,+4.8		+3.5,+4.0
Downscaling	I	II	I	II	I	II	I	II	
	+0.2,+0.9	+0.5,+1.5	+0.6,+1.0	+1.3,+1.8	+1.2,+2.2	+2.5,+3.3	+0.3,+0.5	+0.3,+1.0	

Table 14. Municipality of Patras – Projections for seasonal and annual mean temperature. I = 2046-2065; II = 2081-2100.

With regards to the GCMs projections, the maximum increase for the mean temperature (4.7 °C) is predicted for the summer season, and the minimum increase for the mean temperature (0.5 °C) is predicted for the winter season.
According to the three RCMs, the rise of the mean air temperature during the last decade of the century is estimated to be between 3.5 °C and 4.0 °C, with a warming more pronounced in summer (between 4.5 °C and 5.1 °C) and less in spring (between 2.4 °C and 3.0 °C). Two opposite scenarios (i.e. A2 and B1) introduce in some cases an uncertainty in the variation of mean

temperature of about 1.0 °C wide. This uncertainty is likely to be wider when more models are considered.
Two out of three models used in statistical downscaling are in agreement in predicting that the highest temperature variations occur in summer. Patras is the location with the lowest seasonal temperature variations compared to Ancona and Bullas, and autumn is the season with the lowest variations.

CLIMATE SCENARIOS (2046-2065, 2081-2100) – HEATWAVES						
	HWII		LWII		NWII	
Downscaling	I	II	I	II	I	II
	-0.6,+34.1	+16.1,+74.1	+1.0,+20.1	+14.0,+41.1	-0.03,+1.4	+1.8,+2.6
	SU		TR		FD	
	I	II	I	II	I	II
	-12.7,+85.9	-2.5,+107.4	-0.9,+22.3	+3.4,+74.9	-16.9,-9.4	-16.2,-12.2

Table 15. Municipality of Patras – 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 in general to severely increase in the future decades in particular in terms of average intensity and length, but relatively large uncertainty characterizes their prediction. Some results, in fact, even indicate a slight decreasing trend. 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).

5.2 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 table 16 illustrates the ranges (minimum and maximum values) of change predicted for cumulated precipitation to 2100 (Desiato et al., 2010).

CLIMATE SCENARIOS (2100) – CUMULATED PRECIPITATION (%)					
	Winter	Spring	Summer	Autumn	Annual
GCMs	-53.8,-13.8	-60.0,-4.2	-88.9,+5.0	-59.8,-6.0	-56.8,-9.4
RCMs	-23.0,+8.7	-27.8,-15.3	-44.6,-22.6	-29.2,+14.3	-28.3,-5.5

Table 16. Municipality of Patras – Projections for seasonal and annual cumulated precipitation (2100).

In the pessimistic case GCMs predict a drop of the annual precipitation up to - 56.8%, while in the optimistic scenario the global CNRM model predicts a drop of - 9.4%.

The three RCMs estimate a reduction of the annual cumulated precipitation at the end of the 21st century, ranging between - 5.5% and - 28.3%. The uncertainty associated with this climate variable determines such a wide range of the estimates. With regards to the annual precipitation, all the RCMs show a regular decreasing tendency over the century. Summer is the season whose precipitation is characterised by the strongest reduction of the seasonal values, ranging between - 22.6% and - 44.6% at the end of the century. Finally, only two models predict an increase of the seasonal precipitation: RACMO2 in autumn (+ 14.3%) and SMHIRCA in winter (+ 8.7%) (Desiato et al., 2010).

5.3 Sea level variations

Sea level variations along the coasts are the sum of various components: eustasy, glacio-hydro-isostasy, and vertical movements. The contribution of each of these components to the Relative Sea Level Rise (RSLR) has been analysed in order to formulate local parameters of expected sea level rise for 2050 and 2100.

Predicted values for RSLR for the site of Patras indicate a range between 33 mm and 361 mm for 2050 and between 64 mm and 1282 mm for 2100 (table 17). Tectonic and isostatic component contribution varies according to sea level rise: in the case of Patras, the vertical shift component, due to the uplift in the areas, will contribute to decrease the relative sea level rise in the future.

In conclusion, isostatic and tectonic components will have a more significant role in the future outline of the coast if sea level rise due to global change will stay within the lowest values among those provided for by various models currently available in the Mediterranean (Silenzi, 2010).

CLIMATE SCENARIOS (2050 and 2100) – SEA LEVEL VARIATIONS (mm)			
2050 (mm)		2100 (mm)	
Min	Max	Min	Max
33	361	64	1282

Table 17. Municipality of Patras – Projections for Relative Sea Level Rise.

6. AUDIT AND LOCAL IMPACT ASSESSMENT RESULTS

6.1 Impacts, vulnerabilities and adaptive capacity

A great number of observations and evidences shows that climate change is already affecting natural systems and social and economic sectors in the area of Patras.

Many of the consequences arising from gradual change cannot be attributed just to climate change, since they are affected by other 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 the region of Patras experienced extreme events that may be linked to global warming. In fact, repeated heatwaves occurred during the period from June to August and reduced rainfall season were experienced during the period from October to April.

In Greece, and there are not particular reasons why Patras should experience different conditions, heat waves represent the first cause of mortality due to natural disaster. No official data account for the percentage of the population that is affected by the extreme weather events every years. However, in the last years extreme weather events in the Achaia prefecture have become more frequent and have affected people living both in the urban and the rural areas. People in the urban area are mostly affected by flooding and people in the mountainous areas are affected by heavy snowfall as well as flooding.

