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**Climate adaptation at local level: characterising adaptation
options in Portugal**

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Mestrado em Ecologia e Gestão Ambiental

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2019

Acknowledgements

I could not have written this dissertation without the help of the following people, whom I wish to thank.

To Tiago Capela Lourenço, my advisor and former boss, for his encouragement, for all the fruitful discussions, and for his ability to share his encyclopedic knowledge of adaptation in a way that is both intelligible and captivating.

To João Pedro Nunes, my advisor, for his support and for all the pragmatic comments and good advice he gave me through the process of writing my dissertation.

To the current and former members of CCIAM. A special thank you to the constant support and motivation from Luís, Mário, Bruno, Andreia, Ângela, Sílvia, Ana Lúcia, Tomás, Marta, Ricardo, Ana de Jesus, Helena, and of course my advisors Tiago and João.

To the wonderful professors of the Masters in Ecology and Environmental Management, especially Filomena Magalhães and José Costa Lino.

To the ClimAdaPT.Local municipality officials for their work, with a special thank you to the ones I talked to during the early stages of my dissertation (when it was going in a different direction): Mariana Oliveira from Guimarães, Ana Lourenço and Inês Metelo from Lisbon, Pedro Conde from Seia, Margarida Frade and Sandra Pedro from Torres Vedras, Rosa Lopes from Coruche and Inês Rafael from Loulé.

To Bruno, Luís, Mário and Carolin, whose help and feedback I am very grateful for.

To my friends, who have always been wonderfully kind and supportive, especially Inês, Marta, Carolin, Ricardo, Rita Mendes, Rita Basto, Mara, Filipa and Jorge.

E como os últimos são os primeiros, o meu maior agradecimento (e na língua materna) é à minha Família, pelo amor e apoio incondicionais. Obrigada, Mãe, Pai, Lena, Margarida e Martinho. E aos meus queridos Avós, a quem dedico esta dissertação, obrigada por me ensinarem que nada se consegue sem trabalho.

Susana

Resumo (Português)

As alterações climáticas são um assunto cada vez mais importante e urgente. O aumento das emissões de gases com efeito de estufa e as alterações nos usos do solo causam mudanças profundas na atmosfera e provocam alterações nos padrões climáticos. As tendências atuais a nível global e regional, bem como as projeções climáticas para o futuro, apontam para um agravamento dos eventos climáticos extremos em todo o mundo. No contexto europeu, Portugal encontra-se particularmente vulnerável às alterações climáticas devido à sua localização, dado que o Mediterrâneo é a região europeia que enfrenta um maior número de impactos, e a Península Ibérica em especial tem sido alvo dos maiores aumentos de temperatura da Europa, estando projetado que estas tendências continuem a agravar-se. O aumento dos episódios de ondas de calor e dos incêndios florestais, a diminuição do volume de precipitação (com consequente agravamento das situações de seca) e a subida do nível médio das águas do mar têm causado impactos em Portugal e antevê-se que continuem a piorar no futuro.

Dada esta tendência que se verifica, é urgente atuar sobre as alterações climáticas através da mitigação (reduzindo as emissões de gases com efeito de estufa) e adaptação (evitando e/ou reduzindo danos e aproveitando as oportunidades que as alterações climáticas proporcionam). Estas duas formas de ação estão interligadas e são complementares, sendo ambas essenciais para lidar com as alterações climáticas e salvaguardar o futuro de ecossistemas, populações e atividades económicas.

Esta dissertação propôs a avaliação dos padrões de adaptação à escala local em Portugal. Os objetivos foram categorizar, padronizar e analisar as opções de adaptação de municípios portugueses, avaliar se existe uma ligação entre análise de risco, dados climáticos e adaptação, mapear o risco e a adaptação para eventos climáticos específicos, e induzir como o país se irá adaptar no futuro.

Como contextualização introdutória, analisou-se o estado-da-arte mundial, europeu e nacional em relação à adaptação, tornando o foco gradualmente mais local. Atualmente, existem vários instrumentos de adaptação a diferentes escalas. Portugal está bem encaminhado relativamente à adaptação, tendo 13 estratégias/planos a nível intermunicipal e 47 a nível municipal (EMAAC), com mais alguns a ser atualmente desenvolvidos, o que significa que a maior parte do continente e regiões autónomas está coberta por um ou mais instrumentos de adaptação.

O foco principal desta dissertação foram as 27 estratégias municipais de adaptação produzidas por técnicos municipais no âmbito do projeto ClimAdaPT.Local, que decorreu entre 2015 e 2016. Este projeto contou com o apoio de uma equipa científica e baseou-se numa metodologia específica denominada ADAM (Apoio à Decisão em Adaptação Municipal), que inclui a identificação de vulnerabilidades atuais e futuras, análise de risco, identificação e avaliação de opções de adaptação, integração nos instrumentos de gestão territorial, monitorização e revisão. Para uma análise mais objetiva das visões e intuições dos municípios, nesta dissertação as opções de adaptação foram classificadas em 21 clusters, de acordo com o seu âmbito e objetivos principais. Esses dados padronizados permitiram ter uma visão geral das tendências de adaptação em Portugal: prevenir cheias/inundações, poupar água, sensibilizar a população e os técnicos locais, adaptar as práticas agroflorestais e realizar monitorização são as principais ações que os municípios se propõem a implementar.

O tipo de adaptação mais comumente referido pelos municípios estudados é referente às opções não estruturais (*soft adaptation*), as quais dizem respeito a ações que não requerem intervenções físicas, podendo ser de gestão, políticas, sociais, entre outras, sendo um dos exemplos mais comuns a educação ambiental. 63% das opções elencadas pelos municípios incluem-se nesta classe. Esta tendência é

particularmente relevante já que as opções não estruturais são mais flexíveis em relação à incerteza e frequentemente acarretam custos de implementação menores do que ações que requeiram a construção de infraestruturas.

Na maioria dos casos estudados nesta dissertação não há uma correlação direta entre adaptação, dados climáticos e análise de risco, havendo apenas duas exceções: i) a correlação significativa (p -value $<0,02$) entre a área municipal ardida e a proporção de opções para prevenir/recuperar de incêndios florestais, o que demonstra que os municípios reagem aos fogos florestais de grande dimensão, procurando evitar que se repitam no futuro, ou seja, são mais reativos do que proativos no que diz respeito à forma como se adaptam a este tipo de evento climático; ii) a correlação (p -value $<0,10$) entre o risco futuro de seca e a proporção de opções para poupança de água, mostrando um certo grau de preocupação com a forma como as secas afetam uma multiplicidade de setores. Para todos os outros casos, embora os municípios estejam geralmente a adaptar-se aos impactos esperados, a proporção de opções de adaptação para lidar com uma vulnerabilidade específica não tem relação com a gravidade desse risco ou com o quão extremo o clima se está a tornar. Além disso, algumas vezes um risco específico não foi analisado, mas foram elencadas opções de adaptação para lidar com esse risco, ou, contrariamente, o risco foi analisado, mas não foram criadas opções para se adaptar ao mesmo.

O processo de adaptação é complexo e depende de uma multiplicidade de fatores difíceis de quantificar e avaliar, tais como as especificidades e prioridades dos municípios e os *backgrounds* e funções dos técnicos envolvidos. Em última análise, a estratégia tem de ser aprovada pela hierarquia superior no município, portanto a sua estrutura e decisões estarão também dependentes das agendas políticas e dos orçamentos alocados ou expectados.

Tendo em conta os resultados desta dissertação, foram induzidas algumas tendências futuras relativamente à adaptação às alterações climáticas em Portugal: i) espera-se que o aumento de estratégias intermunicipais seja baixo, uma vez que quase todas as comunidades intermunicipais já possuem atualmente uma estratégia; ii) o desenvolvimento de EMAACs será mais lento do que até agora, mas esta tendência poderá mudar caso surjam novas oportunidades de financiamento; iii) é expectável que a prevenção e recuperação de fogos florestais continue a ser um processo reativo num futuro próximo, a menos que haja uma mudança de paradigma no país; iv) nos próximos anos haverá uma crescente implementação de opções de adaptação, marcando a passagem das políticas à prática; v) os técnicos locais estarão cada vez mais sensibilizados e informados sobre a temática das alterações climáticas, estando mais seguros das suas escolhas e propostas de adaptação; vi) o processo de adaptação continuará a ser complexo e difícil de prever ou analisar, no entanto poderá ser mais eficiente do que atualmente se forem seguidas algumas recomendações.

Assim, tendo em conta a importância crescente da adaptação às alterações climáticas em Portugal, e por forma a contribuir para o aumento da eficiência do processo adaptativo ao nível local e regional, foi criada uma lista de recomendações: assegurar que as equipas que elaboram as estratégias são transdisciplinares, estão bem informadas e conscientes das bases científicas que suportam as suas decisões; assegurar que as estratégias intermunicipais são suficientemente abrangentes e detalhadas para que as problemáticas de cada município sejam abordadas; avaliar todos os riscos possíveis em contexto de alterações climáticas e assegurar que são listadas opções que permitam a adaptação a cada um deles; adotar um formato específico para os nomes das opções de adaptação, tornando-as mais objetivas; visitar o ciclo da metodologia ADAM periodicamente ao longo do tempo, atualizando cada um dos passos tendo em conta a situação atual e as projeções futuras.

Summary (English)

Climate change is an increasingly important and urgent issue. The rise in greenhouse gas emissions and the changes in land use result in deep changes in the atmosphere and cause shifts in the climatic patterns. The current global and regional trends and the future climate projections point to a worsening of extreme climate events across the world. In the European context, Portugal is particularly vulnerable to climate change due to its location. Increases in hot temperatures/heat waves and forest fires, decreases in precipitation volume and the rising sea level have been impacting Portugal and are projected to keep worsening in the future.

Given this current trend, it is urgent to act on climate change through mitigation (reducing the emissions of greenhouse gases) and adaptation (avoiding/reducing harm and taking advantage of opportunities that climate change provides).

This dissertation proposed the assessment of adaptation patterns at the local level in Portugal. The purpose is to identify trends and assess if there is a connection between risk analysis, climate data and adaptation.

As an introductory contextualisation, the state-of-the-art of the country regarding adaptation was analysed. Portugal currently has 13 adaptation strategies/plans at the inter-municipal level and 47 at the municipal level, with several more currently being developed, which means that most of the country is covered by one or more adaptation documents.

The core of this dissertation was the 27 municipal adaptation strategies that were developed by municipal officials in the scope of the ClimAdaPT.Local project, using a specific methodology that included risk analysis, with the support of a scientific team. To more objectively analyse the municipalities' views and goals, the adaptation options were classified into clusters, according to their main scope and objectives. This data allowed to have an overview of the adaptation trends: saving water, preventing flooding, raising awareness and adapting agricultural/forestry practices are the main actions the municipalities propose to implement.

The analysis showed that, for the majority of the cases, there is no direct correlation between adaptation, climate trends and risk analysis, with only two exceptions: i) significant correlation (p -value $<0,02$) between the municipal burnt area and the proportion of forest fire prevention/recovery options; ii) correlation (p -value $<0,10$) between the future risk of drought and the proportion of water saving adaptation options. For all the other cases, while the municipalities are generally adapting to the expected impacts, the proportion of adaptation options to deal with a specific vulnerability does not have any relation with how severe that risk is or how extreme the climate is becoming. Moreover, sometimes a specific risk was not evaluated, and there were adaptation options to address it, or oppositely the risk was evaluated but occasionally there were no options to adapt to it. The adaptation process is complex and depends on a multitude of factors such as the municipalities' specificities and priorities and officials' backgrounds. Since the methodology is cyclic, it should be revisited over time in order to ensure that adaptation responds to the pressing climate change issues in the municipality. Ultimately, the strategy must be approved by the higher hierarchy within the municipality, therefore the structure and decisions will also depend on what the political agenda is.

Finally, given the growing importance of climate change adaptation in Portugal, a list of recommendations was made with the purpose of contributing to the efficiency of the adaptation process at the local and regional level.

Palavras-chave

adaptação às alterações climáticas; eventos extremos; políticas de adaptação; impactos climáticos; análise de risco

Keywords

climate change adaptation; extreme events; adaptation policies; climate impacts; risk analysis

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List of abbreviations and acronyms

Acronym/ abbreviation	Full spelling
ADAM	Decision Support in Municipal Adaptation [in Portuguese, <i>Apoio à Decisão em Adaptação Municipal</i>]
AI	Aridity Index
APA	Portuguese Environment Agency [in Portuguese, <i>Agência Portuguesa do Ambiente</i>]
AR5	IPCC's Fifth Assessment Report
CAOP	Official Administrative Map of Portugal [in Portuguese, <i>Carta Administrativa Oficial de Portugal</i>]
CCIAM	Climate Change, Impacts, Adaptation and Modelling [research group]
cE3c	Centre for Ecology, Evolution and Environmental Changes [research centre]
CO ₂	Carbon Dioxide
COP	Conference of the Parties
EEA	European Environment Agency [when followed by the word "Grants", it means European Economic Area]
EMAAC	Municipal Climate Change Adaptation Strategy [in Portuguese, <i>Estratégia Municipal de Adaptação às Alterações Climáticas</i>]
ENAAC	National Climate Change Adaptation Strategy [in Portuguese, <i>Estratégia Nacional de Adaptação às Alterações Climáticas</i>]
EC	European Commission
EU	European Union
FCUL	Faculty of Sciences of the University of Lisbon
FPC	Portuguese Carbon Fund
GHG	Greenhouse gases
GIS	Geographic Information System
ICNF	Institute for Nature Conservation and Forests [in Portuguese, <i>Instituto da Conservação da Natureza e das Florestas</i>]
IPCC	Intergovernmental Panel on Climate Change
IPMA	Portuguese Institute for Sea and Atmosphere [in Portuguese, <i>Instituto Português do Mar e da Atmosfera</i>]
NUTS	Nomenclature of Territorial Units for Statistics [in Portuguese, <i>Nomenclatura das Unidades Territoriais para Fins Estatísticos</i>]
PDM	Municipal Master Plan [in Portuguese, <i>Plano Diretor Municipal</i>]
PIC-L	Local Climate Impacts Profile [in Portuguese, <i>Perfil de Impactos Climáticos Locais</i>]
PMAC AML	Lisbon Metropolitan Area Climate Change Adaptation Metropolitan Plan [in Portuguese, <i>Plano Metropolitano de Adaptação às Alterações Climáticas da Área Metropolitana de Lisboa</i>]
PMDFCI	Municipal Plan to Defend Forests Against Fire [in Portuguese, <i>Plano Municipal de Defesa da Floresta Contra Incêndios</i>]
PNAC	National Climate Change Programme [in Portuguese, <i>Programa Nacional para as Alterações Climáticas</i>]

PO SEUR	Operational Programme for Sustainability and Efficient Use of Resources [in Portuguese, <i>Programa Operacional Sustentabilidade e Eficiência no Uso de Recursos</i>]
ppm	Parts per million
QEPiC	Strategic Framework for Climate Policy [in Portuguese, <i>Quadro Estratégico para a Política Climática</i>]
RCP	Representative Concentration Pathway
SLR	Sea level rise
UNFCCC	United Nations Framework Convention on Climate Change
WWTP	Wastewater treatment plant

1. Introduction

1.1. Climate change: from global to local scale

Climate change is “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer” (IPCC 2014a).

The cause of such changes can consist of natural processes or, most relevantly since the industrial era, in anthropogenic changes. Anthropogenic climate change is caused by the emission of greenhouse gases (GHG) into the atmosphere and by changes in land use, which result in shifts in the climatic patterns (IPCC 2014a).

The concentration of the three main GHG¹ in the atmosphere is currently the highest of the last 800.000 years (IPCC 2014a). Carbon dioxide (CO₂) is the more important individual GHG (Cloy and Smith 2018) and the main sources of its emissions are the use of fossil fuels (oil, coal, natural gas) and deforestation. The average CO₂ concentration has already reached 400 parts per million (ppm), which corresponds to a 40% increase since the year 1750 (EEA 2017a), and this value keeps rising. As an example, for the week beginning on the 15th of September 2019, the average CO₂ concentration at Mauna Loa Observatory² was 408,50 ppm. In the same week, 1 year before, that value was 405,67 ppm, while ten years earlier it was 384,59 ppm (Figure 1.1) (NOAA 2019).

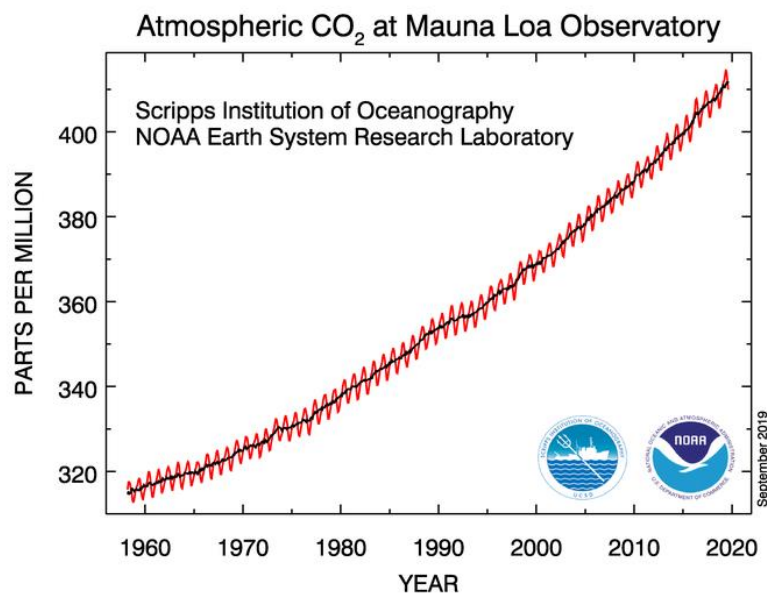


Figure 1.1. Carbon dioxide data, measured at Mauna Loa Observatory (NOAA 2019). The red curve represents the seasonal variation, while the black curve shows the seasonally corrected data

The increase in the global average temperature is the main expression of climate change, due to the change in energy flux (radiative forcing) caused at the top of the atmosphere (IPCC 2014a). Since the

¹ The three main GHG are CO₂ (carbon dioxide), CH₄ (methane) and N₂O (nitrous oxide) (Cloy and Smith 2018).

² Mauna Loa Observatory, in Hawaii, holds the longest record of direct measurements of CO₂ in the atmosphere (since 1958).

pre-industrial period, the global worldwide average temperature has already increased by approximately 1,0°C (IPCC 2018).

Global warming is not the only manifestation of climate change. Changes in the atmosphere cause sea level rise (SLR) and an increase in the frequency and intensity of extreme weather events such as heat waves, droughts, fires and extreme rainfall events (IPCC 2014a).

All these events cause vulnerabilities, many of which are difficult to assess. For example, food production is affected, water quality and availability decreases, biodiversity is pressured and disaster risk increases (Arnell and Gosling 2016; Rolim et al. 2017; Thom et al. 2017). In human systems, disadvantaged social groups are the ones with a lower ability to deal with the most severe climate impacts, which leads to increased exposure and creates a vicious cycle of inequality (UNDESA 2016).

Past trends and future climate change projections show a strong variability across the planet and impact regions and sectors differently (IPCC 2013, 2014b), with the possibility of the same area being affected by different hazards simultaneously (Mora et al. 2018).

Regarding Europe in particular, there is a very clear climate heterogeneity within the continent. South-eastern and southern Europe have the highest number of sectors and domains severely affected by climate change, thus being considered hotspot regions (EEA 2017a). The Mediterranean faces more impacts than any other European region, such as a large increase in heat extremes, expansion of habitats for southern disease vectors, increasing risk of forest fires and increasing water demand for agriculture, which combined with a decrease in precipitation causes a decline in water availability (Navarra and Tubiana 2013; EEA 2017a). Meanwhile, the decreasing rainfall and increasing evaporation results in a decrease in flood discharges for medium to large scale catchments and an increase for small ones (Blöschl et al. 2019).

The Iberian Peninsula has experienced the strongest warming in Europe, mainly in the summer season, while Central and north-eastern Europe also experienced strong warmings. These trends are projected to worsen in the future (EEA 2017a) (Figure 1.2).

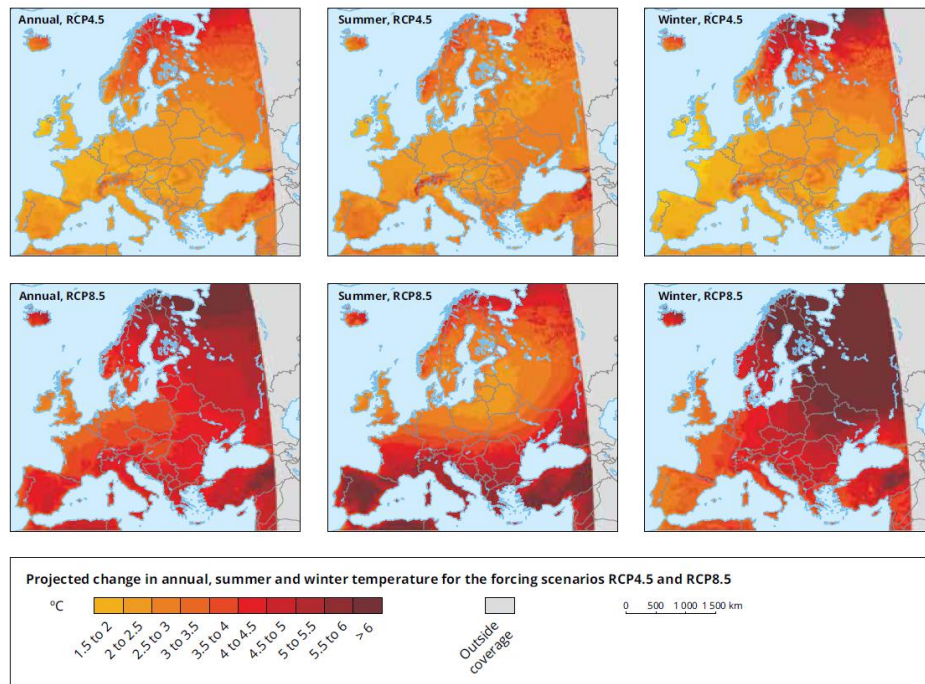


Figure 1.2. Projected changes in mean annual, summer and winter temperature in Europe for the forcing scenarios RCP4.5 and RCP8.5³ (EEA 2017a)

Because of its geographical position in the most southwestern part of Europe, Portugal is one of the most vulnerable European countries regarding the impacts of climate change (Santos et al. 2002). The temperature in Portugal is increasing (EEA 2017b); the annual mean precipitation has had one of the highest decreases in Europe since 1960 (EEA 2016); forest fires burn thousands of hectares every year and generate massive ecological and economic losses (RCM n.º 6-B/2015 2015); and the mean sea level keeps rising (Santos et al. 2002; Santos and Miranda 2006). The latest projections point to the worsening of these trends in the future, with an increase of 3,7°C in temperature⁴ (IPMA 2019a) and a decrease of 146mm in annual mean precipitation⁵ (IPMA 2019a) until the end of the 21st century.

1.2. Climate action – Mitigation vs adaptation

Climate change is considered a global issue (United Nations 2018), and the 13th goal of the United Nations' 17 Sustainable Development Goals consists of taking urgent action to combat climate change and its impacts (United Nations 2015a).