Research studies have shown the occurrence of impacts in the natural regeneration of fir and pine forests in one of the most interesting protected area which is the Mount Panachaikos (Natura 2000). In this area several important vegetation ecosystems are identified:

- eight forest ecotopes protected under Habitats Directive;
- one forest ecotope part of Natura 2000;
- seven other ecotopes also protected under Habitats Directive;
- three ecotopes part of Natura 2000;
- two important ecotopes that are not included in the guide-map of Natura 2000,

including:

- ecotopes of high ecological value (i.e. endemic, rares, protected species such as *Abies cephalonica;* communities of "shaved" meadows; communities of steppic meadows; chasmophytic communities of limestone rocks; communities of sarres; eutrophic lake of Rakita)
- endemic, rare and protected flora species (i.e. *Dianthus androsaceus, Peucedanum achaicum, Gymnospermium altaicum ssp. Odessanum; Ophrys argolica*)
- sensitive species (i.e. *Platanus orientalis, Salix alba*).

Here, the dry period lasts for more than four months, starting from Mid-May until September, with a consequent high risk of fire for vegetation. Forest fires, in fact, have historically been one of the most important factors that have contributed to the degradation of forests of this area especially at its lower part (i.e. zone of evergreen broadleaf), in particular during the summer months (about 38% in August and 16% in July) when it is burned the 95% of the annual burned area.

In Greece, as elsewhere in the world, biodiversity losses can be caused indirectly by air, water and soil pollution, fragmentation and destruction of habitats, forest fires, intensive agricultural and forestry practices, exotic invasive species, etc. However, climate change is becoming an increasingly important factor in this equation (Local Impact Assessment on biodiversity, 2011).

In socio-economic terms, the importance of Patras is mainly associated to the presence of the second most important port in the country (tourism and logistics) which handles a large number of tourists during the period from May to September. The port is therefore a fundamental tourist infrastructure and tourism, together with commerce and transports, contribute to a high percentage in the local GNP. Up to now Achaia prefecture, although it has a wealth of natural and cultural heritage and has comparative advantages from a climate and geographical point of view, has not conquered a significant specialization in tourism and it has not managed to represent a permanent attraction. Nevertheless, Patras is making efforts in order to become an attractive destination for some of the many travellers that use its port each year (Municipality of Patras – Questionnaire on past, current, future impacts, vulnerability, policies related to climate risk, 2010).

On the basis of available data, fish and shellfish landings from the fleets based in the port of Patras was of about 9,000 tonnes per year in 2000-2003 (Leroy et al, 2007), and the comparison with data regarding the subdivision of marine fishing in Greek waters shows a downward slope of -30%-40% compared to ten years before (Stergiou et al., 1997). Because of the EC policy that reduces the fleets, it appears possible that over the next 10-15 years the catches will tend to decrease with approximately the same intensity.

Over the past 20 years sea bass and sea bream farming has undergone turbulent development and about 1/3 of the plants are located along the coasts of the NE Ionian Sea (Lovatelli and Cardia, 2007), so the economic weight of this subsector is now higher than that of the fishing sector. According to the above, the fish farming businesses should continue to have a positive economic trend, albeit with much lower growth rate than in the past.

For the Patras area, it is important to note that the imposition of a climate with higher atmospheric temperatures and less precipitation should have a considerable impact on the Messolonghi lagoon (12 Km^2 according to Leroy et al., 2007), which thanks to the abundance of phytoplankton, due to the nutrients from the river, hosted fairly good fishing and fish farming activities (Kotsionas, 1984).

In the near future, it is foreseeable that evaporation will tend to increase in the lagoon whereas the contribution of fresh water will decrease, therefore the area should shrink, the salinity of the water should increase and therefore also the frequency of crises in the food web (the formation, in conditions of absence of oxygen in the waters of the sea bed, of sulphurated oxygen due to bacteria), which can lead to the death of aquatic animals in the relevant areas. However, it is necessary to note that Leroy et al. (2007) hypothesised the total disappearance of the lagoon over the long term (>100 years) due to the rise in sea level (Climate Change Impact Assessment and Local Vulnerability – Fisheries, Romanelli, Giovanardi, 2010).

Future climate change poses a further challenge to the municipality due to the projected variations in climate variables.

As seen in the previous paragraph, projections of temperature rise, increasing intensity, length and occurrence of extreme temperature events, variation in the precipitation patterns and sea level rise give reason to expect further climatic effects in the coming decades in the area of Patras. The greater the magnitude of global climate change, the stronger these effects will be. In fact, the magnitude and timing of impacts will vary with the amount and timing of climate change and also the capacity to adapt. Problems that are currently experienced, will be likely accelerated and exacerbated by climatic factors.

The table 18 lists the main results of the Local Impact Assessment for Patras.