Given the threats and trends described above, it is urgent to act on climate change and reduce its cause, i.e. GHG concentration in the atmosphere. Mitigation consists of the decrease in the emission of those gases into the atmosphere. The countries that signed the Paris Agreement in 2015 committed to hold global warming to well below 2°C above pre-industrial levels and pursue efforts to limit warming to 1,5°C, with the purpose of preventing the most severe risks of climate change, particularly the

³ RCPs (Representative Concentration Pathways) are scenarios that take into consideration the concentration of GHG emissions, other compounds, and land use/cover, over time. The higher the change in energy flux (radiative forcing), the more severe/pessimistic the scenario is. In RCP4.5, radiative forcing is stabilized at about 4.5 W/m² after 2100. In RCP8.5, radiative forcing is above 8.5 W/m² by 2100 and continues to increase for some time (IPCC 2014a).

⁴ Calculations were made based on the difference (known as anomaly) between the yearly average of mean temperature for 1971-2000 and the most pessimistic future scenario (RCP8.5) for 2071-2100 in mainland Portugal.

⁵ Calculations were made based on the difference (known as anomaly) between the yearly average of accumulated precipitation for 1971-2000 and the most pessimistic future scenario (RCP8.5) for 2071-2100 in mainland Portugal.

irreversible ones (United Nations 2015b). However, current trends of GHG emissions show it is highly unlikely that these targets will be met, as the observed data is following the pattern of the most pessimistic future scenario (Sanford et al. 2014) (Figure 1.3). And even if there was a drastic reduction in the emissions of GHG, climate would continue to change and its effects would still increase in severity for a very long time, due to the climate system's characteristics of inertia⁶ (IPCC 2014a).

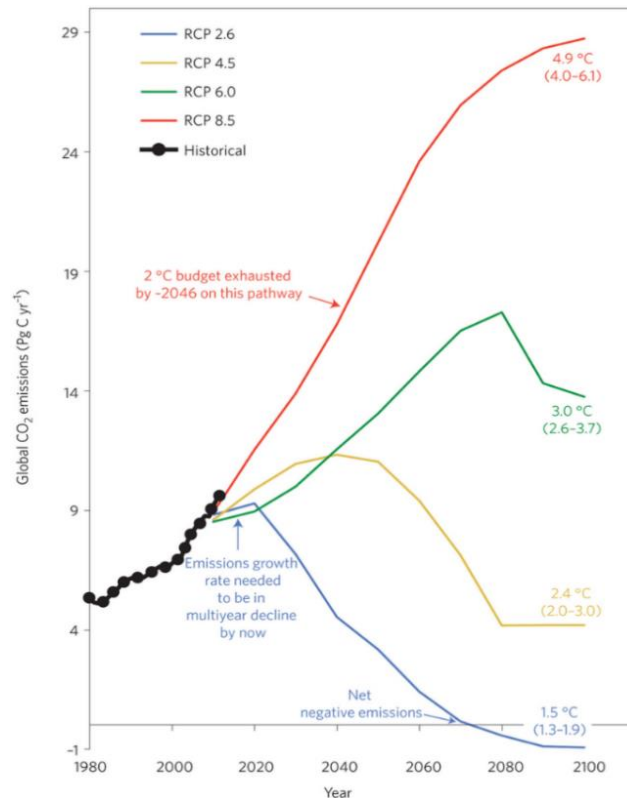


Figure 1.3. Observed and projected trends in global CO₂ emissions under four RCP scenarios (Sanford et al. 2014)

Therefore, to deal with the effects of unavoidable extreme climate events (and their environmental, social and economic impacts), it is necessary to act through adaptation. In human systems, the purpose of adaptation is to moderate or avoid harm (and costs) or take advantage of positive opportunities caused by climate change (IPCC 2014c). By taking preventive measures, many subsequent costs can be avoided. For example, the investment of 1 Euro in adaptation measures to prevent flooding can save 6 Euro in damage costs (Feyen and Watkiss 2011); and if the focus is on early warning systems, the investment-savings ratio can increase to over 1:400 (Pappenberger et al. 2015). Regarding natural systems, human intervention can help the system's adjustment to the effects of projected climate change (IPCC 2014c).

Thus, mitigation and adaptation are the two essential and complementary ways to tackle climate change (IPCC 2014a). They are strongly interconnected and often even overlap. For example, efforts like green infrastructure, building insulation and low-input agriculture are considered as both mitigation and adaptation (Winkelman et al. 2017).

As this dissertation focuses on climate change adaptation efforts, the following subtopics go more into detail regarding factors that should be taken into consideration when addressing adaptation.

⁶ An example of inertia in the climate system is how heat is transferred from the surface of the ocean to its depths, which causes a continuing warming of the ocean for centuries, no matter what the emission scenario might be.

1.2.1. Adaptation concepts

Since adaptation is a very broad topic, it is important to be aware of the concepts, approaches and terminology related to it, while keeping in mind that the frontiers between definitions are often tenuous. Below are some essential concepts in adaptation.

- *Strategies, options and measures*

There are different approaches and terminologies regarding strategies, options and measures in the climate change adaptation context.

An adaptation **strategy** can be seen as a specific approach or a goal, i.e. those that develop adaptation might have multiple different strategies (Gregg et al. 2018).

Another point of view regarding strategies is that they can be seen as a type of strategic planning that consists of guidelines to define a vision and goals, and allows for the analysis of vulnerabilities and risk, and for the definition of options or measures to adapt to climate change (Capela Lourenço et al. 2017). It is, in short, a document that comprehensively analyses the needs for adaptation and lists what actions should be done to address it. This definition is more complete and in line with the approach in the study area of this dissertation (Portugal), therefore this is what will be used from now on in this dissertation.

It is important to highlight that, whatever the approach is, strategies are key in helping practitioners to deal with – and prepare for – climate change impacts, reducing vulnerability and promoting resilience (Capela Lourenço et al. 2017; Gregg et al. 2018).

Regarding adaptation **options**, the IPCC defines them as “The array of strategies and measures that are available and appropriate for addressing adaptation. They include a wide range of actions that can be categorized as structural, institutional, ecological or behavioural” (IPCC 2018).

Going into more detail, it can be said that adaptation options are the result of operational planning, in which there is a selection between different possible adaptation actions through careful analysis and evaluation, in line with the knowledge and resources available (Capela Lourenço et al. 2017). This is the approach that will be used in this dissertation.

Adaptation **measures** consist of the specification and operationalisation of adaptation options, i.e., they are concrete actions that are taken in order to achieve the strategy’s goals. Measures can be objectively dimensioned and they are assigned a specific time and place (Capela Lourenço et al. 2017).

The concept of adaptation **plan** is often referred to in Portugal as a more operational document than a strategy. For example, a strategy aggregates options, while a plan would aggregate measures. However, in practice, the two concepts are used interchangeably and can almost be considered synonyms.

- *Uncertainty*

Uncertainty can be caused by insufficient information being available or from disagreements about already existing information (Capela Lourenço et al. 2014). This happens mainly because the cause of climate change, i.e. GHG emissions, cannot be precisely predicted or forecasted (Hallegatte 2009). These emissions depend on an unquantifiable number of variables and sectors (Cloy and Smith 2018).

Nowadays, climate projection models are becoming more robust and future trends can be identified. Although the gap between scientists and decision-makers is narrower than it was in the past, often the information provided by scientists is not usable by decision-makers due to diverging views on what is relevant, credible and usable (Porter and Dessai 2017), as well as a lack of clearly defined concepts and terminology (Capela Lourenço et al. 2014).

- *Barriers*

Three factors have been identified in the literature as being the main direct barriers for successful climate change adaptation (Biesbroek et al. 2013):

- The time span of climate change is much longer than that of politics and decision-making;
- The sole way to study and communicate climate change is through scientific models;
- There are always uncertainties and ambiguities inherent to climate change.

Governments can either enable adaptation across scales or act as a barrier to it, as often top-down approaches can reduce the possibility of local action (Biesbroek et al. 2013).

- *Proactive vs reactive adaptation*

Climate change adaptation can be autonomous or planned, proactive or reactive.

Autonomous adaptation (also referred to as “market-driven adaptation” or spontaneous adaptation) is a “response to experienced climate and its effects, without planning explicitly or consciously focused on addressing climate change” (IPCC 2014b).

Meanwhile, planned adaptation (also referred to as “policy-driven adaptation”) refers to intentional policy decisions made towards the maintenance or achievement of a certain state. These decisions are connected to the knowledge that there have been (or there are about to be) changes in the current conditions (IPCC 2007).

Anticipatory adaptation (also referred to as proactive adaptation) “takes place before impacts of climate change are observed” (IPCC 2007), while responsive adaptation (also known as reactive adaptation) involves acting only when certain climate impacts are experienced and their negative effects are realized (Yousefpour et al. 2017a).

Figure 1.4 shows a summary scheme of these concepts.

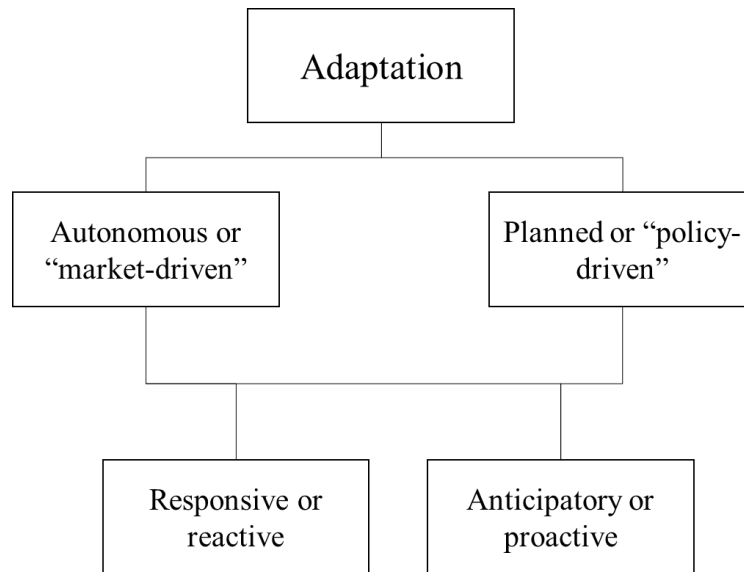


Figure 1.4. Types of climate change adaptation. Source: Own elaboration based on (IPCC 2007, 2014b; Bosello et al. 2009)

- *Economic*

There are different factors that influence how much is invested (both financially and on human resources) on climate change adaptation. Regarding the local level in particular, adaptation is only one in many issues faced by municipalities on a daily basis, so when decisions need to be made, often other issues seen as more relevant/urgent take the lead on the political agenda, such as health and education (Dannevig et al. 2013). This is even more common in low-income developing countries (Biesbroek et al. 2013), and there are studies that show that adaptation spend is more driven by the municipality’s wealth than by how vulnerable the population might be (Georgeson et al. 2016), which causes the more vulnerable communities to become even more at risk. Thus, it is important and urgent that the benefits of proactive adaptation – and the cost-reduction that comes with it – become more broadly known (Picketts 2018).

- *No regrets, low regrets, win-win*

According to the kind of benefits that they provide, adaptation options can be described as:

- No regrets: it makes sense to implement this kind of adaptation options regardless of climate change since they provide benefits under any kind of future scenario, even if the future’s uncertainty does not allow for a better-oriented policy action (Heltberg et al. 2009; Kundzewicz et al. 2018; Sanderson et al. 2018). These options are particularly beneficial because they provide immediate benefits and equip people with adaptation experience that can be further developed in the future (UKCIP 2007).
- Low regrets: this kind of adaptation options is similar to “no regrets”, but the benefits are primarily obtained under future climate change conditions (UKCIP 2007).
- Win-win: an adaptation option that has other positive outcomes besides the minimisation of climate risks. This might include social, economic or environmental benefits (UKCIP 2007). For example, when trees are planted to provide shade, they also contribute towards mitigation.

- *Categories of adaptation options*

Adaptation options can be categorized into green, grey and soft (EEA 2013; Climate-ADAPT 2017):

- ‘Green’ adaptation refers to nature-based actions and takes advantage of natural ecosystem services to increase adaptive capacity and resilience; natural systems should be regarded as an essential part of the solution – and not of the problem – to fight climate change (Leitner and Capela Lourenço 2019); river restoration and tree planting are two of the most common examples of *green* adaptation;
- ‘Grey’ adaptation actions consist of technological and civil engineering constructions – such as dykes or the improvement of water sewage within a city – which promote the adaptation of built systems, land and humans;
- ‘Soft’ adaptation actions do not involve physical interventions and consist of managerial, legal, social, financial and policy approaches that potentiate adaptive capacity and increase awareness about climate change; their non-structural nature means they are often cheaper to apply (Parry et al. 2009); two examples are environmental education and extreme weather warning systems.

Certainly, different types of adaptation actions can (and should) be combined for optimum results. For example, a retention basin to prevent floods might need ‘grey’ infrastructure to complement the ‘green’ adaptation.

1.3. The climate change adaptation context

This subsection of the Introduction is divided into six topics (systematised in Figure 1.5). The climate change adaptation reality is zoomed in, from the worldwide to the municipal Portuguese context.

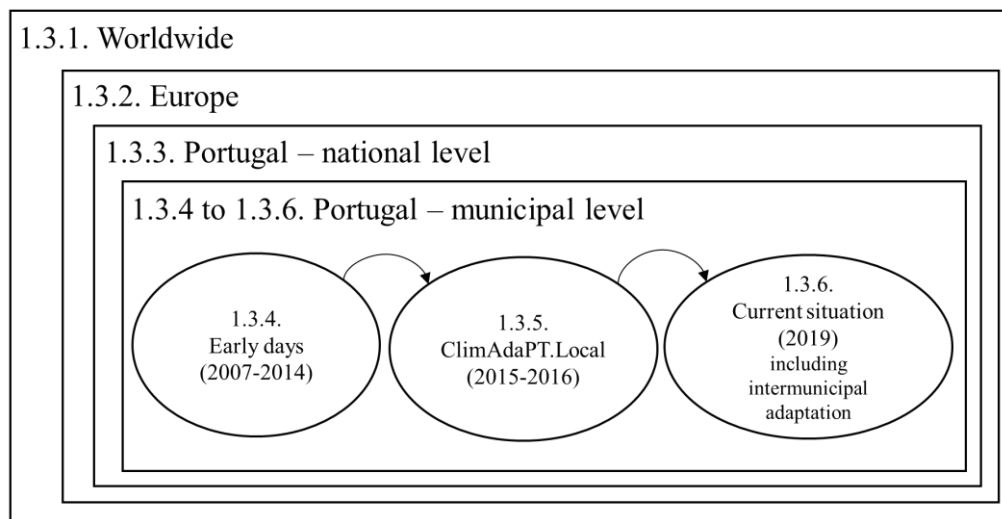


Figure 1.5. Systematisation of subsection 1.3 of the Introduction: The climate change adaptation context.

1.3.1. Worldwide

The climate change discussion in a major conference started in 1979 with the first World Climate Conference. Already at this early stage of climate change awareness, one of the urgent necessities pointed out by the conference was “to foresee and prevent potential man-made changes in climate that might be adverse to the well-being of humanity” (Zillman 2009). In 1988, the IPCC was formed and

two years later, together with the second World Climate Conference, they called for a global treaty on climate change (United Nations 2015c).

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty that was adopted in 1992 and entered into force in 1994. Its main objective is to stabilise the concentration of GHG in the atmosphere, so that “dangerous anthropogenic interference with the climate system” is prevented (United Nations 1992), in a time scale that is sustainable and realistic to avoid threats for the different systems (ecological, agricultural, economic, etc) (United Nations 1992). Although it is very focused on mitigation, the adaptation component is also highlighted in the listed commitments: “cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods” (United Nations 1992).

In 1995, the first Conference of the Parties (COP) was held, and these meetings have continued to happen yearly since then (United Nations 2015c, 2019a). One of the most important ones was COP21, which led to the Paris Agreement entering into force in 2016 (United Nations 2015b, 2019b). The Paris Agreement built upon the UNFCCC and, like the Convention, it addresses mitigation and the importance of reducing GHG emissions. However, the highlight on adaptation and its urgency is much stronger than before, coming hand-in-hand with mitigation and being perceived as equally crucial: “Parties recognize that adaptation is a global challenge faced by all with local, subnational, national, regional and international dimensions, and that it is a key component of and makes a contribution to the long-term global response to climate change to protect people, livelihoods and ecosystems” (United Nations 2015b).

The most current event regarding climate change at the time of the elaboration of this dissertation is the United Nations Climate Action Summit that will take place by the end of September 2019, which is particularly important due to the increasing urgency of the topic. The main purpose of this summit is “boosting ambition and rapidly accelerate action to implement the Paris Agreement” (United Nations 2019c).

1.3.2. European context

In 2013, the European Commission (EC) released a climate change adaptation strategy in order to encourage adaptation by EU member states (particularly in the most vulnerable sectors), while promoting knowledge for better-informed decision-making (European Union 2013). There are eight actions in which the strategy is based on, which include providing funding, bridging the knowledge gap and ensuring more resilient infrastructure (European Union 2013).

Five years after its publication, the EC released an evaluation of the strategy, which reflected on lessons learned and encouraged improvements for the strategy (European Union 2013; European Commission 2018; Sanderson et al. 2018).

1.3.3. National level adaptation in Portugal

Adaptation to climate change has increasingly gained prominence in Portugal since the beginning of this century. One key-moment for climate change adaptation at the national level happened in 2010

when the National Strategy for Adaptation to Climate Change (ENAAC) was approved (APA 2010), making Portugal a pioneer at the European level (RCM n.º 56/2015 2015).

ENAAC is currently in its second phase of implementation for 2014-2020, named ENAAC 2020 (APA 2015; RCM n.º 56/2015 2015). It is framed within the Strategic Framework for Climate Policy (QEPiC), which also includes the National Climate Change Programme for 2020/2030 (PNAC 2020/2030)⁷ (RCM n.º 56/2015 2015).

The ENAAC 2020 built upon the 2010 version while also improving and increasing its scope, promoting a better interaction between sectors, scales, communities and procedures (RCM n.º 56/2015 2015). The strategy envisions “a country that is adapted to the effects of climate change through the continuous implementation of solutions based on technical-scientific knowledge and good practices” (RCM n.º 56/2015 2015). Its main objectives are improving the climate change knowledge level, implementing adaptation measures, and promoting the integration of adaptation in sectoral policies (RCM n.º 56/2015 2015). ENAAC 2020 has defined a set of 9 priority sectors and six main thematic areas to help put the theory into practice (Figure 1.6).

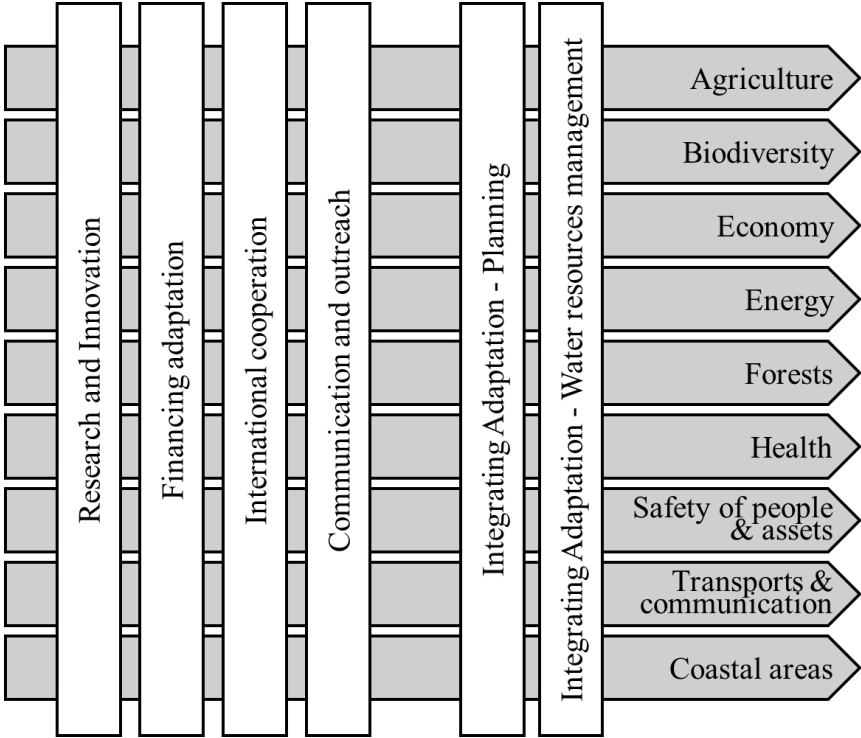


Figure 1.6. Thematic areas (vertical) and priority sectors (horizontal) in ENAAC 2020 (translated to English by this dissertation’s author) (APA 2015; RCM n.º 56/2015 2015)

The coordination of each thematic area is a shared task between the Portuguese Environment Agency (APA) – which is the general coordinator of ENAAC – and the entities that have specific competences in each of those themes. Regarding the priority sectors, each of them has a working group which is coordinated by the central government entity that has jurisdiction in the sector. For example, the Biodiversity working group is coordinated by the Institute for Nature Conservation and Forests (ICNF), while the Health working group is coordinated by the Directorate-General for Health (RCM n.º 56/2015 2015).

⁷ The PNAC 2020/2030 mostly addresses low carbon policies through a compilation of the already existing instruments (RCM n.º 56/2015 2015).

ENAAAC 2020 is having its final evaluation in 2020, after which a reviewing process will begin (RCM n.º 56/2015 2015).

1.3.4. The early days of municipal adaptation in Portugal (2007-2014)

Portuguese municipalities are very heterogeneous regarding the importance they give to climate change in their policy agendas (Campos et al. 2017), following Europe's general trend (Aguiar et al. 2018).

The municipal level action in climate change adaptation in Portugal started in 2007, when Almada presented its Local Strategy for Climate Change (Município de Almada 2007). Although this strategy was mainly focused on mitigation, it also mentioned key actions for adaptation.

A few years later, two municipal Strategic Plans for Climate Change were released: Sintra, in 2009 (Município de Sintra 2009), and Cascais, in 2010 (Município de Cascais 2017).

By the end of the year 2014, these were the only three adaptation documents in Portugal at the local level.

1.3.5. The ClimAdaPT.Local project (2015-2016)

ClimAdaPT.Local, a large-scale project, took place in 2015-2016 (ClimAdaPT.Local 2016). Its main objective was to support the development of municipal climate change adaptation strategies by the technicians of 27 Portuguese municipalities.⁸

At least two municipal officials from each municipality were engaged in the process since the beginning. This engagement of motivated and interested officials is crucial to achieving good results (Dannevig et al. 2013).

The municipalities involved in this project were selected based on geographical heterogeneity criteria. Those municipalities would have to be representative of the variety of the Portuguese territory, which includes socioeconomic diversity and vulnerability to different climate impacts (Penha-Lopes et al. 2016). At least one municipality per inter-municipal community (NUTS III⁹) of the Portuguese mainland was selected, as well as one municipality for each of the autonomous regions/archipelagos: Madeira and Azores (each autonomous region also corresponds to one NUTS III). Figure 1.7 shows the spatial representation of the 27 municipalities. The municipality list per NUTS II and III can be found in Annex I.

⁸ For information about ClimAdaPT.Local's funding, please refer to section 3 (*Framework*) of this dissertation.

⁹ The NUTS classification (Nomenclature of Territorial Units for Statistics) consists of a "hierarchical system for dividing up the economic territory of the EU". Its main objectives are to make European regional statistics more homogeneous and comparable, to analyse the regions in different scales, and to frame EU regional policies (Eurostat 2018).