MAIN POTENTIAL IMPACTS, VULNERABILITIES and ADAPTIVE CAPACITY			
	Potential impacts/opportunities	**Main vulnerabilities**	**Adaptive capacity**
Terrestrial biodiversity	- Increase in the potential risk of forest fire due to increasing temperature and decreasing precipitation	Highest frequency of fires during August (38,3%) followed by July (16,2%)	
Tourism	- Decrease in comfort conditions for tourism activity between June and October (2050 and 2100). "Acceptable" conditions will be always guaranteed. - The other months will likely maintain the same conditions or will experience an improvement of climatic conditions (2050 and 2100).	- About 200.000 foreigners arrivals through the port in july and august - Water shortage during the summer period	- Cheap vacations promoted from tourist offices during the whole year - Low level of promotion and modernization of basic infrastructure - Low interest in the creation of private facilities

	"Acceptable" conditions will be always guaranteed.		and businesses
	- Decrease of tourist arrivals flows (between -11.4% and -19.8%)		
	- Reduction/loss of biodiversity and ecosystems	- Natural assets relevant for tourism (i.e. the Cave of the Lakes, the Acorns in the area of Kalamia of Egion, the Pafsanias plane-tree in Egion, the 12 founts in Egion, the vine of Kalavrita, the plane-tree of Agia-Lavra in Kalavrita) - Medium vulnerability	- Lack of systematic programming for protecting and conserving the natural and cultural heritage
	- Damages to tourist infrastructure due to sea level rise and extreme weather events	- Medium vulnerability	
Health	- Estimated value of the increased risk of mortality due to the increase in the occurrence and intensity of heat waves (natural, cardiovascular, respiratory): 19.5% to 20.5% (all ages population) and 26.5% to 27.7% (population over 75)	- Population > 80 years old: 2% - Population between 65 and 79 years old: 11%	- Presence of Heat early warning systems - Presence of Health surveillance system for heat wave - Presence of measures to reduce urban heat island effects
Other sectors	Potential impact of temperature increase, increase in frequency and intensity of weather extreme events (heat waves, flooding, drought), precipitation regimes variation, sea level rise, sea surface temperature increase		
- Desertification	- Increase of desertification risk due to drier and hotter conditions in the future	- Low sensitivity to desertification in the area of Patras	
- Fisheries	- Sea surface temperature increase	- Sensitivity of fish and mesopelagic fish species	
	- Increase of alien species		
	- Decrease in precipitation	- Sensitivity of cephalopods and crustaceans	
- Landslides	- Increase of landslide		

	risk (from 1.5 up to 3 times)		
- Flooding	- Increase of flooding risk (from 2.6 to 3 times)		

Table 18. Municipality of Patras – Impacts, vulnerabilities and adaptive capacity.

Predictions of the 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.

The future temperature increase together with the precipitation decrease, predicted in particular for the summer period, will probably lead to an increase of forest fire risk for the several ecosystems of the Mount Panachaiko. Such a risk, in addition to the overpasturing occurring at the highest altitudes, will result in a more intense threat to vegetation. Furthermore, according to climate projections results, climate change will likely produce impacts on species distribution and composition (Local Impact Assessment on biodiversity, 2011).

The results of the impacts assessment of climate change on tourism showed that climate change may have a potentially significant impact on tourism. The TCI (Tourism Climate Index) has been calculated for different scenarios based on different climate change models. Although the calculation suffers from a lack of some data, the results showed that in the future (2050 and 2100) climate conditions, for the so called “light outdoors activities”, will worse between June and October, showing less attractive climatic conditions, compared to current conditions. The other months will likely maintain the same conditions or will experience an improvement of climatic conditions.

In the future climatic conditions of Patras will be always relatively comfortable for light outdoor tourist activities, although the summer season will become less climatically attractive than today. Furthermore, estimates of the impacts on tourist flows show a future decrease of tourist arrivals flows in Patras in 2100 ranging between about -11.4% and -19.8% (Local Impact Assessment on tourism, 2011).

According to the maximum temperature projection for summer season, and considering specific assumptions and the maximum baseline value for Patras 30.6 °C, the increase in mortality risk (natural, cardiovascular, respiratory diseases) could be considered very high (Local Impact Assessment on health, 2011).

The results of climate projections give reason to expect further impacts which may concern other important sectors of the municipality of Patras. In fact, natural resources, such as marine biodiversity, water resources, landslide and flooding risk and coastal environment, and sectors such as cultural heritage, fisheries 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.

6.2 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 Patras 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 19 lists the main gaps and needs on the way towards the adaptation process of the municipality of Patras.

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	
- 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
- Scarce availability of models for the estimate of future impacts	- Advances in research

GAPS		**NEEDS**
Marine and terrestrial biodiversity	- Scarce knowledge about the climate trends in the area	- Local equipment of meteorological station for the area
	- Scarce knowledge about the sensitivity of flora and fauna to climate change	- Advances in research - Enhance transfer of knowledge from research communities to local decisions makers
	- Lack of knowledge and monitoring activity on the future impacts of climate change on biodiversity (i.e. impacts on physiology and behaviour of species, impacts on phenology, impacts on range distribution, impacts on composition and species interactions in ecological communities)	

	- Lack of knowledge and monitoring activity on the future spreading of allochtonous species, both animals and plants	
Tourism	- Lack of climate predicted data for the appropriate calculation of TCI - Lack of sufficiently long time series of data on past tourist arrivals in Patras	- Advances in research - Enhance transfer of knowledge from research communities to local decisions makers - Data collection at local level
Health	- Lack of monitoring systems	- Data collection at local level
	- Lack of systematic data collection on databases (air quality, population exposure, potential impacts, vulnerability)	
	- Lack of specific data for epidemiological studies	
	- Lack of official data accounting for the percentage of population affected by extreme weather events	
Other sectors	- Lack of quantitative analysis of other potential impacts and vulnerabilities to climate change.	
- Cultural heritage	- Lack of systematic recording of the vulnerability parameters for monuments and sites	- Network of air quality stations
	- Lack of calculation of risk for cultural heritage	
- Desertification	- Lack of a local assessment of desertification	- Downscaling of assessment from the Mediterranean scale to the local scale
	- Lack of future projections of the risk of desertification	- Enhance transfer of knowledge from research communities to local decisions makers
- Fisheries	- Scarce availability of analysis at local level	- Promotion of specific study on local fisheries and fish farming (diffusion of alien thermophilic species, distribution of size/age in fish and shellfish samples, decrease of average size of first reproduction, adult/young ratio, decrease of catches per unit of fishing effort (CPUE) in scientific fishing surveys; increase of temperature in sea water at various depths; increase of hypoxia and anoxia episodes in coastal areas; "explosions" of undesired species)
- Landslide	- Lack of analysis at local level	
- Coastal environment	- Lack of analysis at local level	
- Water resources	- Lack of analysis at local level	

Table 19. Municipality of Patras – Main knowledge gaps and needs.

6.3 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 Patras 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 affect the knowledge of global and regional processes, but the more 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 Patras will have to deal with uncertainties at different levels (table 20).

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	
Terrestrial biodiversity	- Projections of survival of animal and plant species particularly sensitive to climate change
	- Projections of the geographical distribution of species - Projections of the spreading of allochtonous species
Tourism	- Projections of sunshine, wind, humidity - Seasonality of tourist flows
Health	- N and frequency of heat waves - Demographic indexes variations

Table 20. Municipality of Patras – Main uncertainties to manage.

PART B. THE ROAD MAP FOR THE LOCAL ADAPTATION PLANS

1. STARTING POINTS AND SCOPE

As shown in the next figure 1 and table 1, the **adaptation process** consists of four key components (UNFCCC):

(i) Assessment of climate impacts and vulnerability;
(ii) Planning for adaptation;
(iii) Implementation of adaptation measures;
(iv) Monitoring and evaluation of adaptation actions.

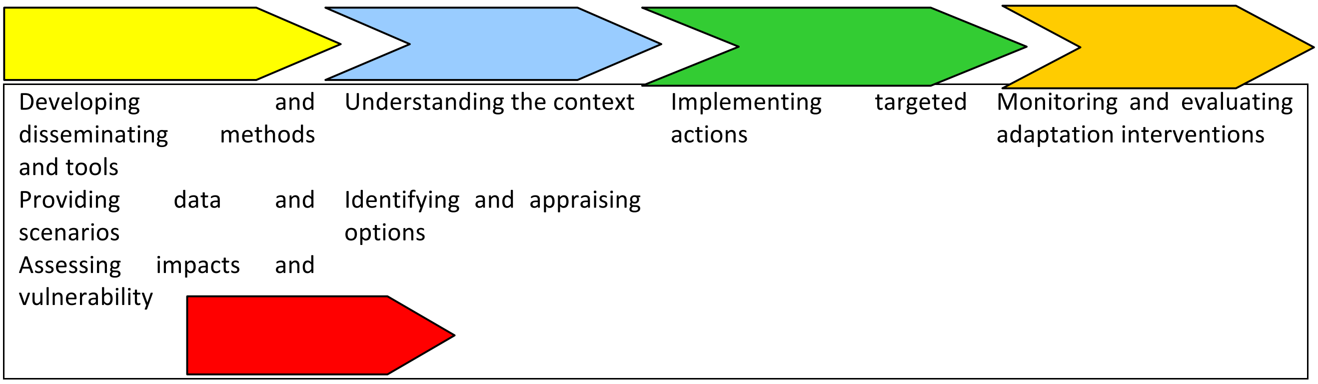

Figure 1 – The key components of the adaptation process (UNFCCC).

Each of these components is associated with, and/or supported by, relevant data and information, methods and tools, and practices.

ASSESSMENT	Gaining a better understanding of how and in which way climate change will affect natural systems and socio-economic sectors is fundamental for adapting to climate change. The assessment of vulnerability (environmental, economic and social) is an important way to measure potential harms using more than just climate impacts information. Furthermore, an assessment of the ability to adapt, the identification of climate and socio-economic scenarios and the prioritisation of risks and opportunities associated to climate change are needed.
PLANNING	Once determined the need for adaptation on the basis of the impacts and vulnerability assessment, the range of possible adaptation options has to be identified. There is no a best single method, tool or process for adaptation planning: the selection of methods, tools and processes should be tailored to the specific planning context, including the objectives, scope, stakeholders involved, time constraints, technological and financial resources available.
IMPLEMENTATION	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.
MONITORING, EVALUATION AND REVIEW	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 to keep up to date with climatic, scientific and technological developments.

Table 1 – The purposes of key components of the adaptation process.

The present Road Map for the Local Adaptation Plans can be considered as a tool, a linking document between the Assessment and the Planning phase which will be implemented by each municipality. Starting from the outcomes of the actions carried out under the Life Project ACT, the Road Map is intended to provide general and specific guidelines for Local Authorities to develop and adopt local adaptation plans.
In particular, the document builds on the outcomes of Action 2 (Mediterranean basin scenario and State of the art review) and Action 3 (Local Impact Assessment), and is therefore specifically addressed to each case in order to:

- support needs for process start up/development;
- define the most vulnerable sectors to tackle in the local adaptation strategies;
- identify key approaches to be adopted locally for the development of the local adaptation strategy.