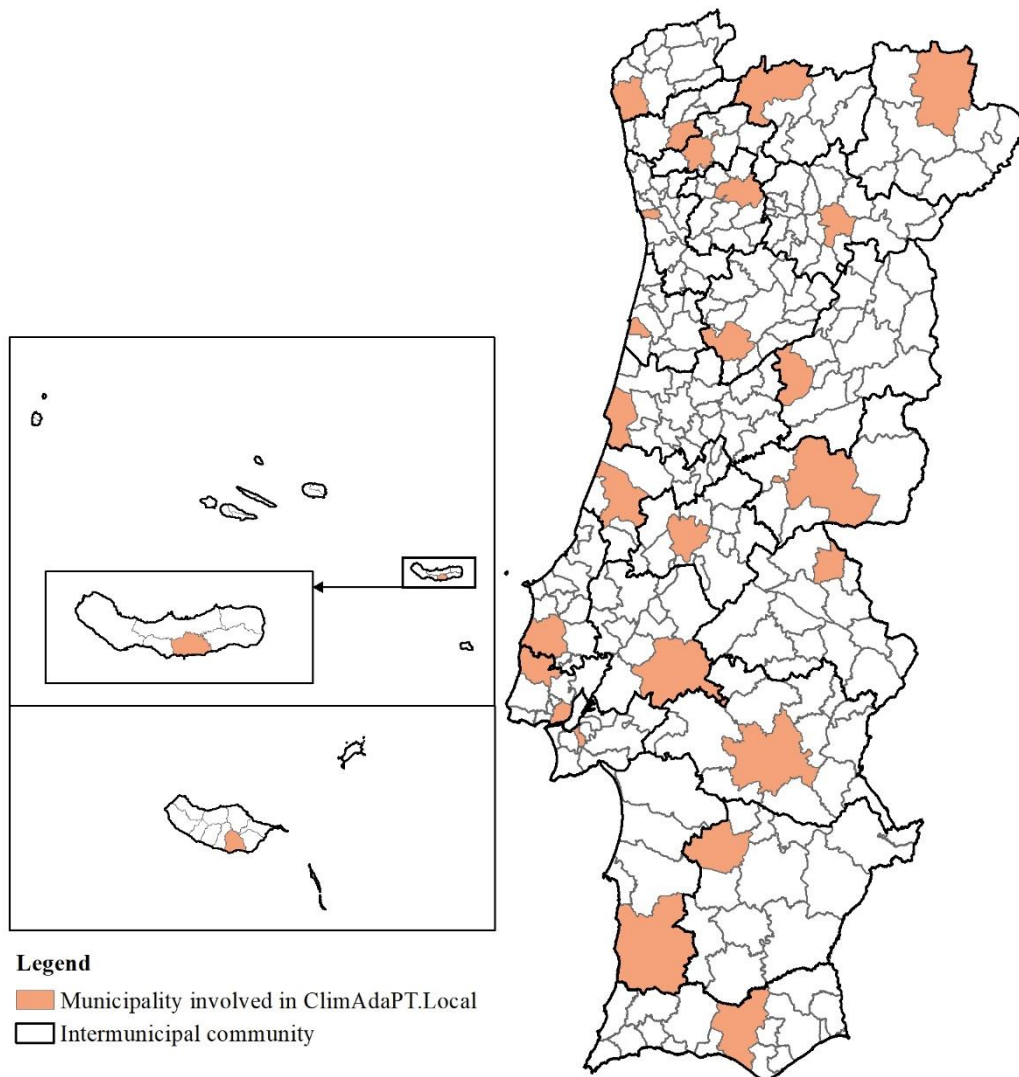


Figure 1.7. Map of the 27 municipalities involved in the ClimAdaPT.Local project and their respective inter-municipal community (which corresponds to the NUTS III). Top left: Azores, with zoom on the São Miguel island; bottom left: Madeira; right: mainland Portugal. Source: own work based on *ClimAdaPT.Local 2016*; *INE 2019*.

The methodology used in ClimAdaPT.Local was called **ADAM** (Decision Support in Municipal Adaptation) and resulted from a partnership between the Faculty of Sciences of the University of Lisbon and the UK Climate Impacts Programme (UKCIP)¹⁰ (Capela Lourenço et al. 2017). ADAM is a 6-step cyclic methodology in which each step builds upon the previous ones (Figure 1.8). This methodology was disseminated through training sessions between the scientific team and the municipal officials. Additionally, guidebooks were produced, which clarified each step and the rationale behind it, in a way that would allow ADAM to be replicated in other municipalities in the future (ClimAdaPT.Local 2016; Capela Lourenço et al. 2017).

¹⁰ The UKCIP (UK Climate Impacts Programme) is an institution from the Environmental Change Institute at the University of Oxford. It focuses on studying climate change and adaptation through the development of tools and partnerships, with the purpose of bridging the gap between science, politics and practical action. The UKCIP Adaptation Wizard consists of five subsequent steps that should be followed in order to adapt to climate change as thoroughly as possible (UKCIP 2013).

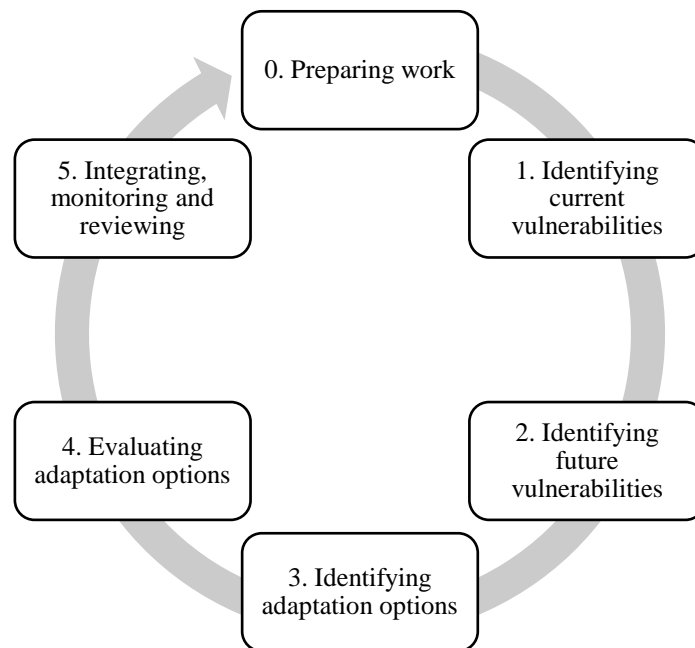


Figure 1.8. Conceptual scheme of the ADAM methodology, which was used to make the EMAACs during the ClimAdaPT.Local project

The ADAM methodology steps consist of:

0. Preparing work

The main goals of “Step 0” of the methodology are to ensure that municipal officers and technicians are prepared to start the process, namely through understanding why there is a need/motivation for adaptation in the municipality, what the EMAAC’s main goals will be, who will be part of the municipal strategy team and how the procedures will be organised (Capela Lourenço et al. 2017).

1. Identifying current vulnerabilities

In this first step, the municipal officers are expected to do research in order to identify the typology of climatic vulnerabilities the municipality was exposed to in the past. The sources for this information may include municipal databases/registries, civil protection information, news articles, etc. The information should be gathered in a Local Climate Impacts Profile (PIC-L), an Excel spreadsheet which works as a database and includes fields such as date of climate event, type of climate event, main impacts and details about the consequences, and which entities acted on it. This collection of information is particularly important to understand what were the most serious consequences experienced, where they took place, which actions were taken to deal with them and what the main knowledge gaps are (Capela Lourenço et al. 2017).

2. Identifying future vulnerabilities

After analysing the current vulnerabilities, the second step of the methodology focuses on future vulnerabilities. It is crucial in this step to have access to future climate projections, in order to promote a reflection on how future climate might affect the municipality and what the main changes are when compared to the current situation.

To better analyse and understand the evolution of risk in the municipality, a matrix evaluation was made for three time periods: current climate, medium-term future (2041-2070) and long-term

future (2071-2100). Each time period had an associated risk matrix, which incorporated two variables: frequency of the climate event's occurrence and consequence of the impact, each of which would be given a number between 1 and 3 (where 1 means low and 3 means high). The result of the multiplication of the two numbers would be the risk value for a certain climate event. The municipality would be responsible for evaluating the consequence of the impact, while a scientific team should provide the evaluation for the frequency of the event's occurrence based on climate projections. In the concrete case of the ClimAdaPT.Local project, that information was provided by the scientific team at the Faculty of Sciences of the University of Lisbon (FCUL). Figure 1.9 shows an example of the risk matrix, in which the green cell corresponds to a low risk of 1 (1×1) and the red cell represents a higher risk of 9 (3×3). The matrix is particularly useful to study which risks are to be given a higher priority in the municipality (Capela Lourenço et al. 2017).

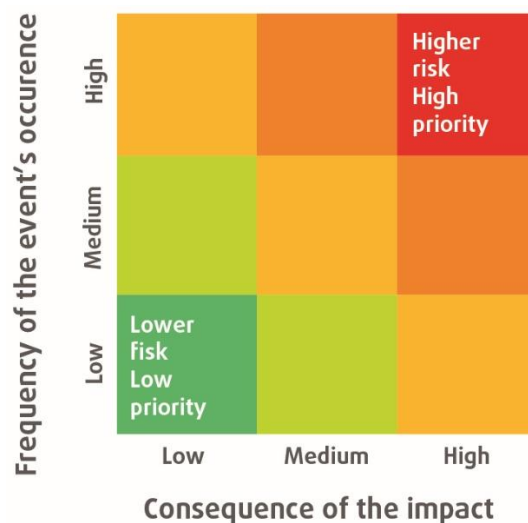


Figure 1.9. Risk matrix used in step 2 of the ADAM methodology

3. Identifying adaptation options

Step 3 is about identifying and describing a list of potential adaptation options that would make the municipality more apt to respond to the risks and take advantages of the opportunities identified in the previous steps of the methodology. The list of adaptation options should include a description of each option, its main objectives, potential barriers, key sectors and main actors related to it (Capela Lourenço et al. 2017).

4. Evaluating adaptation options

This step is closely connected to the previous one as its main goal is to evaluate the adaptation options listed before. Each option will be evaluated against a series of criteria: effectiveness, efficiency, equity, flexibility, legitimacy, urgency, synergies and costs. Each criterion should be given a score between 1 (low) and 5 (high), and the final average of the eight criteria for each adaptation option would determine where it sits on the ranking (Capela Lourenço et al. 2017). This evaluation should be made by several colleagues from different departments in the municipality in order to ensure that different backgrounds and areas of expertise are contributing to the strategy.

5. Integrating, monitoring and reviewing

The final step of the methodology is divided into two parts:

- Integrating the adaptation options into the municipal planning documents: it is important that the planning documents are aligned with the adaptation options, in order to make the adaptation process more straightforward. To make sure that is the case, those documents should be studied and their ability to respond to adaptation options (either strategic, regulatory, operational or regarding spatial governance) should be assessed (Capela Lourenço et al. 2017).
- Monitoring and Evaluation of the adaptation strategy: in order for the strategy to keep its usefulness within the municipality, it should be monitored and evaluated regularly. The methodology should not be perceived as inflexible, and the steps should be revisited as often as it is necessary to ensure that the latest relevant information is taken into consideration. (Capela Lourenço et al. 2017).

At the ClimAdaPT.Local project’s final conference, the Network of Municipalities for Local Climate Change Adaptation was founded, with 30 municipalities. The main objective of this network is to increase the Portuguese municipalities’ ability to integrate climate change adaptation action (Fórum das Cidades 2016). The network currently includes 32 member municipalities and 14 partner institutions (Adapt.local 2019).

1.3.6. Overview – current situation in Portugal (September 2019)

Currently, there are 47 EMAACs in Portugal and 18 others in development (Base 2019).

To add to the EMAACs, there are also inter-municipal strategies, corresponding to the NUTS III. Thirteen inter-municipal strategies/plans have been implemented and 8 are currently being developed (Base 2019).

The most recent years have witnessed a slower pace in the development of EMAACs (Base 2019) and a fast growth of inter-municipal strategies/plans, triggered by the Operational Programme for Sustainability and Efficient Use of Resources (PO SEUR) funds (PO SEUR 2016; Base 2019)¹¹.

Some municipalities do not have an adaptation strategy/plan per se, but are developing other actions, such as defining specific adaptation measures, raising awareness about climate change, developing working groups, integrating projects that are studying different municipalities, and installing weather stations to improve warning systems (disaster preparedness) (AdaptForChange 2017; Mais Algarve 2018; Base 2019; CLIMRisk 2019; Município de Montemor-o-Velho 2019; Município de Murça 2019; Município de Sabrosa 2019). These municipalities are represented in the map below in the category “Other studies”.

In short, the current situation regarding adaptation in Portugal is that a considerable area of the country is (or will soon be) covered by at least one climate change adaptation document (Figure 1.10) (Base 2019)¹².

¹¹ PO SEUR is a programme created to operationalise the Portugal 2020 strategy, which is a partnership between Portugal and the EC created with the purpose of promoting economic, social and territorial development in Portugal. With a strong focus on sustainability, this programme awarded Portugal with 25 billion Euro until the year 2020 (PO SEUR 2019).

¹² It is relevant to mention two uncommon situations: 1) although not all inter-municipal regions in the Alentejo have their own adaptation strategies, they are covered by a larger scale adaptation document: the Alentejo region adaptation strategy. 2) the inter-municipal region of Terras de Trás-os-Montes is subdivided into two smaller municipal associations, which are both creating their adaptation strategies, therefore it was considered that the intermunicipal region is creating its own adaptation strategy.

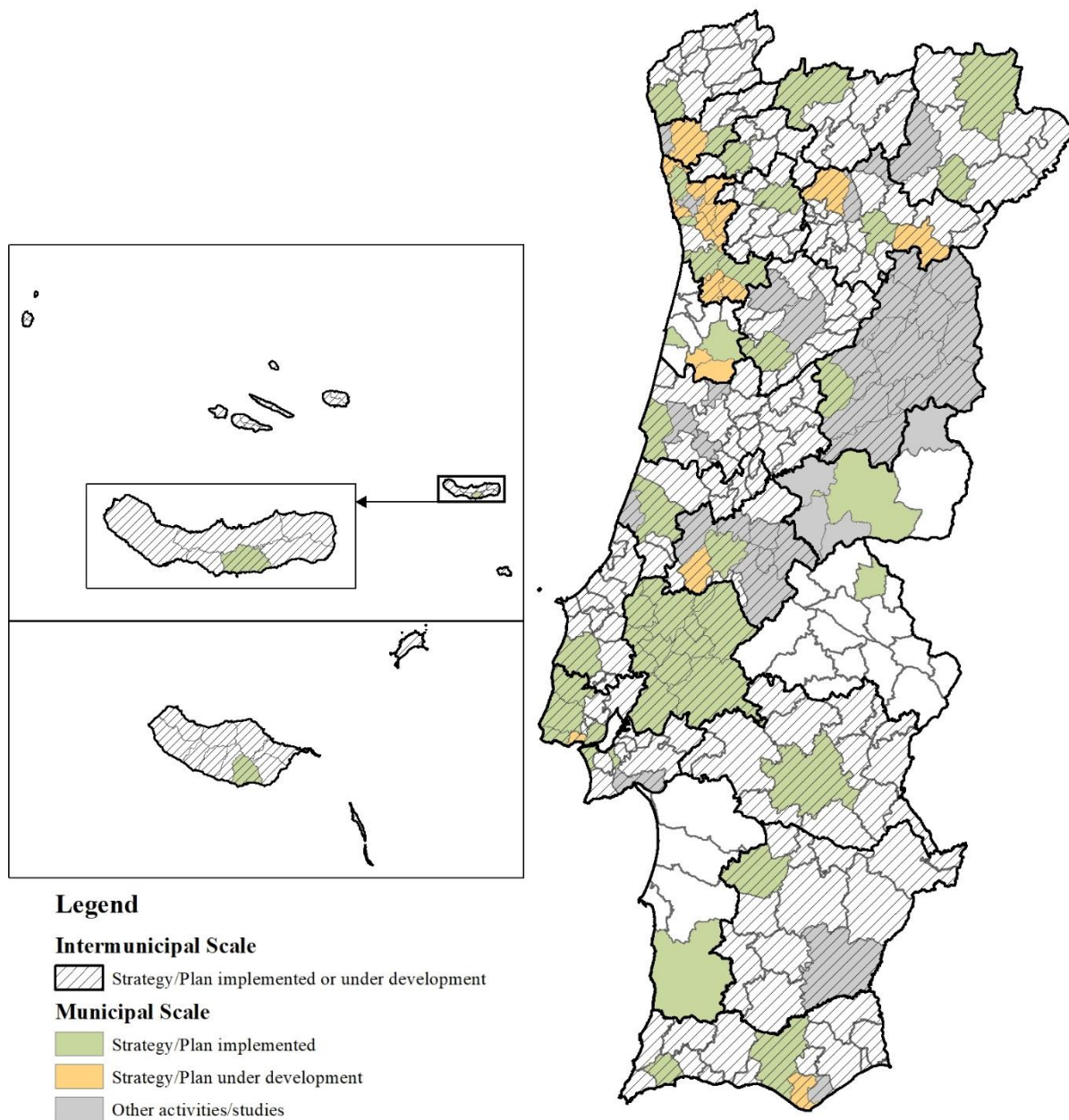


Figure 1.10. Current state of climate change adaptation plans/strategies at municipal and inter-municipal level for the Azores, Madeira and mainland Portugal. Source: own work based on Base 2019.

2. Objectives

The main goal of this dissertation is to improve the understanding of climate change adaptation at the local level in Portugal, through the identification of trends and types of adaptation options.

This goal was divided in four specific objectives:

- 1) Categorise, standardise and analyse the adaptation options of the 27 municipalities that participated in the ClimAdaPT.Local project, in Portugal;
- 2) Study the correlation between risk analysis, climate data and adaptation options within these 27 municipalities;
- 3) Map risk and adaptation for specific climate events affecting those municipalities;
- 4) Based on this sample, induce how the country might plan for adaptation in the future.

3. Framework

This dissertation was elaborated within the Master Programme in Ecology and Environmental Management, hosted by the Faculty of Sciences of the University of Lisbon (FCUL).

A substantial and essential part of the data collected for the elaboration of this dissertation was publicly available and resulted from the ClimAdaPT.Local project (ClimAdaPT.Local 2016). This project was a part of the AdaPT Programme (managed by the Portuguese Environment Agency (APA)). It was co-financed at 85% by the EEA Grants¹³ and at 15% by the Portuguese Carbon Fund (FPC) (Capela Lourenço et al. 2017).

The dissertation's author was directly involved in the ClimAdaPT.Local project through her research grant at the Climate Change, Impacts, Adaptation and Modelling (CCIAM) research group, which is part of FCUL's Centre for Ecology, Evolution and Environmental Changes (cE3c).

¹³ The European Economic Area Grants (EEA Grants) are funded by Iceland, Liechtenstein and Norway and their main goals are to contribute towards a more socially and economically equal Europe, and to strengthen the relations between the three funder countries and the 15 beneficiary European countries (EEA Grants 2019).

4. Methodology

The next three subsections (4.1 to 4.3) consist of a detailed description of the methodology used in this dissertation: analysing the adaptation options, correlations between variables and mapping risk and adaptation. Subsection 4.4 presents a schematic representation of the whole methodology.

4.1. Analysing the adaptation options

Starting off with the analysis of the ClimAdaPT.Local municipalities' adaptation options, the first step of the methodology included several actions that will be described in the subsections below: screening the adaptation options; initial mapping, standardising the options into clusters; discarding the least common clusters; and calculating absolute and relative frequencies.

4.1.1. Screening the adaptation options

A total of 653 climate change adaptation options were collected from the 27 municipal strategies created within the ClimAdaPT.Local project. No options were discarded at this point. The full list of adaptation options can be found in Annex II.

4.1.2. Standardising the options into clusters

Each municipality listed their adaptation options freely according to the ADAM methodology, which does not mention any specific rule on how to write and describe the options. This resulted in a variety of options written in different ways but that often have the same meaning. There was also a large difference regarding detail, with some options being more comprehensive than others.

Taking this into account, and in order to be able to analyse the adaptation options quantitatively, the first action to take was to standardise them, creating clusters that grouped similar options.

At first it was decided that, whenever necessary, one adaptation option could be included into two different standardised clusters, in order to preserve the main messages of that option. However, the use of that methodology meant that including each option in more than one cluster would artificially increase the number of adaptation options and the frequencies would not be possible to analyse. Therefore, it was decided that, in order to preserve the frequency of options, each should only be included into one standardised cluster - the main one, which often is the most specific one that mentions vulnerability to a specific kind of climatic event or is integrated into a specific sector.

Naturally, this categorisation meant the loss of information mentioned above. For a more detailed discussion about this, please refer to section 6 of this dissertation (*Discussion*).

After some changes in the standardised names and merges between similar options, the initial list of standardised clusters of adaptation options is represented on Table 4.2.¹⁴

¹⁴ For the full list of standardised clusters and their respective adaptation options view Annex III.

Table 4.1. Initial list of 24 standardised adaptation option clusters

#	Adaptation option cluster
1	Agroforestry practices
2	Aquaculture choices adaptation
3	Awareness-raising (general public)
4	Coastal management
5	Cold spell management
6	Disaster preparedness
7	Economic capacitation
8	Ecosystem protection
9	Energy efficiency improvement
10	Flood prevention
11	Forest fire prevention/recovery
12	Green areas improvement/increase
13	Heat wave management
14	Invasive species/pests management
15	Knowledge promotion (municipality officials and agents)
16	Land degradation prevention
17	Land use planning
18	Monitoring
19	Policy development/reviewing/implementation
20	Sustainable mobility improvement
21	Tourism promotion
22	Urban design improvements
23	Water saving
24	Water streams/aquifers sustainable management

A detailed description of each cluster of adaptation options follows below.

1. Agroforestry practices

This cluster of options relates to agricultural and forestry changes. It conveys a new attitude from the municipalities towards the new climatic reality, taking advantage of opportunities to produce new species that better deal with warmer temperatures, while also promoting the current native species that are more resilient to the effects of climate change and changing the urban paradigm by promoting urban gardens where inhabitants can grow their own crops.

Examples of pre-standardised adaptation options

Creating and promoting urban gardens; using autochthonous species on public gardens.

2. Aquaculture choices adaptation

This type of option was not included into any other cluster due to its distinctiveness. The need to study and promote aquaculture was mentioned due to the concern with the impacts of climate change in the fishing industry.

3. Awareness-raising (general public)

Given the urgent nature of climate change, it is crucial that the population is educated about it. Thus, this cluster includes every adaptation option that relates to awareness-raising and environmental education related to climate change issues. It might be targeted towards a specific age group, such as adults or school students.

Examples of pre-standardised adaptation options

Encouraging behavioural change; improving the residents' knowledge about climate change in general; improving the farmers' knowledge of best agricultural practices considering climate change; creating good-practice guides for the general public.

4. Coastal management

As a country with a proportionally large coastline, the Portuguese municipalities whose borders include the ocean are particularly concerned with coastal erosion and other damages that might arise from sea level rise and storm surge. This cluster relates to building protection infrastructures or restoring seaside ecosystems (dunes, beaches).

Also, with the seaside areas being threatened by these more intense climate events, it could be the case that the only way to avoid damage is to evacuate permanently from the more exposed locations. This cluster also gathers those adaptation options whose purpose is to retreat from vulnerable coastal areas.

Examples of pre-standardised adaptation options

Beach nourishment; dune restoration; creating breakwaters, ripraps and/or other kinds of coastal protections; relocating infrastructures situated in vulnerable areas.

5. Cold spell management

The climate projections for Portugal – and the World – point out to an increase in global mean temperatures and “it is virtually certain¹⁵ that, in most places, there will be more hot and fewer cold temperature extremes” (IPCC 2013). Even though the municipality officials were aware of this reality, they addressed the need to deal with snow and ice in a few adaptation options.

6. Disaster preparedness

This cluster includes all the adaptation options that involve being ready to deal with the impacts of extreme weather events, including the creation of warning systems or the improvement of already existing ones in the municipality. Those warning systems are described generally, being aimed at “extreme events” and covering more than one kind of climatic event.

Examples of pre-standardised adaptation options

Implementing a municipal warning system for imminent risk associated with extreme climatic events; improving the means to assist the most vulnerable groups in society (e.g. the elderly and the homeless).

¹⁵ According to the IPCC, the term *virtually certain* refers to a probability of 99–100% (IPCC 2013).

7. Economic capacitation

Europe's economy is negatively affected by climate change in a significant way (Du et al. 2017). This fact was reflected upon by the officials of some ClimAdaPT.Local municipalities, who listed options to adapt the economy to climate change, reducing weaknesses and taking advantage of economic opportunities.

Examples of pre-standardised adaptation options

Promoting the development of sustainable economic activities; improving insurances to take into consideration the climate change trends; complementing the municipal budget with external financial funding.

8. Ecosystem protection

This cluster is comprised of adaptation options that have the purpose of protecting the habitats, including specific vulnerable communities. References to climate change are scarce in this category and it can be argued that these options would be implemented even if climate change was not a reality, thus they are *no regrets* options (view subsection 1.2.1 of the Introduction: *Adaptation concepts*). Please note that options related to coastal management have their own specific cluster and are not included in this.

Examples of pre-standardised adaptation options

Protecting the cork oak forest; protecting areas with special botanic value; management of natural resources.

9. Energy efficiency improvement

Energy efficiency can relate to energy saving, acclimatisation, biomass (e.g. using green cuttings) and use of renewable energies. This cluster is very broad, as it includes options that can be categorised as both mitigation and adaptation.

Examples of pre-standardised adaptation options

Using biomass for energy production; using renewable energies; promoting energy/thermic efficiency in buildings.

10. Flood prevention

These are adaptation options that prevent flooding. Many of the options improve drainage systems, while some of the options mention the creation of a specific plan.

Examples of pre-standardised adaptation options

Creating flood management plans; avoiding construction near water streams, increasing the permeable areas; separating the sewage systems (wastewater/rainwater); improving/restoring the drainage network; creating retention basins.

11. Forest fire prevention/recovery

With the warming temperatures and the lower humidity levels, forest fires are expected to become more frequent in Portugal, and several municipalities express that concern with adaptation options that relate to forest fire prevention and dealing with impacts after a fire.

Examples of pre-standardised adaptation options

Operationalising the PMDFCI; inspecting mandatory fuel management zones.

12. Green areas improvement/increase

This is another example, like with *ecosystem protection*, in which references to climate change are scarce and it can be argued that these options would be implemented even if climate change was not happening, thus being *no regrets* options. This cluster consists of options to improve the greenery in the municipalities, which will help to deal with climate change in different ways, such as reducing the urban heat island effect, improving energy efficiency in the buildings and preventing flooding. However, since the municipalities rarely stated directly what the green areas' purpose regarding climate change adaptation was, they were included in this cluster and not in one of the others. They are also separate from *ecosystem protection* as in this case there was no direct reference to the biodiversity of ecosystems.

Examples of pre-standardised adaptation options

Using vegetation to increase the shade in urban areas; creating vertical gardens and green roofs; implementing green corridors.

13. Heat wave management

Given the warming trends in the world and in Portugal (please view the Introduction of this dissertation), the municipalities expressed concern about this, thus this cluster includes every adaptation option that directly mentions the increase in temperature and heat waves.

Examples of pre-standardised adaptation options

Contingency plans; improving warning systems for heat waves in particular; creating shade.

14. Invasive species/pests management

The increase in temperature is gradually creating better conditions for invasive species to occupy the habitats of native species, often competing with (and ultimately threatening) them. The municipalities show awareness and concern regarding the fact that the temperature increase might also potentiate the frequency and severity of vector-borne diseases and pests.

Examples of pre-standardised adaptation options

Creating and implementing a plan to tackle invasive species and pests; creating a database for monitoring invasive species.

15. Knowledge promotion (municipality officials and agents)

This includes every option that relates to the municipality's intentions in improving the knowledge of its officials or partners (like the civil protection), as well as in researching about how climate change is/will affect the municipality. This will improve the database/knowledge bank and thus make the municipality more prepared to deal with the expected effects of climate change.

It also includes the improvement of communication between different entities (municipal or not), in order to improve the overall knowledge of the technicians and officials who have to deal with the effects of climate change.

Examples of pre-standardised adaptation options

Improving municipal geographic information system (GIS) database; improving knowledge about the most vulnerable to climate change societal groups; improving communication between municipality officials; creating good-practice manuals for municipality officials.

16. Land degradation prevention

Although climate change is often not the only driver of land degradation, it can play an important role in it as damages in the soil can occur as a result of extreme climate events such as temperature increases, heavy precipitation and changing precipitation patterns (IPCC 2019). This cluster includes the adaptation options that were listed with the purpose of reducing the impacts of climate change in land degradation.

17. Land use planning

Land management strategies should be refined taking into consideration climate change and how important it is to adapt and mitigate (Hu et al. 2019). Some municipalities show concern for land use improvements. However, it is important to note that most of the land-use planning adaptation options listed could have been released in another kind of municipal action or plan, as they are often quite general.

Examples of pre-standardised adaptation options

Limiting construction in areas of high risk; reinforcing policies to improve environmental management and reducing abandonment; management of the multifunctionality of rural areas.

18. Monitoring

These adaptation options have at least one of three main purposes:

a) reviewing and monitoring the impacts of climate change. This often shows the municipalities' intention on continuing the work that was started with the ADAM methodology in the ClimAdaPT.Local project, in which the municipalities started their assessment of past climate impacts by listing them in a matrix, creating their PIC-L (please refer to subsection 1.3.5 of this dissertation, *The ClimAdaPT.Local project (2015-2016)*). This can also include monitoring climate variability and climatic events *per se* and can be used as an initial prospection to then develop warning systems;

b) monitoring biodiversity, aiming to understand how climate change affects different habitat components;

c) monitoring the already implemented adaptation options and strategies;

It was decided to integrate these kinds of options in this *monitoring* cluster instead of separating them because they are often interconnected.

Examples of pre-standardised adaptation options

Keeping the PIC-L up-to-date; monitoring the sanitary conditions of the trees; creating a plan for monitoring biodiversity in different scales; monitoring the coastline changes; monitoring the water cycle; monitoring the adaptation strategy.

19. Policy development/reviewing/implementation

This is the most theoretical of all clusters. Any adaptation option that requires the creation, review or implementation of a generic municipal programme or plan is included here.

Policies that affect a certain specific object area are not included in this cluster, as a way to better convey the municipalities' intentions. For example, an option to create a plan to prevent forest fires is categorised as *forest fire prevention/recovery*.

Examples of pre-standardised adaptation options

Improving planning in order to create better responses; defining protected areas; including climate change in plans and regulations.

20. Sustainable mobility improvement

This includes any adaptation option related to environmentally friendly mobility, either it be walking, cycling or using public transport. It is important to bear in mind that these are not adaptation options *per se*, as they do not help to deal with the impacts of climate change. They are actually mitigation options, as they reduce the municipality's emissions of greenhouse gases. However, it was decided to still analyse these options as they were frequently mentioned by the municipalities.

Examples of pre-standardised adaptation options

Improving the bicycle path network; creating pedestrian lanes.

21. Tourism promotion

This cluster includes the options that intend to take advantage of new touristic opportunities created by the warmer temperatures and the resulting balance between touristic seasons. For example, in Spring and Autumn the temperatures will be warmer (although not as warm as Summer), and this could potentiate those two seasons and spread tourism more evenly throughout the year.

Examples of pre-standardised adaptation options

Creating new touristic opportunities; attenuating the effects of seasonality in tourism.

22. Urban design improvements

Municipalities show a specific concern with the design of urban areas, as it can play an important role in how susceptible that area is to the effects of climate change.

This cluster does not include biodiversity measures within the city, like tree planting. Those are included in the cluster *green areas improvement/increase*.

Examples of pre-standardised adaptation options

Adapting precarious structures; giving tax benefits to those who adapt their dwellings to climate change; promoting good construction practices.

23. Water saving

With the increase in frequency and severity of droughts due to climate change, saving water is one of the municipalities' main concerns. The municipalities intend to make sensible use of water in every sector, from agriculture to green urban areas and industry, as well as to promote a conscious use among the general public and to better deal with drought episodes.

Examples of pre-standardised adaptation options

Reusing treated water; capturing rainwater for watering purposes; restoring the water supply system to minimize losses; minimising and optimising the watering in public gardens/parks; creating contingency plans for periods of drought.

24. Water streams/aquifers sustainable management

All the adaptation options that relate to the maintenance and management of water streams are included in this cluster. The main goal is to keep the rivers and streams (and other bodies of water) under healthy conditions even with the threats of climate change.

Examples of pre-standardised adaptation options

Restoring vegetation in water streams; cleaning water streams; limiting construction near vulnerable water streams.

4.1.3. Discarding least common clusters

It was expected that each cluster would have a very diverse range of options associated with it, with some clusters being more common than others. In order to only feature representative clusters in the analysis, it was decided to set a threshold: clusters that contain less than 1% of the total amount of adaptation options (i.e. the total sum of all municipality's adaptation options) were discarded. This means that "outlier options" are taken out of the analysis.

4.1.4. Calculating absolute and relative frequencies of adaptation options

After the standardisation of the option names, the next step was to find a way to compare municipalities.

As stated in the previous subsection, the ADAM methodology did not feature any specific rule on how to write the adaptation options. Besides the aforementioned consequences (differences in writing and in scale of the options), there are also substantial differences between the number of adaptation options listed in each municipality, which ranges between 10 (Odemira) and 52 (Porto). This difference can create difficulties in comparing the municipalities, therefore, it is a better alternative to analyse the relative frequencies of each kind of standardised adaptation option.

4.2. Correlations between variables

In order to assess if there was a relation between the adaptation options listed by the municipalities, the risk analysis, and the climate context (present and projected), different correlations were analysed. This involved selecting specific adaptation option clusters, gathering the risk analysis, gathering climatic data and finally calculating the correlations. These steps are described in more detail below.

4.2.1 Selecting specific adaptation option clusters

From the adaptation option clusters, five were chosen for this analysis. The reason behind this choice was to provide a direct relation to a specific kind of climatic event (that is worsened by climate change) and being connected to a specific kind of risk analysed by the municipalities. The pre-selected clusters can be found in Table 4.2.

Table 4.2. Selected adaptation options and climatic events they are directly connected to

Adaptation option cluster	Climate event it is connected to
Coastal management	Sea level rise
Forest fire prevention/recovery	High temperatures/heat waves
Flood prevention	Extreme precipitation/flooding
Heat wave management	High temperatures/heat waves
Water saving	Drought

4.2.2. Gathering the risk analysis

The risk analysis, corresponding to step 2 of the ADAM methodology (view subsection 1.3.5. of the Introduction: *The ClimAdaPT.Local project (2015-2016)*) was collected from the 27 EMAACs (ClimAdaPT.Local 2016), for the three time periods:

- Present
- Medium-term future (2041-2070)
- Long-term future (2071-2100)

The climate events whose risk analysis was gathered for this study are the ones listed above in Table 4.2, due to their direct connection to the adaptation option clusters.

The table with the municipalities’ risk analysis can be found in Annex IV.

4.2.3. Gathering climate data

In order to assess the relationship between adaptation clusters and climate impacts, it was necessary to collect climate data. The variables chosen had to be representative of the main concerns expressed by the municipalities and be directly linked to a specific climate event.

The past climate data taken from IPMA was the simulated historical data¹⁶ for the 1971-2000 30-year period. Future projections taken from IPMA were obtained through the RCP8.5 climate scenario for 2071-2100, which is the most severe future scenario.

Table 4.3 presents a summary of the climate data variables that were selected.

Table 4.3. Summary of the selected variables of climate data and their details

Climate data	Time period(s)	Source of data	Climate event it is related to	Reasons for selection
Aridity Index (AI)	1971-2000 & 2071-2100	(IPMA 2019b)	Drought	The AI is the ratio between precipitation (amount of water coming from rain) and potential evapotranspiration (potential losses of water to the atmosphere) (Rosário 2004; IPMA 2019b).
Maximum temperature	1971-2000 & 2071-2100	(IPMA 2019b)	High temperatures/ heat waves; wildfires	The maximum temperature is used to analyse high temperatures and heat waves. High temperatures are also one of the variables that influences fires, along with humidity, length of rain-free intervals and wind speeds (Jolly et al. 2015).
Maximum accumulated precipitation in 5 days	1971-2000 & 2071-2100	(IPMA 2019b)	Extreme precipitation/ flooding	This variable can be considered a flood indicator proxy, as it specifies the short-term precipitation intensity (Costa and Soares 2009).
Burnt area	Observed data (2001-2016)	(INE 2019)	Wildfires	The burnt area (in hectares) indicates the size of wildfires in each municipality per year.

The data from IPMA was downloaded through Portal do Clima in Network Common Data Form (netCDF), which consists of a set of libraries and formats used for creating, sharing and accessing scientific data (Unidata 2017). Then they were imported to ArcGIS where a raster layer was created and then converted to points. By intersecting this information with the Official Administrative Map of Portugal (CAOP) (DGT 2019), the mean was calculated for the points contained in each municipality, thus producing a value for each climate data variable, time period and municipality. An anomaly was

¹⁶ The choice of using the simulated historical data instead of observed historical data was due to the fact that bias correction was applied to the simulated data. Bias correction “is the correction of model output towards observations in a post-processing step” and thus it “narrows the uncertainty range of simulations and predictions” (Ehret et al. 2012).

then calculated (subtracting the historical data from the future projections), in order to identify future trends. This data can be found in Annex V.

Regarding the data from INE (Burnt area), the information collected did not require the use of ArcGIS because it was already separated by municipality. The data consisted of the yearly burnt area per municipality, for a time frame of 16 years (the maximum number of years for which data was available), and can be found in Annex VI. This information was then crossed with the municipality’s total area in order to create a percentage of burnt municipal area. After this, the higher value per municipality was selected.

The analysis was performed for the mainland Portugal municipalities. The two island municipalities (Funchal in Autonomous Region of Madeira and Vila Franca do Campo in Autonomous Region of the Azores) were not included in the analysis due to the lack of climatic data for these two municipalities.

4.2.4. Calculating correlations

Correlations consist of the degree of association between variables, which means that if data is correlated, a modification in one variable is associated with a modification in another variable (Schober and Schwarte 2018).

In the context of this dissertation, the purpose was to assess if there were correlations between a number of variables regarding risk analysis, adaptation and climate impacts. To do this, Spearman correlations were calculated. The Spearman Rank Correlation assesses monotonic relationships in small data series (relative variation through a ranking of the variables), which is more appropriate for the type of data analysed in this dissertation, since it can uncover ordinal associations between adaptation options and climate data/risk analysis, even when changes in the magnitude of these variables are not well correlated.

Table 4.4 summarises the variables studied.

Table 4.4. List of correlations studied

Variable 1 (adaptation option clusters)	Variable 2 (climate data and risk analysis)
% <i>Forest fire prevention/recovery</i> options	Maximum Municipal Burnt area (2010-2016) (%)
	Future risk for heat waves (2100)
% <i>Flood prevention</i> options	Maximum accumulated precipitation for 5 days anomaly (%)
	Future risk for flooding (2100)
% <i>Water saving</i> options	Aridity index anomaly (%)
	Future risk for drought (2100)
% <i>Heat wave management</i> options	Maximum temperature anomaly (%)
	Future risk for heat waves (2100)

Figure 4.1 presents a summary of the methodology for the correlation analysis.

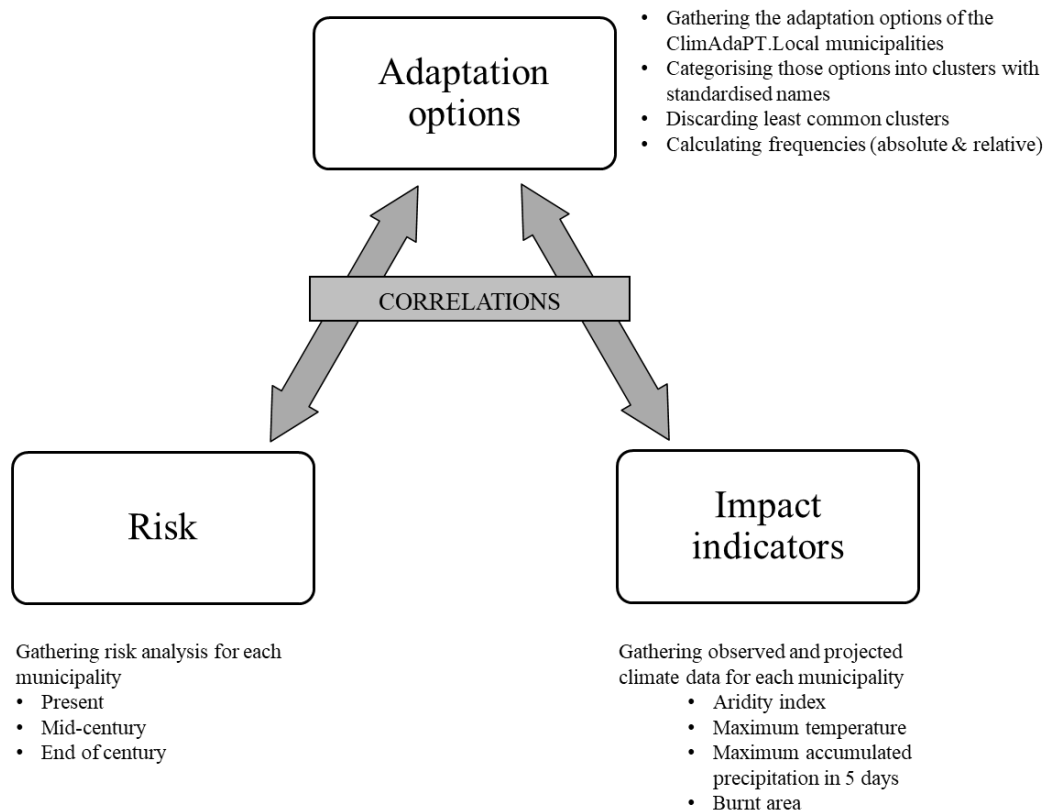


Figure 4.1. Schematic summary of the correlation analysis

4.3. Mapping risk and adaptation

Trends can be identified through the analysis of GIS maps, which helps to understand data in ways that a spreadsheet might not (ESRI 2019). Thus, by mapping and comparing risk and adaptation, the tendencies, choices and preferences of the municipalities become more evident.

The map used as a base for the visualisation of the data was the CAOP 2018 (DGT 2019) for mainland Portugal and the autonomous regions (Azores and Madeira), and the data consisted of the risk analysis for different climate events and the proportion of adaptation options to deal with each risk.

4.4. Methodology summary

The methodology shown in the previous subsections is summarised in a scheme in Figure 4.2.

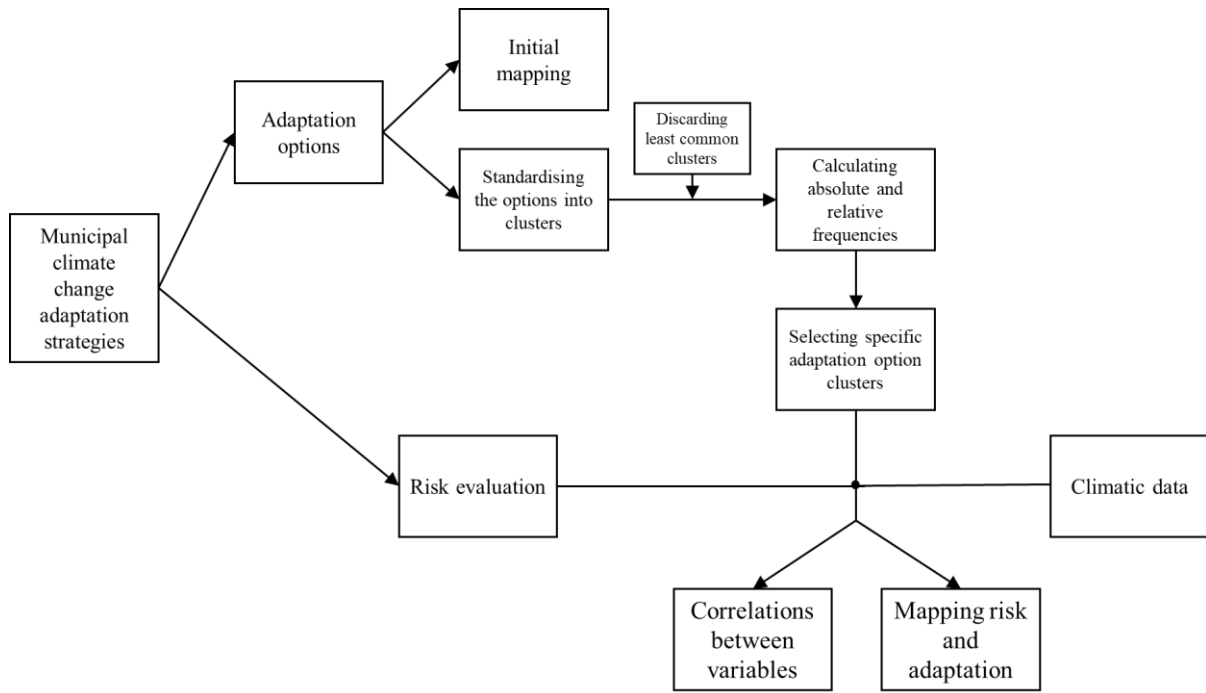


Figure 4.2. Summary of the methodology used in the elaboration of this dissertation

5. Results

5.1. Initial distribution mapping of adaptation options by type

The adaptation options were classified by the municipalities according to the *Grey*, *Green* and *Soft* categories (view subsection 1.2.1. of the Methodology: *Adaptation concepts*). This classification was cumulative, which means that each of the initial 653 options was included in one or more categories.