2. STRUCTURE OF THE ROAD MAP

On the basis of the request by the municipalities to have greater freedom of action, the Road Map does not provide a specific timescale, although several important steps must be made in order to ultimately arrive at a widely accepted adaptation plan.
The structure of the Road Map is illustrated in the figure 2.
Adapting to climate change is an iterative process. This means that some tasks should be performed throughout the whole process or at certain stages of it (i.e. *Stakeholder engagement*, *Communication and Dissemination*). Also, some tasks should be revised periodically in order to ensure that data, assessments and resulting decisions remain valid and up-to-date (i.e. *Monitoring, Evaluation and Review*).
The Road Map is conceived to guide by the current time (October 2011) to the design of the adoption of the LAPs. The Assessment step is therefore considered to be completely performed and no assessment actions are included in this process.
Obviously, some preliminary actions are needed before starting the real Planning step in order to verify if the previous actions have been performed in the most appropriate way. In fact, as it is emerged from the outcomes of the Local Impact Assessments, there is a strong need to verify whether some specific previous tasks have achieved their objectives effectively.
In particular, it will be important to verify that political backing is still strong and the managerial commitment is adequate in order to address the problems emerged in the assessment task.
Once the preliminary actions will be performed, the municipalities will be ready to start their process towards the adoption of the LAPs by the end of March 2012.
It is important to point out that *Implementation* and *Monitoring, Evaluation and Review* are successive to the *Planning* step, but the planning of specific elements that are functional to these steps is required before the adoption of the Plan. These elements have been therefore identified respectively in "*Planning the implementation*" and "*Planning the monitoring, evaluation and review*".

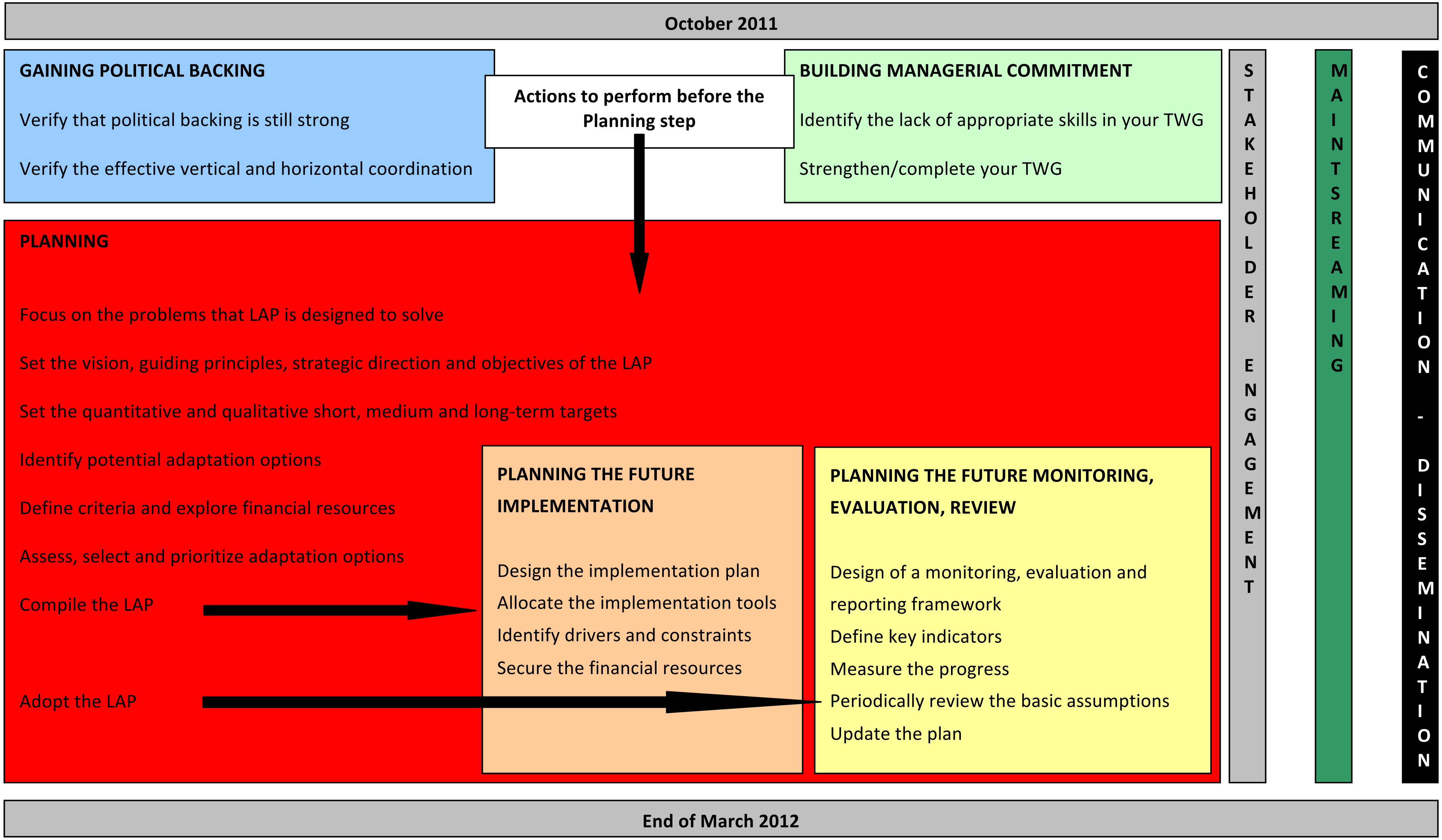

Figure 2 – Structure, tasks and recommended actions of the Road Map towards the Local Adaptation Plans.

Gaining political backing

Political backing could change during time, for several reasons. Before start activity it is therefore necessary to verify if it is still strong.