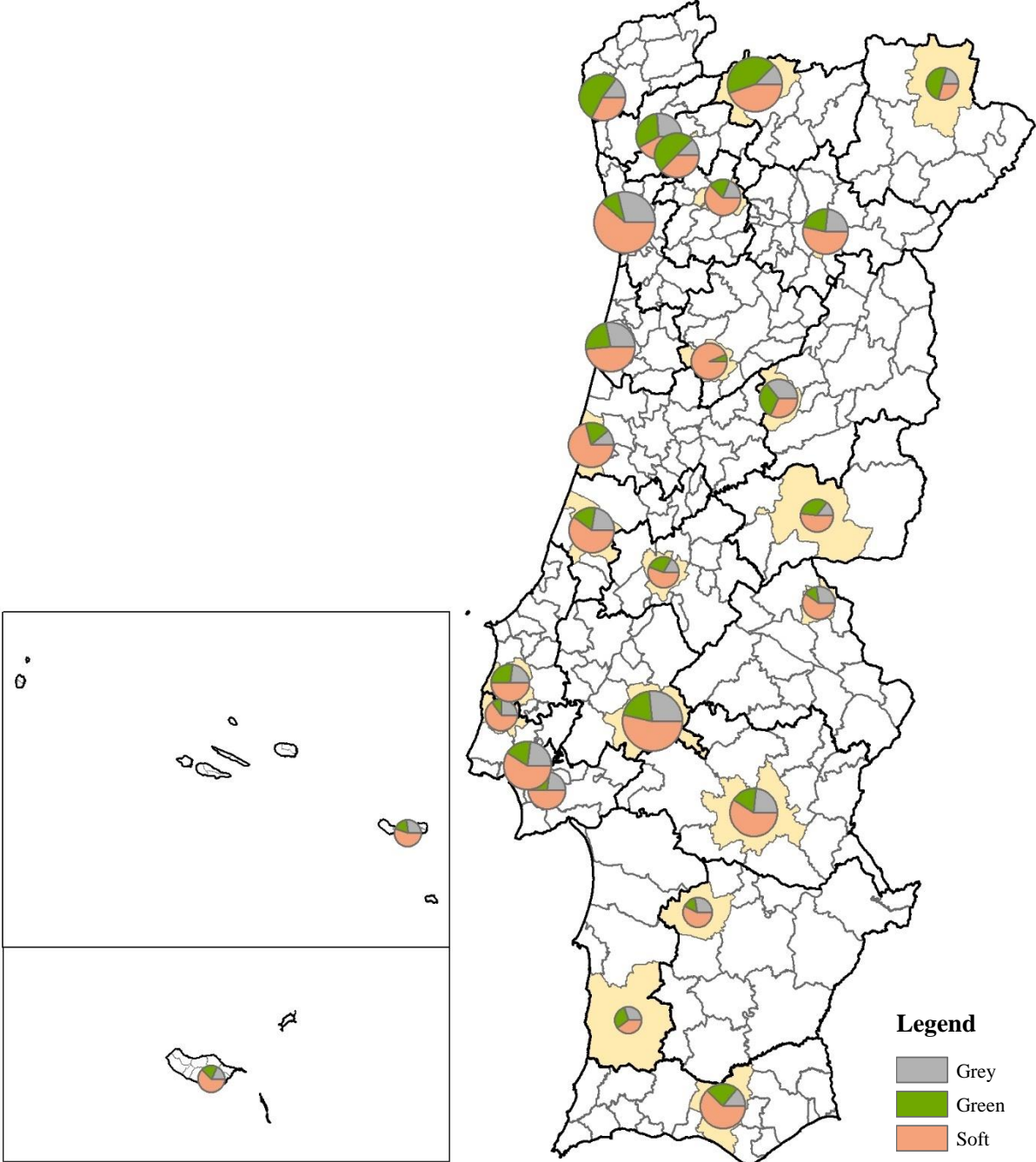


Figure 5.1. ClimAdaPT.Local municipalities' proportion of adaptation options according to their category (grey; green; soft). The size of each pie chart is proportional to the total number of adaptation options in each municipality. The light-yellow municipalities correspond to the 27 municipalities that created their EMAACs through the ClimAdaPT.Local project. Top left: Azores; bottom left: Madeira; right: mainland Portugal

By analysing Figure 5.1, it becomes evident that the soft adaptation options are the most common ones among the municipalities – this is the main category in 23 out of the 27 municipalities. There is also a very clear difference in the amount of adaptation options per municipality.

5.2. Initial list of standardised clusters

Each of the 653 adaptation options was standardised according to the methodology. Each of the “clusters” had between 1 and 61 individual options. Table 5.1 shows a list of the options and their respective count.

Table 5.1. Initial list of 24 standardised adaptation option clusters and respective option count for each one

#	Adaptation option cluster	Count
1	Agroforestry practices	48
2	Aquaculture choices adaptation	1
3	Awareness-raising (general public)	47
4	Coastal management	36
5	Cold spell management	2
6	Disaster preparedness	15
7	Economic capacitation	7
8	Ecosystem protection	10
9	Energy efficiency improvement	49
10	Flood prevention	56
11	Forest fire prevention/recovery	35
12	Green areas improvement/increase	22
13	Heat wave management	25
14	Invasive species/pests management	26
15	Knowledge promotion (municipality officials and agents)	46
16	Land degradation prevention	6
17	Land use planning	7
18	Monitoring	38
19	Policy development/reviewing/implementation	34
20	Sustainable mobility improvement	18
21	Tourism promotion	9
22	Urban design improvements	21
23	Water saving	61
24	Water streams/aquifers sustainable management	34
Total		653

5.3. Discarded clusters

As stated in the methodology, it was decided that clusters that contain less than 1% of the total amount of adaptation options would be discarded. The total number of options was 653, which means that 1% of the options = 6,53 options. Therefore, any cluster with 6 options or less was discarded from the analysis (Table 5.2).

Table 5.2. List of discarded clusters and respective count (number of adaptation options) for each one

Adaptation option (cluster)	Count
Aquaculture choices adaptation	1
Cold spell management	2
Land degradation prevention	6
Total	9

5.4. Final list of standardised clusters

The final list of standardised clusters consisted of 21 clusters, which are listed on Table 5.3.

Table 5.3. Final list of 21 standardised adaptation options and respective count for each one

#	Adaptation option (cluster)	Count
1	Agroforestry practices	48
2	Awareness-raising (general public)	47
3	Coastal management	36
4	Disaster preparedness	15
5	Economic capacitation	7
6	Ecosystem protection	10
7	Energy efficiency improvement	49
8	Flood prevention	56
9	Forest fire prevention/recovery	35
10	Green areas improvement/increase	22
11	Heat wave management	25
12	Invasive species/pests management	26
13	Knowledge promotion (municipality officials and agents)	45
14	Land use planning	7
15	Monitoring	38
16	Policy development/reviewing/implementation	34
17	Sustainable mobility improvement	18
18	Tourism promotion	9
19	Urban design improvements	21
20	Water saving	61
21	Water streams/aquifers sustainable management	34
	Total	644

5.5. Absolute and relative frequencies of adaptation options

The relative frequencies of each type of adaptation option were calculated for each of the 27 municipalities. Table 5.4 presents an excerpt of that table (whose full version can be found in Annex VII). The relative frequencies allow for a comprehensive analysis of the municipalities' choices. For example, 32% of the adaptation options listed by Ílhavo are for coastal management, while this municipality has no options for forest fire prevention/recovery.

Table 5.4. Excerpt from the table of relative frequencies created for the 27 municipalities and 21 standardised adaptation option clusters.

	Coastal management	Forest fire prevention/recovery
Bragança	0%	17%
Castelo de Vide	0%	20%
Ílhavo	32%	0%
Leiria	15%	4%
Mafra	15%	8%
Odemira	20%	0%
Porto	8%	0%
Seia	0%	30%
Tondela	0%	17%
Torres Vedras	21%	5%
Viana do Castelo	10%	10%

While some options are evenly distributed throughout most of the municipalities, other options are more common in specific municipalities.

Taking into consideration the proportion of adaptation options in the 27 municipalities, the average was calculated for each cluster, and the most common ones (> 5% average) are listed on Table 5.5.

Table 5.5. Most common options listed by the municipalities (proportionally)

Adaptation option	Average proportion of options per municipality
Flood prevention	10%
Water saving	9%
Awareness-raising (general public)	8%
Agroforestry choices adaptation	7%
Monitoring	7%
Knowledge promotion (municipality officials and agents)	7%
Energy efficiency improvement	7%
Forest fire prevention/recovery	6%
Policy development/reviewing/implementation	6%
Coastal management	6%
Water streams/aquifers sustainable management	5%

5.6. Climate data

Table 5.6 shows the maximum burnt area for each municipality considered in the study, between 2001 and 2016. The proportions vary between 0 and 35% of burnt municipal area.

Table 5.6. Maximum proportion of municipal area that was burnt in a year, for each of the 25 mainland Portugal ClimAdaPT.Local municipalities, between 2001 and 2016

Municipality	Maximum Burnt Municipal area (2001-2016) (%)
Amarante	12%
Barreiro	3%
Braga	7%
Bragança	2%
Castelo Branco	7%
Castelo de Vide	35%
Coruche	0%
Évora	2%
Ferreira do Alentejo	1%
Figueira da Foz	6%
Guimarães	5%
Ílhavo	0%
Leiria	9%
Lisboa	0%
Loulé	19%
Mafra	10%
Montalegre	5%
Odemira	7%
Porto	0%
São João da Pesqueira	2%
Seia	21%
Tomar	10%
Tondela	23%
Torres Vedras	1%
Viana do Castelo	24%

For the full climate data please refer to Annexes V and VI of this dissertation.

5.7. Correlations between variables

25 mainland municipalities (n) were considered in the correlation analysis. By consulting the critical values for the Spearman Rank Correlation Coefficient (Zar 1999), the p-value¹⁷ was found for each correlation, for a two-tailed test¹⁸.

The results for the correlation analysis can be seen on Table 5.7.

¹⁷ A level of significance (p-value) lower than, for example, 0,05 indicates that there is a less than 5% chance of the correlation being “accidental”.

¹⁸ A two-tailed test ($\alpha(2)$) uses not only the positive but also negative tails of the distribution, thus it can test if there are positive or negative differences.

Table 5.7. Results of the calculations of Spearman correlations

Variable 1 (adaptation option clusters)	Variable 2 (climate data and risk analysis)	Spearman correlation (r _s)	p-value
% <i>Forest fire prevention/recovery</i> options	Maximum Municipal Burnt area (2010-2016) (%)	0,4947	< 0,02
	Future risk for heat waves (2100)	0,0347	> 0,50
% <i>Flood prevention</i> options	Maximum accumulated precipitation for 5 days anomaly (%)	0,1732	< 0,50
	Future risk for flooding (2100)	-0,1109	> 0,50
% <i>Water saving</i> options	Aridity index anomaly (%)	-0,0955	> 0,50
	Future risk for drought (2100)	0,3458	< 0,10
% <i>Heat wave management</i> options	Maximum temperature anomaly (%)	0,1113	> 0,50
	Future risk for heat waves (2100)	-0,0904	> 0,50

The correlation between the maximum proportion of burnt area in a municipality and that municipality's proportion of *forest fire prevention/recovery* options has a p-value lower than 0,02, which means that this correlation is statistically significant. This is the highest correlation encountered (view Figure 5.2).

The correlation between the future risk of drought and the proportion of *water saving* adaptation options has a p-value just under 0,10, which is still notable.

The rest of the correlations are above (or in one case, slightly under) a p-value of 0,50, which is not so relevant.

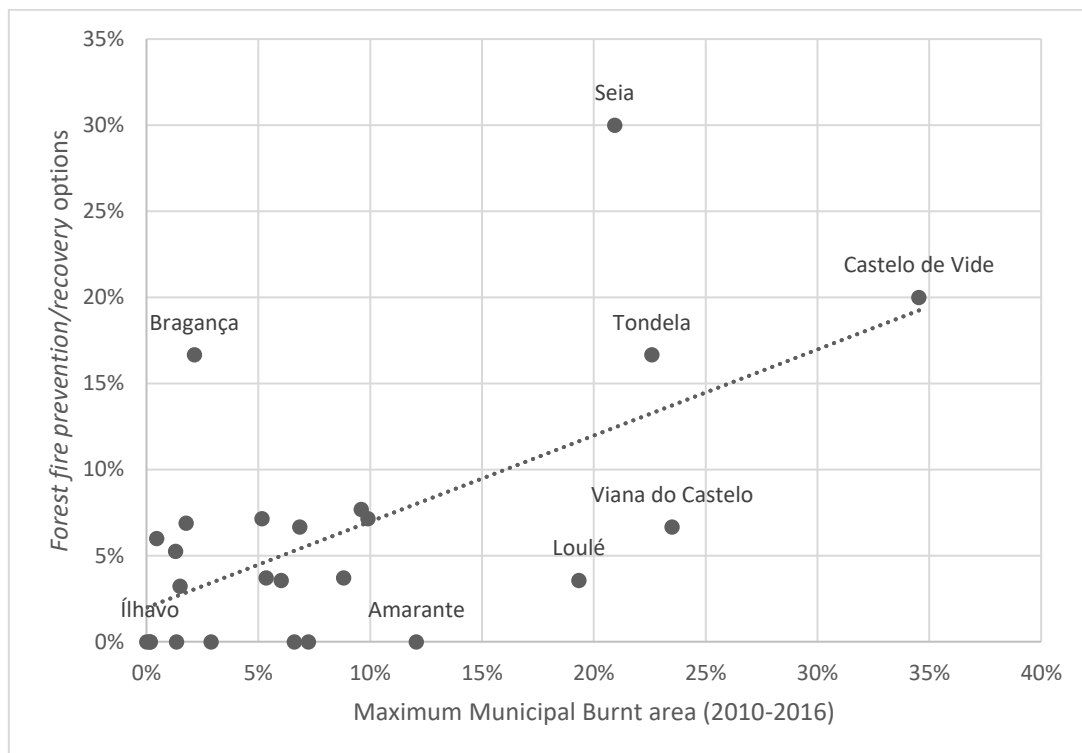


Figure 5.2. Scatter plot showing the highest analysed correlation, between the proportion of *forest fire prevention/recovery* options and the proportion of maximum municipal burnt area

5.8. Mapping risk and adaptation

The analysis through mapping provides many interesting insights about the municipalities' choices regarding adaptation.

Please note that, in the risk analysis mapping, the colour shades chosen are the same as the ones that were used in the ADAM risk matrixes (view Figure 1.9 of the Introduction), hence why risk levels of 3 and 4 have the same colour.

5.8.1. High temperatures/heat waves

Figure 5.3 shows the municipalities' risk analysis for high temperatures, as well as the proportion of options for *heat wave management* and *forest fire prevention/recovery*.

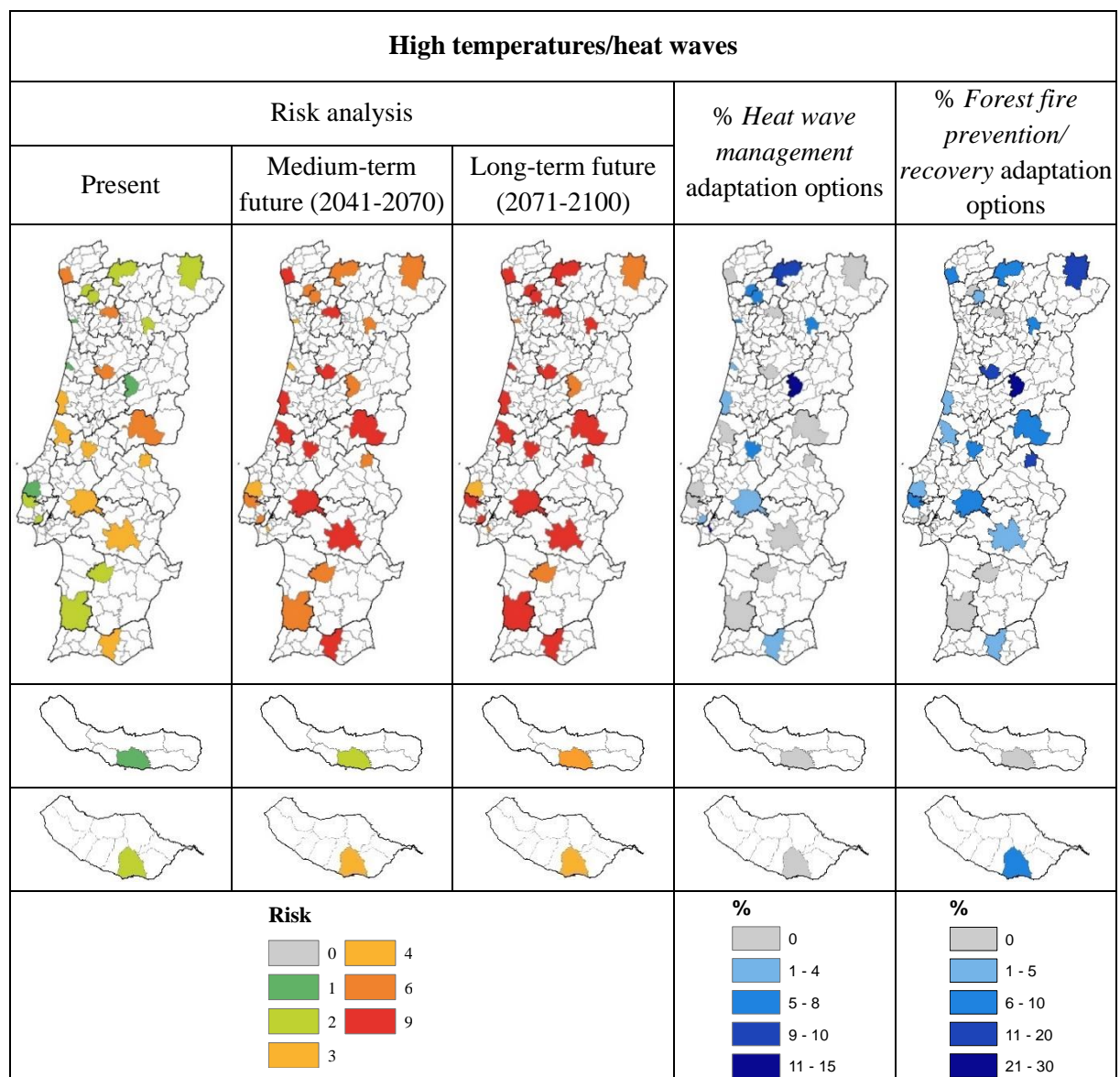


Figure 5.3. Mapping regarding high temperatures/heat waves for mainland Portugal, São Miguel island in the Azores and Madeira island. The first three maps from the left side correspond to the municipalities' risk analysis, while the fourth and fifth maps show, respectively, the proportion of adaptation options to deal with high temperatures/heat waves and to prevent/recover from forest fires, in each ClimAdaPT.Local municipality

All municipalities expressed a concern through their risk analysis. On average, the risk level for high temperatures/heat waves increased by 5 points between the present and the end of the century. There is no particular North-South or East-West gradient – it can be induced that this climate event triggers a generalized concern in the country as a whole, with 19 of the 27 municipalities in the highest risk level (9) by the end of the century, versus 0 in the present and 10 in the middle of the century.

Several municipalities that initially analysed the risk for high temperatures/heat waves did not identify any adaptation option to deal with them.

5.8.2. Forest fires

It is worth it to highlight the two variables that resulted in the best calculated correlation (view the previous subsection in the Results: *Correlations between variables*). Figure 5.4 shows the mapping of those two variables: maximum proportion of burnt area in each municipality and their proportion of forest fire prevention/recovery options.

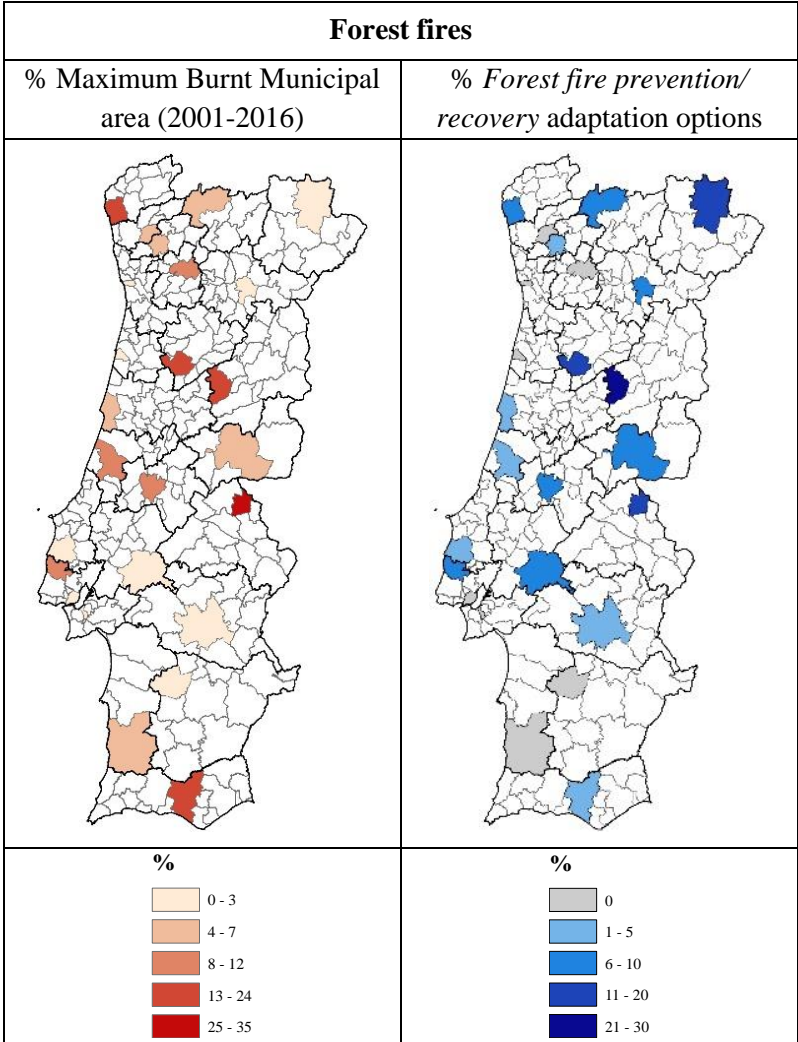


Figure 5.4. Mapping regarding forest fires for mainland Portugal. The first map from the left side corresponds to the maximum yearly proportion of burnt area in each ClimAdaPT.Local municipality between 2001 and 2016, while the second map shows the proportion of adaptation options to prevent/recover from forest fires, in each municipality

By comparing the maps side by side, it is interesting to note that in a few situations, although there have been forest fires in the recent past, the municipalities haven't shown a specific concern with them in their adaptation options. However, the correlation is clear – albeit not very strong – between these two variables: several of the municipalities with a larger burnt area are also the ones with more options to deal with forest fires. The municipalities of Castelo de Vide and Seia are two good examples of this correlation.

5.8.3. Extreme precipitation/flooding

Regarding extreme precipitation/flooding, Figure 5.5 shows the mapping of the municipalities' risk analysis, as well as the proportion of options for *flood prevention*.

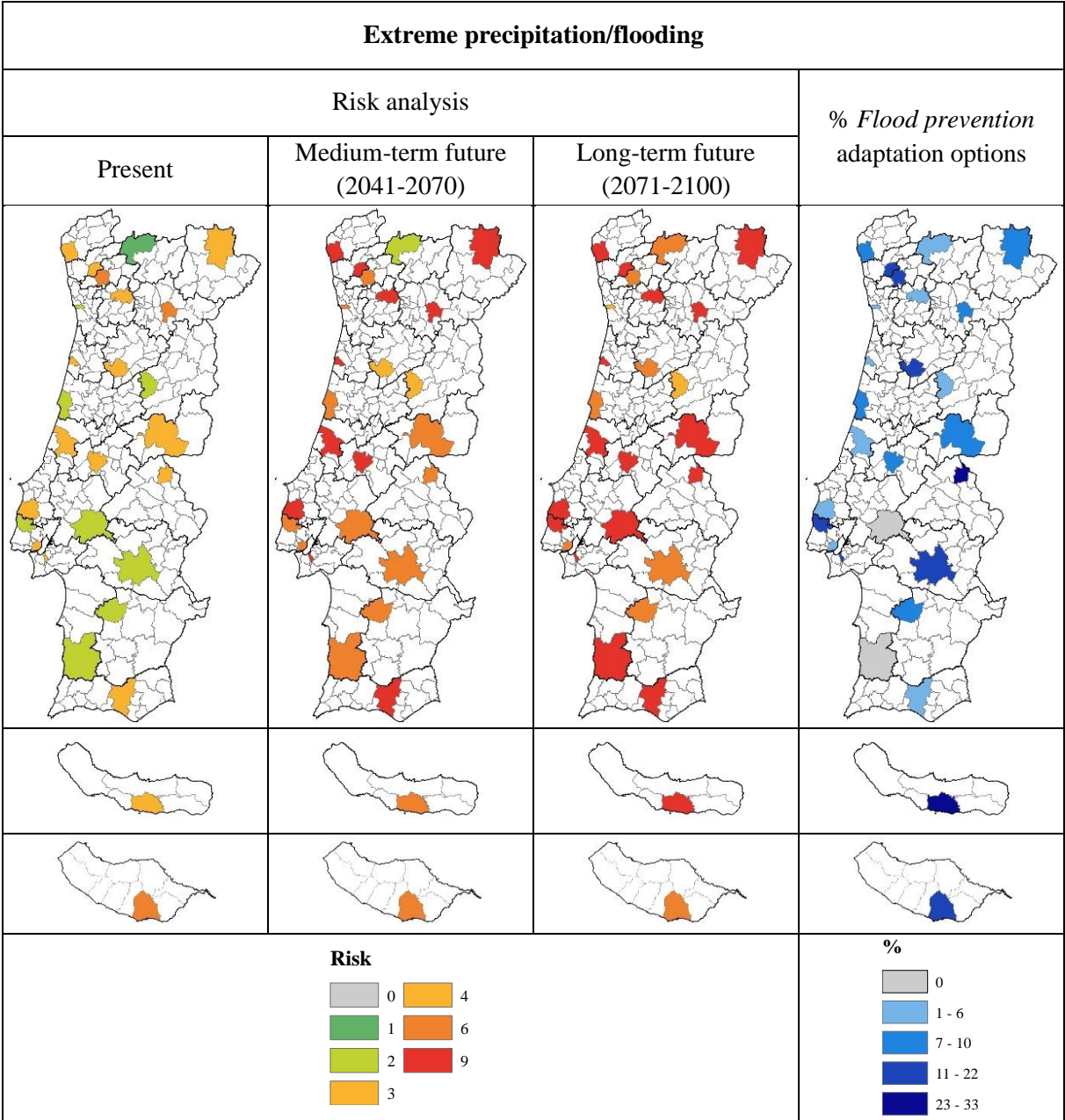


Figure 5.5. Mapping regarding extreme precipitation/flooding for mainland Portugal, São Miguel island in the Azores and Madeira island. The first three maps from the left side correspond to the municipalities' risk analysis, while the fourth map shows the proportion of adaptation options to prevent flooding, in each ClimAdaPT.Local municipality

The average risk level for extreme precipitation/flooding increased by 4 points between the present and the long-term future. This number is lower than that of high temperatures, but this might be explained by the slightly higher average value in the present, and the lower number of municipalities (17 out of 27) in the highest risk level by the end of the century.

It is relevant to mention that, as it happened in the heat waves risk analysis, there are municipalities that evaluate the flooding risk as extremely high and yet did not identify any adaptation option to prevent them. This is visible in the municipalities of Odemira and Coruche.

5.8.4. Droughts

In Figure 5.6 the mapping of the municipalities' risk analysis regarding droughts is presented, along with the proportion of options to promote *water saving*.

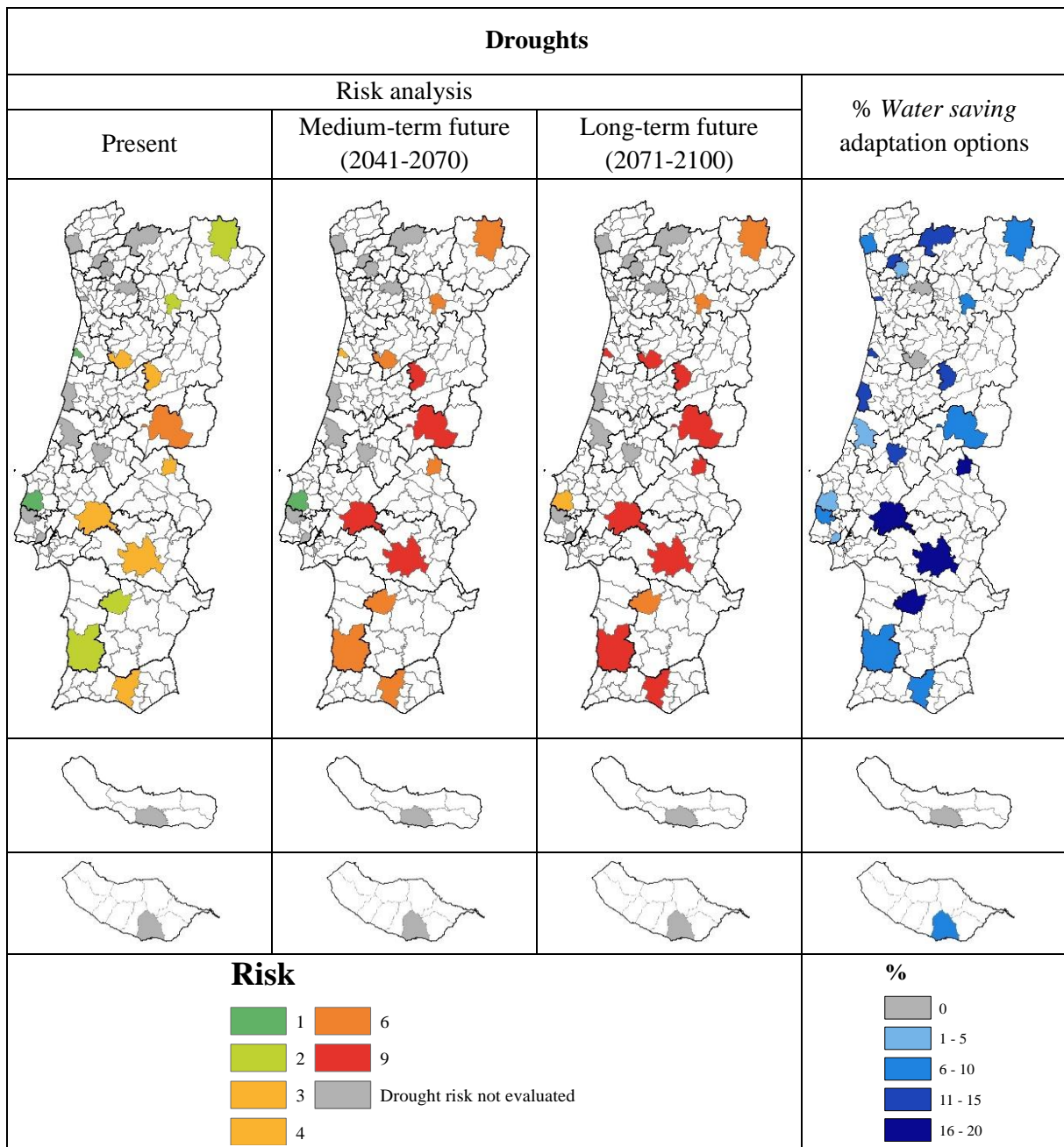


Figure 5.6. Mapping regarding droughts for mainland Portugal, São Miguel island in the Azores and Madeira island. The first three maps from the left side correspond to the municipalities' risk analysis, while the fourth map shows the proportion of adaptation options to save water, in each ClimAdaPT.Local municipality

The average risk level for droughts increased by 5 points between the present and the long-term future. It has to be noted, however, that 14 of the 27 municipalities did not analyse risk for droughts specifically. Out of the 13 municipalities that analysed this risk, 9 were in the highest level by the end of the century, versus 0 in the present and 4 in the middle of the century.

In some cases, such as the island municipalities and several mainland ones, the risk of droughts was not analysed, however some adaptation options to save water were listed, which shows that they have a concern regarding water shortage.

5.8.5. Sea level rise

Regarding sea level rise, Figure 5.7 shows the mapping of the municipalities’ risk analysis, as well as the proportion of options for coastal management. Given the specific seaside nature of this type of risk, only coastal municipalities were considered in the analysis, i.e. 12 out of the 27 ClimAdaPT.Local municipalities.

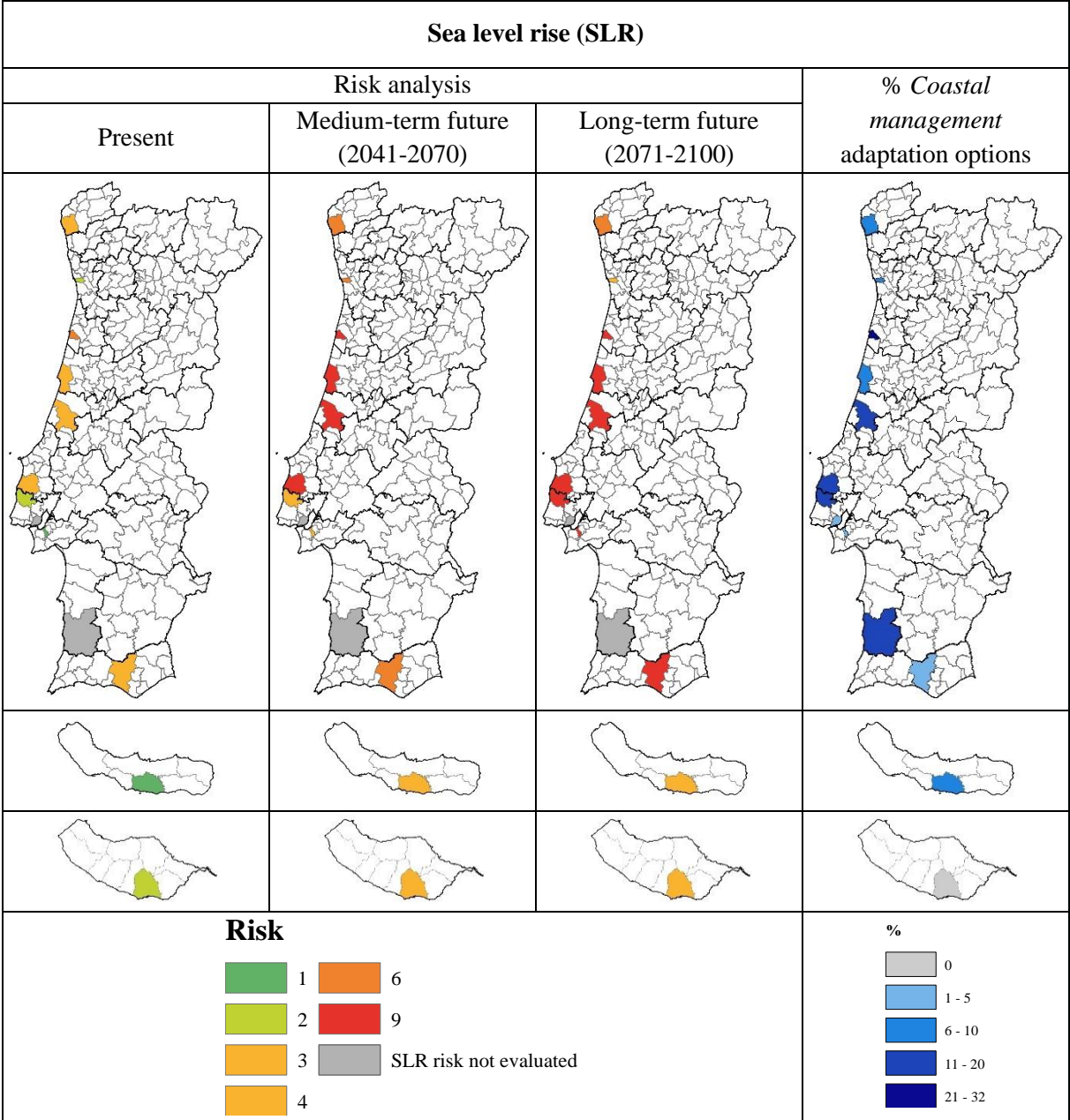


Figure 5.7. Mapping regarding sea level rise for mainland Portugal, São Miguel island in the Azores and Madeira island. The first three maps from the left side correspond to the municipalities’ risk analysis regarding sea level rise, while the fourth map shows the proportion of adaptation options to protect the coast, in each ClimAdaPT.Local municipality

All the coastal municipalities (with the exception of Lisbon in the mainland) evaluated the risk of sea level rise. On average, this risk increased by over 4 points between the present and the end of the century.

It is important to note that a few municipalities already considered the implementation of adaptation options when evaluating this specific risk, thus they did not assume the risk kept increasing until 2100.

The specific case of the Porto municipality is worth highlighting due to the exceptional situation of the risk level actually decreasing between the middle and the end of the century.

Regarding actions to deal with sea level rise, all of the coastal Portuguese municipalities listed this kind of adaptation options, with the exception of Funchal in Madeira island. This might be explained by the medium risk level (4) evaluated for the end of the century, which might not convey a sense of urgency to adapt.

6. Discussion

This section of the dissertation includes the main discussion, as well as a subsection focused on the critique and limitations to this work.

The results have shown that the amount of adaptation strategies in Portugal has increased greatly in the last decade: the number went from 3 EMAACs in 2010, to 30 in 2015 and 47 in September 2019; that number will increase to 65 as soon as the EMAACs currently in development are finalised. The numbers are also notable for inter-municipal strategies: from 0 in 2010 to 13 in September 2019 (soon to be 21). The European trend also shows that a vast area of the continent is covered by local and national strategies (European Union 2016; Aguiar et al. 2018).

The current trend in Portugal points to a slower increase in the development of new EMAACs and a faster increase regarding inter-municipal strategies. This might be explained not only by the recent funding opportunities for inter-municipal strategies but also by the fact that those strategies are very complete, trigger action and raise awareness through their different municipalities, thus emptying the municipal level of a pressing need for an EMAAC. Given this tendency, it is therefore crucial that the inter-municipal strategies address all the relevant issues of their coverage area.

There is a high heterogeneity in the proportion of different adaptation options within and between each of the municipalities studied. The two types of adaptation options most often mentioned by the municipalities are those that deal with water saving and flood prevention. This is a choice in line with the current trends and the future climate projections mentioned in the Introduction: it is projected that there is going to be a shorter volume of rain overall but it is likely that small water streams in Portugal will still experience flooding due to intense rain episodes (Blöschl et al. 2019). Those two types of adaptation options are also the most commonly mentioned in Europe (Aguiar et al. 2018).

Overall, the options generally chosen to deal with the key risks in Europe have all been mentioned by the Portuguese municipalities: the two previously stated options (hard flood-protection, adoption of technologies and strategies to save water), as well as wetland restoration, improvement of river basin/water management, implementation of warning systems, adaptation of buildings, transportation and energy infrastructures, reducing emissions in order to improve air quality, wildfire prevention and management and improvements in insurance products (IPCC 2014c).

There is a high proportion of *soft* adaptation: on average, 63% of the options are included in this class, and this is the most mentioned category in 23 out of the 27 municipalities, which indicates the importance of *soft* options as a central catalyst of adaptation. This is especially noteworthy because *soft* adaptation is often better able to manage uncertainty, and should therefore be considered very seriously when planning and researching for adaptation (Hallegatte and Dumas 2008); it is also often cheaper to implement and thus more easily achievable than *green* or *grey* adaptation. Another interesting result is that 25% of the options were included in the *grey* category, and 29% were classified in *green* adaptation. This indicates that, although municipalities are especially motivated towards *soft* options, both *green* and *grey* options are still seen as vital. *Green* adaptation is particularly beneficial due to the win-win benefits they pose (view subsection 1.2.1 of the Introduction: *Adaptation concepts*).

Climate data, risk analysis and adaptation options are three types of variables that, although interconnected, are not always directly correlated, as it was shown by the calculations presented in subsection 5.7 of the Results (*Correlations between variables*), with two noteworthy exceptions:

i) The correlation between the maximum proportion of burnt area in a municipality and the proportion of *forest fire prevention/recovery* options. There is a significant connection between these two variables, which shows that very impactful, large-scale forest fires remain in the minds of municipality officials for years after they occur. It can be argued, therefore, that adaptation to forest fires is more reactive than proactive, which is in line with what the current global trend has been (Seppälä et al. 2009). A shift in paradigm would be important – proactive adaptation regarding forests can yield several benefits, including the possibility of identifying alternatives in advance, better forest regeneration after disturbances and optimised productivity (Seppälä et al. 2009; Marshall et al. 2017; Yousefpour et al. 2017b). It has to be taken into consideration, however, that the fire regime projections depend on many factors and have a higher uncertainty than the projections for other climate events (Sousa et al. 2015), therefore it might not be an easy task for officials and decision-makers to be proactive.

ii) The correlation between the future risk analysis for drought and the proportion of *water saving options*. Albeit not as strong as the correlation mentioned above, this one is still noteworthy. It is likely that, when listing options to save water, the municipality officials were concerned about the high risk associated with water scarcity. This awareness can be linked to the fact that droughts impair many factors, such as water consumption, energy and irrigation (Javeline et al. 2019), thus affecting multiple sectors. This is in line with ENAAC 2020, in which *water resources management* is viewed as a thematic area, transversal to all sectors (view subsection 1.3.3 of the Introduction: *National level adaptation in Portugal*).

It is not possible to induce if Portuguese municipalities are either more proactive or reactive, or how that might change in the future, with the exception mentioned above regarding adaptation to forest fires. The correlations are not conclusive enough for other climate events, and the diverse nature of climate change adaptation means that categorisation in a very definite way is not possible (Bours et al. 2014) (view subsection 6.1 of this Discussion for more information regarding limitations).

Many aspects of the adaptation process are difficult to quantify or measure (Hallegatte 2009; Fankhauser 2017). In the concrete case of the ClimAdaPT.Local municipalities, it is evident that the amount and proportion of adaptation options that was listed by each municipality did not have a relation with how strong the risk was for each type of climate event or with the climate data (with the only exceptions mentioned above). Events with a higher risk did not always have a higher proportion of options to address them. Besides, sometimes a specific risk was simply not evaluated, and there were adaptation options to address it, or oppositely the risk sometimes was evaluated but there were no options to adapt to it.

The fact that the ADAM methodology did not, at any time, impose a relation between the risk analysis and the definition of adaptation options might partially explain why it was not possible to find those correlations. It is important that the municipalities are aware of the different risks in order to avoid a weak adaptation in some sectors. The ADAM methodology is a cycle, and thus it should be revisited over time in order to ensure that adaptation responds to the pressing climate change issues in the municipality.

Another factor that heavily weighs in this lack of stronger correlations is the fact that each municipality had their own team working on the strategy. Different actors have different perspectives about barriers to climate change, depending on their roles, personal opinions and ideas (Biesbroek et al. 2013). So for example, a municipal official with an education and/or expertise in disaster risk reduction will be more likely to list options to deal with flooding than an official who is specialised on environmental education.

However, the issue that might weigh more in how EMAACs are shaped is the municipalities’ political priorities. Ultimately, the strategy has to be approved by the higher hierarchy within the municipality, therefore the structure and decisions that come from it have to respond to current political agendas and allocated or expected budgets.

6.1. Critique/limitations to this work

Generalisations always lead to loss of information. This is this work’s biggest limitation as it means some potentially relevant aspects were discarded. Therefore, conclusions might be impaired and must be regarded with this limitation in mind. Table 6.1 shows a few examples in which this loss of information happened when standardising the adaptation options into clusters.

Table 6.1. Examples of adaptation options that could have been in more than one cluster

Adaptation option	Cluster it was included into	Cluster it could also have been included into
Improving energy efficiency in health centres and nursing homes	Energy efficiency improvement	Disaster preparedness
Planting trees in the city	Green areas improvement/increase	Heat wave management
Improving the energy efficiency of buildings	Energy efficiency improvement	Heat wave management
Choosing more autochthonous species	Agroforestry practices	Water saving

By analysing just these few examples, it is evident that the loss of information is substantial. The complex nature of climate change adaptation can make it unfitting for standardisation (Bours et al. 2014). It can also be argued that, even if a different approach was taken and all possible clusters were considered, the main concerns and vulnerabilities would probably be the same.

Another limitation related to the loss of information is the fact that some adaptation options are very complex and can be subdivided into distinct actions, while others are more objective. The approach used for creating the clusters was to find the main topic of each option, often by identifying what the key climatic vulnerability was (view subsection 4.1 of the Methodology). This made the standardisation of the options very difficult due to high heterogeneity.

Although the strategies studied were for adaptation only, a substantial amount of options were solely for mitigation, which posed some difficulties in the cluster categorisation (e.g. the *sustainable mobility improvement* cluster contains 100% mitigation and 0% adaptation options). There is an overlapping between the concepts of adaptation and mitigation in this kind of planning documents (Guyadeen et al. 2019), therefore, to minimise confusion and optimise resources, it is important to ensure integration between adaptation and mitigation plans.

7. Conclusions

The final chapter of this dissertation includes the *Main conclusions* and the *Ways forward*.

7.1. Main conclusions

This dissertation studied climate adaptation in Portugal, by characterising adaptation options and analysing the possible correlations between risk analysis, climate data and adaptation, with a focus on the local level.

Adaptation in the country is well under way, especially since this decade. A vast area of the territory is already covered by one or more adaptation documents, which is in line with the European trend.

The most common types of adaptation options identified are related to water saving and flood prevention, which responds to some of the most concerning observed and projected climate trends. These adaptation choices are also the most common in Europe.

Soft adaptation was highlighted through the municipalities' choices and proved its vital importance in the adaptation process.

The results allowed to conclude that the prevention and recovery of forest fires has been a reactive adaptation process and there would be benefits if it became more proactive, although this change might be difficult.

The complex and heterogeneous nature of climate change adaptation, the methodology's limitations and the differences between the variables studied meant that most of the analysed data did not have a significant correlation.

Given the results obtained and the discussion developed in this dissertation, the following future trends for adaptation in Portugal can be induced:

- i) the development of inter-municipal strategies will experience a slower increase since most of the country is already covered by this type of document;
- ii) the development of EMAACs is likely to continue to increase slowly, but that pace can change if new funding opportunities arise;
- iii) forest fire prevention/recovery is likely going to remain a reactive adaptation process in the near future, unless there is an operational change of paradigm in the country;
- iv) the upcoming years will witness an upsurge in the implementation of adaptation options, in which the strategies will go from policy into practice;
- v) the local officials will be increasingly more aware and better educated about climate change, thus surer of their adaptation choices and proposals;
- vi) the adaptation process in general will continue to be very complex and difficult to predict or analyse, but it might be better than now if the process becomes more efficient (view subsection 7.2. *Ways forward*).

7.2. Ways forward

To further develop this dissertation's objectives and ideas, it would be interesting to monitor adaptation in all these municipalities. From the 653 adaptation options that were listed, how many have actually been implemented, and to what extent were they successful? The EMAACs could be subjected to a quality evaluation based on core characteristics (Guyadeen et al. 2019). This monitoring and evaluation would allow for a deeper understanding of the strengths and weaknesses of the EMAACs and facilitate their improvement by the municipality officials in later versions, thus contributing to improve the adaptation process in Portugal.

Finally, based on the experience and the work developed in this dissertation, a list of recommendations for a more efficient climate change adaptation at the local and regional level is presented below:

- Having a transdisciplinary team working on the strategy;
- Ensuring municipal officials are knowledgeable on climate change, ideally through training/courses with a robust scientific background;
- Ensuring inter-municipal strategies are comprehensive enough to address each municipality's problems;
- Evaluating all possible risks in a climate change context;
- Listing adaptation options to deal with every risk;
- Adopting a specific format for the names of adaptation options to make them objective;
- Periodically revising the methodology and updating each of the steps considering the current situation and the future climate.

Given the increasing importance of climate change adaptation in Portugal, these recommendations can be used by officials and agents at the local level to improve the process and help to ensure that they are prepared to deal with the unavoidable effects of climate change.