Climate change is a multi-dimensional problem of global scale, but its impacts locally and at all social, economic and political spheres. Political leaders, bu decision-makers should be aware that climate change will very likely keep on gc the next decades. Thus, they should take responsibility for building long-term ca and ecosystems to adapt to climate change.

Providing consistent policies throughout society is therefore increasingly import multi-level arrangements. This creates the additional challenge of vertical coc various governance levels involved and the horizontal coordination among s Effective coordination is vital in order to deliver a successful LAP. As an importa co-ordination, better communication between levels of governments and effe provision may help to prevent conflicts and ineffectiveness. Coordination is e departments within the same level of government (e.g. within local author between vertical levels (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UN

	**DO** • **Verify that political backing is still strong local, regional and national level** • **Verify the effective vertical and horizontal**

Table 2 – Gaining political backing: next steps.

Building managerial commitment

The assessment results have pointed out several problems in the three mur problems were already well known by the local community, others were just ass also new problems for the community have emerged thus requiring new techn the adaptation team.

In fact, up to now the team leader and the Technical Working Groups of each r conducted the local impact assessment. In some cases, the necessary technical lacking at this level. Therefore, making sure that before the planning step t adequately strengthened will be vital. The Technical Working Group will be thu with a cross-section of representatives from the relevant departments in such a v the adaptation efforts.

Where needed, the working group may include not only in-house experts, t experts in climate change adaptation (Ribeiro M. et al., 2009; ICLEI; Snover A UNDP, 2004).

	**DO** • **Identify the lack of appropriate skills in team** • **Strengthen/complete your TWG in orde with the problems emerged in the assessı** • **Consider the decision-making culture of y** • **Work in partnership with stakeholders**

Table 3 – Building managerial commitment: next steps.

Planning

The outcomes of the Local Impact Assessment should have identified the priority areas of intervention. Lack of data and models, but also scientific uncertainties, have sometimes limited the implementation of the assessment. However, action should be taken despite limits and uncertainties, as both limits and uncertainties will remain at least in the next future.

Once identified risks and opportunities that climate change will pose to the respective community, and therefore the problems that your LAP is designed to solve, you will be ready to establish a strategic direction, define guiding principles for a climate resilient municipality and set the objectives of the LAP. The objectives will vary from one community to another based on a number of factors, including type and magnitude of projected climate change impacts and vulnerability features. Quantitative and qualitative targets will be required, both for the priority systems/sectors emerged from the previous actions and the systems/sectors currently considered as secondary. Systems and sectors which are not considered as vulnerable today, may start to be rapidly affected in the next future.

Also time horizon will be taken into account and short, medium and long-term targets should be defined. Setting the objectives will provide essential structure to the next stages, by identifying exactly what the municipality wants to accomplish in building the resilience of its community.

Adaptation actions are the activities that the local government will undertake to achieve its objectives. Planning concrete adaptation actions will allow to set out what actions each council section and/or partner will take, what the realistic timetable for action will be, who is responsible for delivery and what mechanisms will be used to report progress and to revise the plan over time. At this stage, a candidate list of possible adaptation actions will have to be prepared and the appropriateness of different actions will be evaluated on the basis of a number of criteria (e.g.: cost-effectiveness or cost-benefit). Such criteria will help guide the selection and prioritization of specific actions you will decide to put into practice.

Once adaptation options have been selected, the adaptation plan can be compiled. This stage should effectively engage stakeholders in order to maximise understanding and acceptance of the plan. This is considered a key element to a successful plan.

Even if implementation is successive to this step, the task of ensuring sufficient financial resources needs to be addressed earlier in order to explore if these resources are able to verify if environmental targets are achieved at the minimum possible cost and cover administrative and organizational demands of the projects. Finding the resources to implement the Plan can be challenging and may take some time. It may be possible to allocate some resources while the Plan is being prepared, but in other cases sourcing new funds or reallocating resources may need to be considered in the implementation phase (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UNDP, 2004).

	**DO** • **Focus on the problems that LAP is designed to solve** • **Set the vision, guiding principles, strategic direction and objectives of the LAP** • **Set the quantitative (priority sectors/systems) and qualitative (other sectors/systems) short, medium and long-term targets** • **Identify potential adaptation options and develop a catalogue of a wide range of options** • **Define criteria for the selection of the best adaptation options and explore the financial resources for the implementation of the Plan** • **Assess, select and prioritize adaptation options** • **Compile the Local Adaptation Plan** • **Adopt the Local Adaptation Plan**

Table 4 – Planning: next steps.

A successful LAP will prepare the ground for the successive steps: implementation and the monitoring, evaluation and reporting. The most relevant elements to be focused on before the adoption of the Plan are therefore illustrated in the following paragraphs.

Planning the implementation

In order to finalize the selected actions, the implementation will be drawn on the basis of a variety of existing and new tools. In this phase it may be important to involve all those who will likely be responsible for implementation of the Plan. Many of the tools used to implement adaptation actions are legislative, regulatory and/or fiscal that governments use in its day-to-day operations.
Implementing the adaptation actions is not a one-time event. Many actions will need to be implemented in phases; some of them may take years or decades to be implemented. Finally, securing continued support over time will be a critical element of implementation.
It is essential to agree the resources that will be made available to implement the action plan. This step may be initiated when the Plan is being finalised, but is also likely to continue into the implementation phase (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UNDP, 2004).

	**DO** • **Design the implementation plan** • **Allocate the implementation tools** • **Identify drivers and constraints for the implementation of adaptation options** • **Secure the financial resources for the implementation of the Plan**

Table 5 – Planning the implementation: next steps.

Planning the monitoring, evaluation and review

The purpose of monitoring, evaluating and reviewing the plan 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 you to keep up to date with climatic, scientific and technological developments.
In fact, adaptation, to be continually effective, will need to evolve with changing internal and external circumstances and as such, should be approached as a continuous improvement process. Climate and socio-economic scenarios will continue to change as will risks and/or aversions to those risks. As such, the viability of an adaptive response will need to be periodically reassessed and improvements to existing measures or additional/alternative measures implemented in light of these changes. This continuous improvement process provides an opportunity to incorporate lessons learned through implementation and living with previous adaptation efforts, including those undertaken by others, as well as technological innovations and increased scientific understanding (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UNDP, 2004).

	**DO** • **Design of a monitoring, evaluation and reporting framework** • **Define key indicators against which success will be measured** • **Measure the progress** • **Periodically review of the basic assumptions** • **Update the plan**

Table 6 – Monitoring, evaluation and review: next steps.

Stakeholder engagement
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.
The main players may include local development authorities, public administrations, environmental agencies and central-level and local-level bodies responsible for the coordination and implementation of relevant policies, local communities, private sector organisations, labour unions and non-governmental organisations (NGOs). All the actors will have a role to play in supporting the development of the Local Adaptation Plan and facilitating the integration of adaptation at the regional level.
Stakeholders must be consulted at the appropriate stage in the design of the plan. The involvement of stakeholders will be essential in designing the project, determining the analytical approach to be used, evaluating candidate policies and measures, continuing the process and communicating results of the efforts.
The results of assessment have identified systems and sectors that would be increasingly affected by the foreseen impacts of climate change. As a consequence, people and groups who would be increasingly affected by these impacts, either positively or negatively, as well as those who have a role in influencing adaptation, should be involved.
For this purpose, relevant stakeholders selected from the vulnerable sectors emerged from the Local Impact Assessment, will be involved in order to form the Local Adaptation Board, the body in

charge of defining the Local Adaptation Plan. The Board should be composed by institutional and technical representatives, in order to have all the skills and capacities around the table.
Once the Board is set up, a Local Capacity Building should be organized, in order to facilitate knowledge and skills transfer gained in the previous actions from the Technical Working Group to the whole Board. In this way, the members of the Local Adaptation Board will be able to gain the necessary skills for developing the Local Adaptation Plan.
Together, the project leader and the Adaptation Board will initiate a process for evaluating the viability of the proposed adaptation strategies and identifying key areas for further action (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UNDP, 2004).

	**DO** • **Involve the main local stakeholders, in particular the most vulnerable and make use of their local knowledge and expert judgement** • **Establish/complete the Local Adaptation Board** • **Organize the Local Capacity Building** • **Share the strategic direction, the objectives, the targets and the needs of the community with stakeholders** • **Agree a preferred short list of adaptation options with stakeholders** • **Share the Draft of the Local Adaptation Plan with stakeholders**

Table 7 – Stakeholder engagement: next steps.

Mainstreaming climate change adaptation within existing plans, policies and programmes
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).

	**DO** • **Identify key actors for mainstreaming adaptation into sectoral policies** • **Establish tools and strategies for the integration of adaptation into existing and future strategies, plans, policies and programmes**

Table 8 – Mainstreaming climate change adaptation: next steps.

Communication and Dissemination
Clear and effective communication, together with stakeholder engagement, is the best mean for overcoming the barriers emerging in the adaptation process. A communication and dissemination plan should allow to pave the way towards a successful adaptation process.
Sharing your results publicly will help the community see that your actions achieve the desired results. In addition, disseminating the story of the experience and lessons learned trough a faster, complete and easy exchange and dissemination of information will provide evidence that the

actions deserve funding and political support from other levels of government (Ribeiro M. et al., 2009; ICLEI; Snover A. K. et al., 2007; UNDP, 2004).

	**DO** • **Design the communication and dissemination strategy and plan** • **Communicate your commitment to an ongoing adaptation effort** • **Launch your Local Adaptation Plan and share your results with the community** • **Disseminate the story and lesson learned trough a faster, complete and easy exchange and dissemination of information**

Table 9 – Communication and dissemination: next steps.

THE WAY FORWARD: GENERAL AND SPECIFIC RECOMMENDATIONS

Adaptation to climate change is a big challenge. The actions that the Local Plans will aim to define and implement shall be fit for the main adaptation objective:

making your community 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.
Despite these difficulties, some general recommendations aiming at a successful adaptation can be provided.

Work in partnership – identify and engage your community and ensure that it is well informed.

Frame and communicate Specific, Measurable, Achievable, Results-oriented, and Time-bound objectives – before starting out.

Manage climate and non-climate risks using a balanced approach – assess and implement your approach to adaptation in the context of overall sustainability and development objectives that includes managing climate and non-climate-risks.

Focus on actions to manage priority climate risks – identify key climate risks and opportunities and focus on actions to manage these.

Address risks associated with today's climate variability and extremes as a starting point towards taking anticipatory actions to address risks and opportunities associated with longer-term climate change.

Deal with uncertainties – do not use uncertainty as an excuse for not taking appropriate actions.

Mainstream adaptation into sectoral plans, programmes, decisions.

Explore a wide spectrum of adaptation options, including behavioural, technological, infrastructural, informational, organizational, ecosystem-based and socio-economic options.