8. References

[The citations in this dissertation follow the style of the Environmental Management journal]

- Adapt.local (2019) Rede de Municípios para a Adaptação Local às Alterações Climáticas. <http://www.adapt-local.pt/>. Accessed 10 Aug 2019
- AdaptForChange (2017) AdaptForChange. <http://echanges.fc.ul.pt/projetos/adaptforchange/>. Accessed 21 Jul 2019
- Aguiar FC, Bentz J, Silva JMN, et al (2018) Adaptation to climate change at local level in Europe: an overview. *Environ Sci Policy* 86:38–63. doi: 10.1016/j.envsci.2018.04.010
- APA (2010) Estratégia Nacional de Adaptação às Alterações Climáticas. Resolução do Conselho de Ministros n.º 24/2010
- APA (2015) Estratégia Nacional de Adaptação às Alterações Climáticas – ENAAC 2020, APA
- Arnell NW, Gosling SN (2016) The impacts of climate change on river flood risk at the global scale. *Clim Change* 134:387–401. doi: 10.1007/s10584-014-1084-5
- Base (2019) Base: contratos públicos online. <http://www.base.gov.pt/>. Accessed 22 Jul 2019
- Biesbroek GR, Klostermann JEM, Termeer CJAM, Kabat P (2013) On the nature of barriers to climate change adaptation. *Reg Environ Chang* 13:1119–1129. doi: 10.1007/s10113-013-0421-y
- Blöschl G, Hall J, Viglione A, et al (2019) Changing climate both increases and decreases European river floods. *Nature*. doi: 10.1038/s41586-019-1495-6
- Bosello F, Carraro C, De Cian E (2009) *An Analysis of Adaptation as a Response to Climate Change*. Frederiksberg, Denmark
- Bours D, McGinn C, Pringle P (2014) *Twelve reasons why climate change adaptation M&E is challenging*. Oxford, UK
- Campos I, Guerra J, Gomes JF, et al (2017) Understanding climate change policy and action in Portuguese municipalities: A survey. *Land use policy* 62:68–78. doi: 10.1016/j.landusepol.2016.12.015
- Capela Lourenço T, Dias L, Marreiros S, Carvalho S (eds) (2017) *ClimAdaPT.Local - Guia de Apoio à Decisão em Adaptação Municipal*. Lisboa
- Capela Lourenço T, Rovisco A, Groot A, et al (2014) *Adapting to an uncertain climate: Lessons from practice*. Springer International Publishing
- ClimAdaPT.Local (2016) *ClimAdaPT.Local*. <http://climadapt-local.pt/>. Accessed 24 May 2018
- Climate-ADAPT (2017) *Adaptation options*. <https://climate-adapt.eea.europa.eu/knowledge/adaptation-information/adaptation-measures>. Accessed 14 Aug 2019
- CLIMRisk (2019) *CLIMRisk - Medidas de adaptação às alterações climáticas na gestão dos riscos naturais e ambientais*. <http://www.climrisk.ipt.pt/pt/apresentacao/>. Accessed 21 Jul 2019
- Cloy JM, Smith KA (2018) *Greenhouse Gas Sources and Sinks*. Elsevier Inc.
- Costa AC, Soares A (2009) Trends in extreme precipitation indices derived from a daily rainfall database for the South of Portugal. *Int J Climatol* 29:1956–1975. doi: 10.1002/joc.1834

- Dannevig H, Hovelsrud GK, Husabø IA (2013) Driving the agenda for climate change adaptation in Norwegian municipalities. *Environ Plan C Gov Policy* 31:490–505. doi: 10.1068/c1152
- DGT (2019) CAOP 2018. http://www.dgterritorio.pt/cartografia_e_geodesia/cartografia/carta_administrativa_oficial_de_portugal_caop/caop__download_/. Accessed 2 Jul 2019
- Du D, Zhao X, Huang R (2017) The impact of climate change on developed economies. *Econ Lett* 153:43–46. doi: 10.1016/j.econlet.2017.01.017
- EEA (2017a) Climate change, impacts and vulnerability in Europe 2016 - An indicator-based report. Copenhagen, Denmark
- EEA (2017b) Trends in annual temperature across Europe between 1960 and 2016. <https://www.eea.europa.eu/data-and-maps/figures/decadal-average-trends-in-mean-7>
- EEA (2016) Trends in annual (a) and summer (b) precipitation across Europe between 1960 and 2015. <https://www.eea.europa.eu/data-and-maps/figures/observed-changes-in-annual-precipitation-1961-6>. Accessed 17 Dec 2017
- EEA (2013) Adaptation in Europe - Addressing risks and opportunities from climate change in the context of socio-economic developments
- EEA Grants (2019) EEA Grants - About us. <https://eeagrants.org/about-us>. Accessed 26 Aug 2019
- Ehret U, Zehe E, Wulfmeyer V, et al (2012) HESS Opinions “should we apply bias correction to global and regional climate model data?” *Hydrol Earth Syst Sci* 16:3391–3404. doi: 10.5194/hess-16-3391-2012
- ESRI (2019) What is GIS? In: *What is GIS? A Framew. to Organ. Commun. understand Sci. our world*. <https://www.esri.com/en-us/what-is-gis/>. Accessed 13 Aug 2019
- European Commission (2018) Report from the Commission to the European Parliament and the Council - on the implementation of the EU Strategy on adaptation to climate change. 18
- European Union (2013) The EU strategy on adaptation to climate change
- European Union (2016) Regional and local adaptation in the EU since the adoption of the EU adaptation strategy in 2013
- Eurostat (2018) Regions in the European Union - Nomenclature of territorial units for statistics - NUTS 2016/EU-28. Publications Office of the European Union, Luxembourg
- Fankhauser S (2017) Adaptation to climate change. *Annu Rev Resour Econ*. doi: <https://doi.org/10.1146/annurev-resource100516-033554>
- Feyen L, Watkiss P (2011) Technical Policy Briefing Note 3. The Impacts and Economic Costs of River Floods in Europe, and the Costs and Benefits of Adaptation. Results from the EC RTD ClimateCost Project
- Fórum das Cidades (2016) Rede de Municípios para a Adaptação Local às Alterações Climáticas. <http://www.forumdascidades.pt/?q=content/rede-de-municipios-para-adaptacao-local-alteracoes-climaticas>. Accessed 18 Dec 2017
- Georgeson L, Maslin M, Poessinouw M, Howard S (2016) Adaptation responses to climate change differ between global megacities. *Nat Clim Chang* 6:584–588. doi: 10.1038/nclimate2944
- Gregg RM, Kershner JM, Hansen LJ (2018) *Strategies for Climate Change Adaptation: A Synthesis*. Elsevier Inc.
- Guyadeen D, Thistlethwaite J, Henstra D (2019) Evaluating the quality of municipal climate change plans in Canada. *Clim Change* 152:121–143. doi: 10.1007/s10584-018-2312-1

- Hallegatte S (2009) Strategies to adapt to an uncertain climate change. *Glob Environ Chang* 19:240–247. doi: 10.1016/j.gloenvcha.2008.12.003
- Hallegatte S, Dumas P (2008) Adaptation to climate change: soft vs. hard adaptation. OECD Expert Work Econ Asp Adapt to Clim Chang
- Heltberg R, Siegel PB, Jorgensen SL (2009) Addressing human vulnerability to climate change: Toward a “no-regrets” approach. *Glob Environ Chang* 19:89–99. doi: 10.1016/j.gloenvcha.2008.11.003
- Hu X, Huang B, Cherubini F (2019) Impacts of idealized land cover changes on climate extremes in Europe. *Ecol Indic* 104:626–635. doi: 10.1016/j.ecolind.2019.05.037
- INE (2019) Instituto Nacional de Estatística - Base de dados. https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_base_dados. Accessed 21 Jun 2019
- IPCC (2014a) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
- IPCC (2018) Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,. In Press
- IPCC (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
- IPCC (2014b) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA
- IPCC (2014c) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
- IPCC (2007) Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel. Cambridge University Press, Cambridge, UK
- IPCC (2019) Climate change and Land - Summary for Policimakers (Approved Draft)
- IPMA (2019a) Portal do Clima. <http://portaldoclima.pt>. Accessed 23 Jul 2019
- IPMA (2019b) Portal do Clima. <http://portaldoclima.pt>. Accessed 2 Jul 2019
- Javeline D, Dolšak N, Prakash A (2019) Adapting to water impacts of climate change: Introduction to special issue of Climatic Change. *Clim Change* 152:209–213. doi: 10.1007/s10584-018-2349-1
- Jolly WM, Cochrane MA, Freeborn PH, et al (2015) Climate-induced variations in global wildfire danger from 1979 to 2013. *Nat Commun* 6:1–11. doi: 10.1038/ncomms8537
- Kundzewicz ZW, Krysanova V, Benestad RE, et al (2018) Uncertainty in climate change impacts on water resources. *Environ Sci Policy* 79:1–8. doi: 10.1016/j.envsci.2017.10.008
- Leitner M, Capela Lourenço T (2019) ECCA 2019 Summary: Preparing for change requires action now! Lisbon
- Mais Algarve (2018) Olhão contemplado com Fundos de Adaptação às Alterações Climáticas. <https://www.maisalgarve.pt/noticias/regionais/12919-olhao-contemplado-com-fundos-de-adaptacao-as-alteracoes-climaticas>. Accessed 21 Jul 2019
- Marshall A, Kocher S, Kerr A, Stine P (2017) Adapting Forests to Climate Change. Univ Calif - Agric

Nat Resour 2574:

- Mora C, Spirandelli D, Franklin EC, et al (2018) Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. *Nat Clim Chang* 8:1062–1071. doi: 10.1038/s41558-018-0315-6
- Município de Almada (2007) *Estratégia Local para as Alterações Climáticas no Município de Almada*. Almada
- Município de Cascais (2017) *Plano de Ação para a Adaptação às Alterações Climáticas de Cascais*. Cascais
- Município de Montemor-o-Velho (2019) Câmara Municipal assinalou Dia Mundial da Proteção Civil. <https://cm-montemorvelho.pt/index.php/municipio/comunicacao/item/786-camara-municipal-assinalou-dia-mundial-da-protecao-civil>. Accessed 21 Jul 2019
- Município de Murça (2019) Murça vai ter uma Estação Meteorológica. https://www.cm-murca.pt/pages/574?news_id=944. Accessed 22 Jul 2019
- Município de Sabrosa (2019) Estação Meteorológica instalada em Sabrosa. https://www.sabrosa.pt/pages/442?news_id=252. Accessed 22 Jul 2019
- Município de Sintra (2009) *Plano Estratégico do Concelho de Sintra face às Alterações Climáticas*. Sintra
- Navarra A, Tubiana L (2013) *Regional Assessment of Climate Change in the Mediterranean*. Springer, Dordrecht, Netherlands
- NOAA (2019) Trends in Atmospheric Carbon Dioxide. In: *Earth Syst. Res. Lab. - Glob. Monit. Div.* <https://www.esrl.noaa.gov/gmd/ccgg/trends/>. Accessed 23 Sep 2019
- Pappenberger F, Cloke HL, Parker DJ, et al (2015) The monetary benefit of early flood warnings in Europe. *Environ Sci Policy* 51:278–291. doi: 10.1016/j.envsci.2015.04.016
- Parry M, Arnell N, Berry P, et al (2009) *Adaptation to climate change: Assessing the costs*
- Penha-Lopes G, Dias L, Capela Lourenço T, et al (eds) (2016) *ClimAdaPT.Local - Sumário Executivo*
- Picketts IM (2018) The best laid plans: Impacts of politics on local climate change adaptation. *Environ Sci Policy* 87:26–32. doi: 10.1016/j.envsci.2018.05.017
- PO SEUR (2016) POSEUR-08-2016-57: Call for Applications for Planning on Adaptation to Climate Change. <https://poseur.portugal2020.pt/en/events/poseur-08-2016-57-call-for-applications-for-planning-on-adaptation-to-climate-change/>. Accessed 15 Jul 2019
- PO SEUR (2019) Presentation of the Operational Programme. <https://poseur.portugal2020.pt/en/poseur/about-the-programme/>. Accessed 15 Jul 2019
- Porter JJ, Dessai S (2017) Mini-me: Why do climate scientists’ misunderstand users and their needs? *Environ Sci Policy* 77:9–14. doi: 10.1016/j.envsci.2017.07.004
- RCM n.º 56/2015 (2015) Resolução do Conselho de Ministros n.º 56/2015
- RCM n.º 6-B/2015 (2015) Resolução do Conselho de Ministros n.º 6-B/2015
- Rolim J, Teixeira JL, Catalão J, Shahidian S (2017) The Impacts of Climate Change on Irrigated Agriculture in Southern Portugal. *Irrig Drain* 66:3–18. doi: 10.1002/ird.1996
- Rosário L do (2004) *Indicadores de Desertificação para Portugal Continental*. Núcleo de Desertificação
- Sanderson H, Hildén M, Russel D, et al (2018) *Adapting to Climate Change in Europe: Exploring Sustainable Pathways - From Local Measures to Wider Policies*. Elsevier, Amsterdam, Netherlands

- Sanford T, Frumhoff PC, Luers A, Gullede J (2014) The climate policy narrative for a dangerously warming world. *Nat Clim Chang* 4:164–166. doi: 10.1038/nclimate2148
- Santos FD, Forbes K, Moita R (eds) (2002) *Climate Change in Portugal. Scenarios, Impacts and Adaptation Measures (SIAM Project)*. Gradiva
- Santos FD, Miranda P (eds) (2006) *Alterações Climáticas em Portugal - Cenários, Impactos e Medidas de Adaptação (Projeto SIAM II)*. Gradiva, Lisboa
- Schober P, Schwarte LA (2018) Correlation coefficients: Appropriate use and interpretation. *Anesth Analg* 126:1763–1768. doi: 10.1213/ANE.0000000000002864
- Seppälä R, Buck A, Katila P (2009) *Adaptation Of Forests And People To Climate Change - A Global Assesment Report*. Helsinki
- Sousa PM, Trigo RM, Pereira MG, et al (2015) Different approaches to model future burnt area in the Iberian Peninsula. *Agric For Meteorol* 202:11–25. doi: 10.1016/j.agrformet.2014.11.018
- Thom D, Rammer W, Dirnböck T, et al (2017) The impacts of climate change and disturbance on spatio-temporal trajectories of biodiversity in a temperate forest landscape. *J Appl Ecol* 54:28–38. doi: 10.1111/1365-2664.12644
- UKCIP (2007) *Identifying Adaptation Options*
- UKCIP (2013) *The UKCIP Adaptation Wizard v 4.0*. www.ukcip.org.uk/wizard. Accessed 20 Jan 2019
- UNDESA (2016) *UN-DESA Policy Brief #45 - The nexus between climate change and inequalities*
- Unidata (2017) *Network Common Data Form (NetCDF)*. <https://www.unidata.ucar.edu/software/netcdf/>. Accessed 10 Jul 2019
- United Nations (2018) *Global Issues Overview*. <http://www.un.org/en/sections/issues-depth/global-issues-overview/>. Accessed 29 May 2018
- United Nations (2015a) *Transforming our world: the 2030 Agenda for Sustainable Development*. *Gen Assem 70 Sess 16301:1–35*. doi: 10.1007/s13398-014-0173-7.2
- United Nations (2015b) *Paris Agreement*. In: *Conference of the Parties on its twenty-first session*. Paris, France, p 32
- United Nations (2015c) *Climate negotiations timeline*. <https://www.un.org/sustainabledevelopment/climate-negotiations-timeline/>. Accessed 26 Aug 2019
- United Nations (1992) *United Nations Framework Convention on Climate Change*
- United Nations (2019a) *Conference of the Parties (COP)*. <https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop>. Accessed 26 Aug 2019
- United Nations (2019b) *The Paris Agreement*. <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>. Accessed 26 Aug 2019
- United Nations (2019c) *Information Note on the 2019 Climate Action Summit of the Secretary-General*. New York, USA
- Winkelman S, Nichol E, Harford D (2017) *Taking Action on Green Resilience: Climate change adaptation and mitigation synergies*. *Work Conclusions Livable Cities Forum Pre-Event*
- Yousefpour R, Augustynczyk ALD, Hanewinkel M (2017a) Pertinence of reactive, active, and robust adaptation strategies in forest management under climate change. *Ann For Sci* 74:1–10. doi: 10.1007/s13595-017-0640-3
- Yousefpour R, Temperli C, Jacobsen JB, et al (2017b) *A framework for modeling adaptive forest*

management and decision making under climate change. *Ecol Soc* 22:. doi: 10.5751/ES-09614-220440

Zar JH (1999) *Biostatistical Analysis*, Fourth Edi. Prentice-Hall International, London, UK

Zillman J (2009) A history of climate activities. *World Meteorol Organ Bull* 58:

Annexes

Annex I

List of the 27 municipalities involved in the ClimAdaPT.Local project and their respective NUTS III and NUTS II (INE 2019).

Municipality	NUTS III	NUTS II
Amarante	Tâmega e Sousa	Norte
Barreiro	Área Metropolitana de Lisboa	Área Metropolitana de Lisboa
Braga	Cávado	Norte
Bragança	Terras de Trás-os-Montes	Norte
Castelo Branco	Beira Baixa	Centro
Castelo de Vide	Alto Alentejo	Alentejo
Coruche	Lezíria do Tejo	Alentejo
Évora	Alentejo Central	Alentejo
Ferreira do Alentejo	Baixo Alentejo	Alentejo
Figueira da Foz	Região de Coimbra	Centro
Funchal	Região Autónoma da Madeira	Região Autónoma da Madeira
Guimarães	Ave	Norte
Ílhavo	Região de Aveiro	Centro
Leiria	Região de Leiria	Centro
Lisboa	Área Metropolitana de Lisboa	Área Metropolitana de Lisboa
Loulé	Algarve	Algarve
Mafra	Área Metropolitana de Lisboa	Área Metropolitana de Lisboa
Montalegre	Alto Tâmega	Norte
Odemira	Alentejo Litoral	Alentejo
Porto	Área Metropolitana do Porto	Norte
São João da Pesqueira	Douro	Norte
Seia	Beiras e Serra da Estrela	Centro
Tomar	Médio Tejo	Centro
Tondela	Viseu Dão Lafões	Centro
Torres Vedras	Oeste	Centro
Viana do Castelo	Alto Minho	Norte
Vila Franca do Campo	Região Autónoma dos Açores	Região Autónoma dos Açores

Annex II

List of 653 adaptation options identified by the 27 municipalities, their categories and the adaptation option cluster they were integrated in.

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
1	Amarante	Raising awareness to the population by encouraging behavioural change, disseminating measures and clarifying good management practices			1	Awareness-raising (general public)
2	Amarante	Promoting the pedestrian and bicycle network	1			Sustainable mobility improvement
3	Amarante	Developing new functionalities on the GIS			1	Knowledge promotion (municipality officials and agents)
4	Amarante	Rehabilitating and implementing green corridors		1		Green areas improvement/increase
5	Amarante	Promoting the cleanliness and regularization of water streams, taking into account the need to keep an adequate riparian vegetation		1		Water streams/aquifers sustainable management
6	Amarante	Creating a multidisciplinary team in order to improve environmental performance			1	Knowledge promotion (municipality officials and agents)
7	Amarante	Flood risk management plan and heat wave management plan			1	Disaster preparedness
8	Amarante	Promoting the discarding of leftovers without burning			1	Energy efficiency improvement
9	Amarante	Creating Best Practice Guide			1	Awareness-raising (general public)
10	Amarante	Create Municipal Guides with information on bioclimatic measures and adaptation strategies for buildings (public and private)			1	Energy efficiency improvement
11	Amarante	Promoting the dissemination and exchange of experiences regarding sustainable mobility, such as the “Do The Right Mix” campaigns and the European Mobility Week			1	Sustainable mobility improvement
12	Amarante	Promoting the planting of autochthonous species		1	1	Agroforestry practices
13	Amarante	Invasive species eradication plan			1	Invasive species/pests management
14	Amarante	Creating mechanisms for the municipality and the general population to highlight the importance of rainwater harvesting			1	Flood prevention

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
		and drainage systems, in the natural environment, in surface and buried networks; through awareness, inspection, registration, maintenance, design and expansion scaled for the future				
15	Amarante	Creating more green spaces in and around rustic soils		1		Green areas improvement/increase
16	Amarante	Implementing measures to promote energy efficiency	1		1	Energy efficiency improvement
17	Amarante	Promoting the use of environmentally friendly energy sources (solar, wind and hydric)	1		1	Energy efficiency improvement
18	Amarante	Creating parking lots on the outskirts	1			Sustainable mobility improvement
19	Barreiro	Developing indicators for monitoring, reviewing and risk prevention in the context of EMAAC			1	Monitoring
20	Barreiro	Monitoring and analysis of the Tejo-Sado aquifer, incorporating the possible impacts of climate change (scenarios of water scarcity and/or contamination - this is the region's only drinking water producer)			1	Water streams/aquifers sustainable management
21	Barreiro	Education and awareness raising on climate change adaptation in schools and for the general population			1	Awareness-raising (general public)
22	Barreiro	Water retention basin systems (rural areas / dispersed housing)		1		Flood prevention
23	Barreiro	Urban stormwater control systems	1			Flood prevention
24	Barreiro	Coastal protection systems to prevent the progressive sea level rise, consistent with the projected risks	1			Coastal management
25	Barreiro	Studying the impact of the projected sea level rise (above the current altitude of Barreiro's outskirts territory)			1	Knowledge promotion (municipality officials and agents)
26	Barreiro	Flood prevention in the Ribeira de Coima basin			1	Flood prevention
27	Barreiro	Green infrastructures "green corridors"		1		Green areas improvement/increase
28	Barreiro	Urban forestation		1		Green areas improvement/increase
29	Barreiro	Sustainable forest management (Machada National Forest)		1		Green areas improvement/increase
30	Barreiro	Urban planning considering sun exposure and wind predominance	1	1		Urban design improvements

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
31	Barreiro	Gradual renovation of public buildings as an example of good practices	1			Urban design improvements
32	Barreiro	Creating guides with information on bioclimatic measures and adaptation strategies in public and private buildings			1	Energy efficiency improvement
33	Barreiro	Heat wave contingency plan			1	Heat wave management
34	Barreiro	Creation of specific urban spaces to reduce the impact of heat waves	1	1		Heat wave management
35	Barreiro	Heat wave and high solar radiation warning system			1	Heat wave management
36	Barreiro	Pest disinfestation plan			1	Invasive species/pests management
37	Barreiro	Fighting the appearing of species (insects) and the increase in their life cycles caused by heat waves			1	Invasive species/pests management
38	Barreiro	Strengthen the importance of insurance companies and banks in financing against the impacts of climate events			1	Economic capacitation
39	Braga	Creation of a municipal civil protection centre			1	Knowledge promotion (municipality officials and agents)
40	Braga	Creation of a monitoring system for the streams of rivers and areas that might be flooded (tunnels)			1	Flood prevention
41	Braga	Monitoring of air quality (O ₃) and weather parameters			1	Monitoring
42	Braga	Tree health monitoring			1	Monitoring
43	Braga	Production of a municipal good practice manual			1	Knowledge promotion (municipality officials and agents)
44	Braga	Analysis and definition of a group of tree and shrub species to be preferentially used in both municipal and private projects, in the context of the elaboration of the Good Practices Manual			1	Agroforestry practices
45	Braga	Elaboration of a 'Climate Change Susceptibility map' in GIS for the municipality			1	Knowledge promotion (municipality officials and agents)
46	Braga	Implementation of an annual training and awareness-raising plan			1	Awareness-raising (general public)
47	Braga	Creating retention basins upstream of the city (Sete Fontes Park; Rio Este Valley), Rio Torto (Real, Dume and Frossos)		1		Flood prevention