Define adaptation measures that contribute to building adaptive capacity – by creating information (research, data collecting and monitoring, awareness raising), supportive social structures (organisational development, working in partnership, institutions), and supportive governance (regulation, legislations, and guidance) that are needed as a foundation for delivering adaptation actions – or **delivering adaptation actions** – actions that help to reduce vulnerability to climate risks, or to exploit opportunities.

Recognise the value of no/low regrets and win-win adaptation options in terms of cost-effectiveness and multiple benefits.

Avoid maladaptation – actions that foreclose or limit future adaptations or restrict adaptive actions of others, and may lead to harmful consequences in the medium and long-term perspective.

Review the continued effectiveness of adaptation decisions by adopting a continuous improvement approach that also includes monitoring and re-evaluations of risks (UK Climate Impacts Programme. *Identifying Adaptation Options;* Prutsch A. et al., 2010).

The outcomes of the Local Impact Assessment and their audits, together with the identification of the main knowledge gaps, needs and uncertainties affecting each municipality, have provided the basis for specific recommendations for the future adaptation process at local level. The wide number of knowledge gaps identified in all the three cases, points out a:

strong need of actions aiming at creating information and developing the knowledge base in order to strengthen and build the adaptive capacity of their natural and human systems.

BUILDING ADAPTIVE CAPACITY – Examples of actions
- *Scoping studies to identify the health risks associated to climate change*;
- *Conducting a risk-based assessment to evaluate potential impacts of climate change on specific habitats*;
- *Monitoring the impacts of observed climate*
- *Development of a monitoring and early warning system for forest fire;*
- *Disseminating relevant, up-to-date and accessible information on climate change and the measures requested to face its consequences;*
- *Promoting exchange and dissemination of information on climate change among governments, organizations, social groups and citizens*
- *Promoting information campaigns in schools by distributing interactive games, books, teaching guides.*

Table 10 – Building adaptive capacity: examples of actions.

Such type of actions will represent the foundation for delivering adaptation actions, which are actions that help to reduce vulnerability to climate risks, or to exploit opportunities (Table 11).

DELIVERING ADAPTATION ACTIONS – Examples of actions
Preservation of the biodiversity by avoiding the artificial homogenization of the landscape and the improvement of habitats and communities of the local biodiversity, by reducing habitats fragmentation and by increasing the connectivity among populations with particular attention to endemic or vulnerable taxa
Building climate proof infrastructure and systems;
Restriction of construction in areas particularly vulnerable to climate change;
Promotion of new agricultural crops and develop alternative land use consistent with climate (current and projected)

Table 11 – Delivering adaptation actions: examples of actions.

Bridging the gaps will be therefore among the common adaptation objectives that the three LAPs will try to address. Furthermore, for each municipality specific priorities could be pointed out.

ANCONA

- Focus on the medium-high vulnerability of some **cultural sites** and consider actions aiming at their preservation and/or restoration.

- Give priority to monitoring the large **landslide** of Ancona in order to get the triggering thresholds for the landslide displacement - it is in fact urgent and mandatory to verify the future sustainability of the current monitoring system.

- Focus on the results of the assessment of climate change impacts on **landslide risk** at municipal level, by paying attention, in particular, to the estimated increase in the population living in potential unstable areas.

- Promote more in depth studies in order to better analyse the impacts of current and future landslide on **infrastructure**, as well as the exposed elements to climate change risk.

- Promote studies concerning the **flood risk** at urban level associated to flash flood in order to verify the appropriateness of the drainage system and test the efficacy of the current disposal system.

- Focus on the need of tools for adaptation for **infrastructure**, such as sectoral studies and permanent observatories, in order to bridge the knowledge gap on management aspects, the dynamics of interaction between the development of port and climate change scenarios; to integrate the railway component and the development of indicators for the economic evaluation of investments and management costs for the infrastructure system.

- Address the need of tools and models required for the assessment of **coastal erosion** at local level for the next decades.

BULLAS

- Promote studies for **agriculture** concerning the climate influences on grapevine phenology, grape composition, and wine production and quality;

- Address the need of tools and models required for the assessment of climate change impacts on local agriculture;

- Focus on the results of the assessment of climate change impacts on **tourism**, thus maintaining and/or improving tourist offer during the excellent and ideal climate conditions occurring in Spring and Autumn. Planning the development of tourism during Summer is not really suggested, otherwise adaptation measures should be taken into account in order to address an increasing discomfort during July and August.

- Focus on the results, and in particular on the **soil loss** recognized in the Segura Basin which is over the limit of tolerable erosion recommended by OECD (24,53 t/ha/year vs. 6 t/ha/year*). Certain farming system (soil-friendly practices) can help to achieve a better protection of soil resources, keeping land in good agricultural and environmental condition.

PATRAS

- Address the significant lack of knowledge about the vulnerability of **biodiversity** to climate change impacts in the Panahaiko mountain, by paying particular attention to ecotopes of special ecological value and to endemic, rare and protected flora species.

- Focus on the predicted increase in the **fire risk**, by giving priority to actions addressed to strengthen the adaptive capacity (i.e. early warning systems for fire risk) of the Panahaiko's ecosystems.

- Focus on the results of the assessment of climate change impacts on **tourism** and start taking into account the possibility of de-seasonalizing tourist demand over all the seasons that should maintain at least "acceptable" climate conditions.

- Address the increasing risk of climate change for **health**, by reinforcing the current adaptive capacity and optimizing the warning and surveillance systems for a better and faster response.

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