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
48	Braga	Desilting of water streams and optimization of preventive processes in early autumn, regarding the drainage of rainwater: foliage collection, gutter cleaning, etc.		1		Water streams/aquifers sustainable management
49	Braga	Rehabilitation of riparian galleries		1		Water streams/aquifers sustainable management
50	Braga	Integration between the sustainable drainage systems (bio-gutters or others) and the existing or planned rainwater drainage network	1	1		Flood prevention
51	Braga	Promoting the development of urban design options: creation of infiltration gardens / retention basins / conversion of waterproof pavements		1		Flood prevention
52	Braga	Creation of areas of bushes on slopes that are more susceptible to hydric erosion		1		Land degradation prevention
53	Braga	Addition of vegetation-based shading elements into the most open and busy streets		1		Green areas improvement/increase
54	Braga	Promoting the increase and diversification of green spaces, including vertical gardens and green roofs		1		Green areas improvement/increase
55	Braga	Promotion of shading areas, in artificial structures built in critical areas	1			Heat wave management
56	Braga	Addition of evaporative cooling solutions (such as sprinklers and water mirrors) in green spaces and open public areas	1			Heat wave management
57	Braga	Maintenance of natural ventilation corridors (water streams with vegetation, especially along the sides of the main local RELEVOS) and urban ventilation corridors (streets with trees, with prevailing winds North-South and Northwest-Southeast)		1		Urban design improvements
58	Braga	Promoting bioclimatic and energy efficient construction	1		1	Energy efficiency improvement
59	Braga	Promoting a program for improving the use of treated and free water (boreholes, wells, mines, etc.)	1			Water saving
60	Braga	Restoration, conservation and extension of water storage infrastructures	1			Water saving
61	Braga	Reuse of treated water from WWTP for irrigation	1			Water saving

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
62	Braga	Promoting the use of forest biomass (water heating, pellets, etc.)	1			Energy efficiency improvement
63	Braga	Promoting forest management - giving priority to autochthonous species, creating mosaics, placing water points, etc.			1	Agroforestry practices
64	Braga	Promoting control of invasive species, pests and diseases			1	Invasive species/pests management
65	Braga	Implementation of an integrated mobility plan to effectively reduce the use of individual motorized transportation, promoting commuting in public transports and soft mobility (cycling and walking)			1	Sustainable mobility improvement
66	Braga	Promoting cultivation of alternative agricultural species adapted to climate change			1	Agroforestry practices
67	Braga	Promoting an increase in the area of worked (not abandoned) agricultural land		1		Agroforestry practices
68	Bragança	Develop and implement an annual plan of education, awareness-raising and training of the population			1	Awareness-raising (general public)
69	Bragança	Adoption of local policies and processes in the municipality to adapt to climate change			1	Knowledge promotion (municipality officials and agents)
70	Bragança	Preparation and Implementation of a plan for monitoring and evaluating the main inventoried impacts			1	Monitoring
71	Bragança	Promoting the cleanliness and regularization of water streams, maintaining adequate riparian vegetation	1			Water streams/aquifers sustainable management
72	Bragança	Rehabilitation of water streams, riparian areas, wetlands and green corridors		1		Water streams/aquifers sustainable management
73	Bragança	Improving efficient water use by reducing losses and creating water supply alternatives (e.g. rainwater retention)		1		Water saving
74	Bragança	Improvement of run-off conditions in critical areas and creation of specific rules for potential flood areas and high winds		1		Flood prevention
75	Bragança	Operationalization of the PMDFCI		1		Forest fire prevention/recovery

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
76	Bragança	Promoting forest management			1	Agroforestry practices
77	Bragança	Promoting plantation with autochthonous (more adapted and less combustible) species, creating species diversity and fuel management mosaics		1		Forest fire prevention/recovery
78	Bragança	Management of protected and classified areas		1		Policy development/reviewing/implementation
79	Bragança	Adaptation of subsistence agriculture and farms to prolonged dry climate		1		Agroforestry practices
80	Bragança	Choosing snow and ice resistant pavements	1			Cold spell management
81	Bragança	Acquisition of means of forecasting, signalling and responding to weather events such as snow or ice	1			Cold spell management
82	Castelo Branco	EMAAC monitoring, including review of objectives and risks			1	Monitoring
83	Castelo Branco	PDM review, taking into account the integration of EMAAC			1	Policy development/reviewing/implementation
84	Castelo Branco	Restructuring of the PMDFCI			1	Forest fire prevention/recovery
85	Castelo Branco	Revision of special plans			1	Policy development/reviewing/implementation
86	Castelo Branco	Adaptation of the Castelo Branco Municipal Civil Protection Emergency Plan			1	Policy development/reviewing/implementation
87	Castelo Branco	Implementation of a climate change/adaptation awareness-raising information programme			1	Awareness-raising (general public)
88	Castelo Branco	Creation of the Municipal Program for the efficient use of water	1	1	1	Water saving
89	Castelo Branco	Creation of the Municipal Program for the efficient use and exploitation of renewable energy	1	1	1	Energy efficiency improvement
90	Castelo Branco	Creation/expansion of green spaces and urban gardens		1		Green areas improvement/increase
91	Castelo Branco	Rehabilitation/extension of natural and artificial drainage systems in rural and urban areas	1	1		Flood prevention
92	Castelo Branco	Promoting the use of forest biomass		1		Energy efficiency improvement
93	Castelo Branco	Promoting and dissemination of good agricultural and forestry cultivation practices		1		Agroforestry practices

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
94	Castelo Branco	Consolidation of protected and classified areas		1	1	Policy development/reviewing/implementation
95	Castelo Branco	Implementation of a study of Human Phenomenology due to the impacts of climate change			1	Knowledge promotion (municipality officials and agents)
96	Castelo Branco	Implementation of a database system of weather events, their effects and causes in the municipal territory (PIC-L)			1	Monitoring
97	Castelo de Vide	Creation of an EMAAC municipal monitoring council			1	Knowledge promotion (municipality officials and agents)
98	Castelo de Vide	Restrict the installation of infrastructures in areas with fire hazard equal to or higher than that stated in current legislation.			1	Forest fire prevention/recovery
99	Castelo de Vide	Cartography elaboration, identifying the areas with the highest degree of flood risk			1	Flood prevention
100	Castelo de Vide	Restrict the installation of infrastructure in areas with high degree of flood risk			1	Flood prevention
101	Castelo de Vide	Replacement/widening of the culvert located on Mercado Street, for the transportation of the Ameixoeira stream in Póvoa e Meadas	1			Flood prevention
102	Castelo de Vide	Adaptation/resizing of rainwater collectors	1			Flood prevention
103	Castelo de Vide	Improvement of water supply system	1			Water saving
104	Castelo de Vide	Information, education and awareness-raising			1	Awareness-raising (general public)
105	Castelo de Vide	Preparation of contingency plan for forest fires			1	Forest fire prevention/recovery
106	Castelo de Vide	Preparation of contingency plan for flooding scenarios			1	Flood prevention
107	Castelo de Vide	Elaboration of contingency plan for prolonged drought			1	Water saving
108	Castelo de Vide	Ensure the operability of the municipality's strategic water supply reserves			1	Water saving
109	Castelo de Vide	Promoting the use of vegetation species with lower water use needs in the municipality's green spaces		1		Agroforestry practices
110	Castelo de Vide	Promoting the plantation of autochthonous forest species, adapted to the season and resistant to forest fires, in the areas with the highest fire risk in the municipality		1		Forest fire prevention/recovery

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
111	Castelo de Vide	Promote the improvement of the building's energy efficiency	1			Energy efficiency improvement
112	Coruche	Sustainable and rational land use, minimizing GHG emissions and intensifying their removal by sinks		1	1	Land use planning
113	Coruche	Preservation of natural resources (water and soil), particularly areas of high soil permeability		1	1	Ecosystem protection
114	Coruche	EMAAC integration in planning documents, notably in the PDM revision			1	Policy development/reviewing/implementation
115	Coruche	Integration of Climate Change in the strategic environmental evaluation of Coruche's PDM revision			1	Policy development/reviewing/implementation
116	Coruche	Development of indicators for monitoring climate change adaptation options under the PDM revision			1	Monitoring
117	Coruche	Creation of a monitoring, forecasting and response system - early warning and warning systems in the municipal emergency plan			1	Monitoring
118	Coruche	Preparation of Monte da Barca and Agolada weirs management plans			1	Water streams/aquifers sustainable management
119	Coruche	Promotion of favourable conditions for atmospheric circulation and air temperature control, especially in urban areas, through the use of green elements on roofs and facades and shading outside buildings (narrow streets and trees)		1	1	Heat wave management
120	Coruche	Regeneration and revitalization of urban centres taking into account sustainability criteria, namely through the implementation of the Sustainable Urban Mobility Plan	1	1	1	Sustainable mobility improvement
121	Coruche	Planning of residential areas, equipment, transports and communication systems and economic activities that reduce exposure and improve energy efficiency, taking into account the orientation and morphology of buildings and streets			1	Energy efficiency improvement
122	Coruche	Defining climate change adaptation measures for conservation and rehabilitation works, in the framework of the elaboration of urban rehabilitation detailed plans or municipal regulations,	1		1	Energy efficiency improvement

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
		promoting the implementation of cold roofs and the use of light colours				
123	Coruche	Defining standards for building requirements, taking into account the need for protection from extreme weather conditions. For example: insulation of walls, roofs and floors, external sunshades and improved ventilation and natural lighting	1		1	Urban design improvements
124	Coruche	Introduction of climate change adaptation measures in the Municipal Program for "supporting the improvement of housing comfort"	1		1	Energy efficiency improvement
125	Coruche	Improved communication between entities involved in land management and planning			1	Knowledge promotion (municipality officials and agents)
126	Coruche	Definition of action lines focused on demand control, supply security, protection and promotion of the good condition of water bodies, as well as risk reduction in extreme drought situations			1	Water saving
127	Coruche	Improvement of dam flow management			1	Water saving
128	Coruche	Preparation and dissemination of reports on the quantity and quality of water for public supply, particularly in drought situations, in order to limit its use for agricultural purposes in these situations			1	Water saving
129	Coruche	Protection of higher-level water lines, namely those classified as natural ecologic reserve	1	1		Water streams/aquifers sustainable management
130	Coruche	Requalification and preservation of riparian zones		1		Water streams/aquifers sustainable management
131	Coruche	Increasing urban space resilience to climate change	1	1		Urban design improvements
132	Coruche	Incentive for the creation of a water efficiency plan for industry, namely the cork industry, which uses large amounts of water in its production process	1		1	Water saving
133	Coruche	Improved communication between entities involved in water resources management			1	Knowledge promotion (municipality officials and agents)

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
134	Coruche	Promoting awareness towards the efficient use of water as a scarce natural resource			1	Water saving
135	Coruche	Improved planning for response effectiveness			1	Policy development/reviewing/implementation
136	Coruche	Articulation between the municipality, the national guard and the health administration in order to trigger measures to protect the elderly in case of extreme phenomena			1	Disaster preparedness
137	Coruche	Strengthening emergency teams with appropriate human resources and technical equipment	1		1	Disaster preparedness
138	Coruche	Harnessing solar energy	1			Energy efficiency improvement
139	Coruche	Adaptation of public and building space with the introduction of new techniques that improve thermal comfort, namely through the use of reflective materials on roofs and facades, materials that promote the cooling of outdoor pavements and the use of water to cool the urban space	1	1	1	Urban design improvements
140	Coruche	Reduction of energy requirements for climatization through rehabilitation of glazed surfaces and efficient insulation	1			Energy efficiency improvement
141	Coruche	Tax benefits for A or A+ class buildings in order to increase the number of buildings with a higher level of energy performance			1	Energy efficiency improvement
142	Coruche	Decarbonization and implementation of energy efficiency measures in public buildings	1	1	1	Energy efficiency improvement
143	Coruche	Implementation of energy efficiency measures in the municipality's social solidarity institutions	1		1	Energy efficiency improvement
144	Coruche	Implementation of energy efficiency measures in industries	1		1	Energy efficiency improvement
145	Coruche	Promotion of awareness-raising actions to adopt more energy-efficient behaviours and use of high-efficiency heating and cooling equipment.			1	Energy efficiency improvement
146	Coruche	Knowledge, information and awareness raising: promotion of participation in activities to promote and disseminate good			1	Awareness-raising (general public)

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
		practices; setting up an information sharing network and developing guides on climate change adaptation measures				
147	Coruche	Montado ecosystem protection		1	1	Ecosystem protection
148	Coruche	Local implementation of the adaptation measures defined in the [National] Climate and Agriculture Adaptation Strategy	1	1	1	Agroforestry practices
149	Coruche	Development of genetics scientific studies to increase the resistance of species (cork oak and others)			1	Knowledge promotion (municipality officials and agents)
150	Coruche	Increase the forest's resistance and resilience to fires		1		Forest fire prevention/recovery
151	Coruche	Increase the forest's resistance and resilience to biotic agents		1		Invasive species/pests management
152	Coruche	Increasing water availability through irrigation and storage, promoting efficient water use in agriculture	1	1		Water saving
153	Coruche	Strengthening the climate change adaptation component in planning documents, notably the PDM			1	Policy development/reviewing/implementation
154	Coruche	Strengthening the mechanisms and instruments needed to improve forest management and reduce abandonment			1	Agroforestry practices
155	Coruche	Incorporate appropriate responses to potential climate change impacts into the PMDFCI revision	1		1	Forest fire prevention/recovery
156	Coruche	Development of fire prevention actions, namely the execution and inspection of mandatory fuel management zones			1	Forest fire prevention/recovery
157	Coruche	Promotion of the Cork Oak and Cork Observatory, giving it a fundamental role to promote the transfer of knowledge between science and forest practice			1	Awareness-raising (general public)
158	Coruche	Development of studies and research projects at Herdade dos Concelhos			1	Knowledge promotion (municipality officials and agents)
159	Coruche	Elaboration of the study for stabilization of the Encosta do Castelo / rainwater drainage	1	1	1	Knowledge promotion (municipality officials and agents)
160	Coruche	Introduction of more efficient irrigation systems in agriculture	1			Water saving
161	Coruche	Reuse of WWTP water for irrigation	1			Water saving
162	Évora	Reduction of water contamination by diffuse discharges			1	Water streams/aquifers sustainable management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
163	Évora	Promoting vegetation in areas of maximum infiltration of the aquifer system			1	Water streams/aquifers sustainable management
164	Évora	Management of the cork oak and holm oak grove in the municipality			1	Ecosystem protection
165	Évora	Promoting the maintenance of habitats and species of flora and fauna associated with waterlines and wetlands			1	Ecosystem protection
166	Évora	Maintaining rural multifunctionality			1	Land use planning
167	Évora	Regulation of water efficiency criteria in tourism, industry, agriculture and forests			1	Water saving
168	Évora	Adoption of incentive mechanisms for the use of sustainable building measures			1	Energy efficiency improvement
169	Évora	Progressive increase in the extension of the separative urban drainage network	1			Flood prevention
170	Évora	Implementation of sustainable urban drainage systems	1	1		Flood prevention
171	Évora	Identification and reduction of pollution sources that contribute to the recurrent poor quality of the Monte Novo, Divor and Vigia reservoirs			1	Water streams/aquifers sustainable management
172	Évora	Erosion and transport control of sediment contaminated with fertilizers and pesticides from agriculture		1		Land degradation prevention
173	Évora	Restoration of water stream vegetation		1		Water streams/aquifers sustainable management
174	Évora	Strengthening of the ability to inspect the autonomous effluent treatment systems associated with rural soil uses, especially in the sub-category of the PDM "basin protection zones"			1	Water streams/aquifers sustainable management
175	Évora	Installation of water meters in all water sources for consumption in the public urban space	1			Water saving
176	Évora	Adequacy of irrigation management in gardens and other public green spaces	1			Water saving
177	Évora	Adequacy of soil management in gardens and similar areas		1		Agroforestry practices
178	Évora	Adequacy of planted species		1		Agroforestry practices

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
179	Évora	Replacing or upgrading existing irrigation systems with lower consumption systems	1			Water saving
180	Évora	Implementation of rainwater harvesting systems to feed irrigation systems	1			Water saving
181	Évora	Implementation of a municipal water loss reduction programme			1	Water saving
182	Évora	Assessment of the municipality's susceptibility to the occurrence of floods due to drainage systems overload and lack of planning, which has led to the last recorded floods			1	Knowledge promotion (municipality officials and agents)
183	Évora	Quantification of risk factors associated with the projected increase in precipitation frequency and intensity [Dissertation author's note: precipitation frequency is not projected to increase]			1	Knowledge promotion (municipality officials and agents)
184	Évora	Adequate management of occupation of higher risk areas	1		1	Land use planning
185	Évora	Improvement of flood prediction and warning systems			1	Flood prevention
186	Évora	Duct resizing	1			Flood prevention
187	Évora	Water stream cleaning		1		Water streams/aquifers sustainable management
188	Évora	Strengthening of municipal resources for the implementation of forest fire prevention and control measures			1	Forest fire prevention/recovery
189	Évora	Development of an information platform for the dissemination of available information on climate change adaptation measures to various areas and sectors			1	Awareness-raising (general public)
190	Évora	Inclusion of climate change information in municipal services			1	Awareness-raising (general public)
191	Évora	Dissemination and awareness-raising regarding efficient water use in public and domestic systems, tourism, industry, agriculture and forests			1	Awareness-raising (general public)
192	Évora	Reinforcement of forest fire awareness-raising actions			1	Awareness-raising (general public)
193	Évora	Promoting the development of sustainable economic activities			1	Economic capacitation

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
194	Ferreira do Alentejo	Develop a municipal health education plan			1	Policy development/reviewing/implementation
195	Ferreira do Alentejo	Develop an environmental education plan on climate change at the Centre for Environmental Education of Gasparões			1	Awareness-raising (general public)
196	Ferreira do Alentejo	Improvement of the Sanitation System of the municipality: construction of separate network and improvement of WWTP	1			Flood prevention
197	Ferreira do Alentejo	Develop a municipal plan for efficient water use			1	Water saving
198	Ferreira do Alentejo	Improvement of the water supply network	1			Water saving
199	Ferreira do Alentejo	Elaboration of a housing thermal intervention plan	1		1	Energy efficiency improvement
200	Ferreira do Alentejo	Creating a pedestrian path		1		Sustainable mobility improvement
201	Ferreira do Alentejo	Social/school gardens		1		Agroforestry practices
202	Ferreira do Alentejo	Maintaining and periodically updating the PIC-L			1	Monitoring
203	Ferreira do Alentejo	Developing a municipal sustainable energy plan	1		1	Energy efficiency improvement
204	Ferreira do Alentejo	Research regarding climate change and its impacts on the municipality			1	Knowledge promotion (municipality officials and agents)
205	Ferreira do Alentejo	Attribute tax benefits to the reconstruction/construction adapted to climate change			1	Urban design improvements
206	Figueira da Foz	Elaboration of a management plan for the Morraceira island			1	Policy development/reviewing/implementation
207	Figueira da Foz	Optimization and creation of municipal good practices for irrigation systems			1	Water saving
208	Figueira da Foz	Creation and improvement of water retention infrastructures for agricultural irrigation	1			Water saving
209	Figueira da Foz	Creating incentives for sustainable water use			1	Water saving

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
210	Figueira da Foz	Improvement of the urban rainwater drainage system in critical areas	1			Flood prevention
211	Figueira da Foz	Specific municipal regulation for potential flood and coastal erosion areas			1	Flood prevention
212	Figueira da Foz	Increased water points for human consumption in the urban public area, namely areas with a higher population concentration		1		Heat wave management
213	Figueira da Foz	Reorganization of the agricultural area			1	Agroforestry practices
214	Figueira da Foz	Increasing forest resistance and resilience to forest fires and adapting the PMDFCI			1	Forest fire prevention/recovery
215	Figueira da Foz	Promote the use of forest biomass			1	Energy efficiency improvement
216	Figueira da Foz	Awareness-raising for the introduction of good agricultural/forestry practices			1	Awareness-raising (general public)
217	Figueira da Foz	Forestation to prevent soil erosion in areas at risk of hydric erosion and slope instability		1		Land degradation prevention
218	Figueira da Foz	Artificial feeding of the southern beaches of the county through the desilting of the Mondego River in Figueira da Foz port channel	1			Coastal management
219	Figueira da Foz	Introduce progressive retreat in coastal areas considering criteria such as low altitude to justify and define <i>non aedificandi</i> areas			1	Coastal management
220	Figueira da Foz	Creation of a municipal detection and management system for climate events			1	Monitoring
221	Figueira da Foz	Promote training/awareness-raising sessions (within the scope of climate change adaptation options and related risks) to the population, the municipality and institutions			1	Awareness-raising (general public)
222	Figueira da Foz	Setting up a multidisciplinary team to study/plan strategies regarding climate change and related risks			1	Knowledge promotion (municipality officials and agents)
223	Figueira da Foz	Promoting soft mobility in urban areas through networks of cycling and walking paths		1		Sustainable mobility improvement

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
224	Figueira da Foz	Improving knowledge about vulnerable groups			1	Knowledge promotion (municipality officials and agents)
225	Figueira da Foz	Implementation of good practices for energy efficiency			1	Energy efficiency improvement
226	Figueira da Foz	Urban garden creation		1		Agroforestry practices
227	Figueira da Foz	Creation of an observatory of coastal zone evolution			1	Monitoring
228	Figueira da Foz	Defend and promote protected and classified areas			1	Policy development/reviewing/implementation
229	Figueira da Foz	Harnessing alternative energies: solar, wind and tidal			1	Energy efficiency improvement
230	Figueira da Foz	Promoting the land available in the municipality to increase the use of abandoned land			1	Agroforestry practices
231	Figueira da Foz	Creation of a rural land register			1	Policy development/reviewing/implementation
232	Figueira da Foz	Reorganisation of public spaces, with the introduction of autochthonous and adapted plant species, less demanding in water consumption		1		Agroforestry practices
233	Figueira da Foz	Introduction of good practices in public tree planning and management			1	Agroforestry practices
234	Funchal	Building flood protection infrastructure	1	1	1	Flood prevention
235	Funchal	Developing monitoring plans to deal with risk of extreme phenomena such as floods, heat waves and droughts.			1	Monitoring
236	Funchal	Monitor and fight emerging disease transmission vectors			1	Invasive species/pests management
237	Funchal	Develop a contingency plan for vector-borne disease outbreaks			1	Invasive species/pests management
238	Funchal	Monitor slopes			1	Monitoring
239	Funchal	Improve efficient water use and reduce waste		1	1	Water saving
240	Funchal	Develop a mobility plan that reduces traffic impact and road conditioning			1	Sustainable mobility improvement
241	Funchal	Rehabilitate and restore ecosystems after a fire through a forest management plan	1	1	1	Forest fire prevention/recovery
242	Funchal	Restructuring rainwater drainage networks	1			Flood prevention

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
243	Funchal	Promoting quality tourism			1	Tourism promotion
244	Funchal	Raise awareness and regulate to avoid/prevent construction or reconstruction in critical areas			1	Awareness-raising (general public)
245	Guimarães	Developing a strategic and tactical plan to disseminate and communicate the EMAAC			1	Awareness-raising (general public)
246	Guimarães	Creating an annual information, awareness-raising and training plan			1	Awareness-raising (general public)
247	Guimarães	Adoption of local policies and processes in the municipality to adapt to climate change			1	Policy development/reviewing/implementation
248	Guimarães	Monitoring, evaluation and surveillance of the main listed impacts			1	Monitoring
249	Guimarães	Minimize soil sealing, or when necessary, objectively assess its effects and carefully size the stormwater drainage network taking into account the capacity of the receiving water stream		1		Flood prevention
250	Guimarães	Restrain construction near water streams			1	Flood prevention
251	Guimarães	Monitoring and preservation of flood protection and defence infrastructures	1			Flood prevention
252	Guimarães	Cleaning and clearing water streams without harming the ecological system while enriching the landscape		1	1	Water streams/aquifers sustainable management
253	Guimarães	Creation, regeneration and restoration of green corridors		1		Green areas improvement/increase
254	Guimarães	Ecological restoration of water lines, bringing the population closer to them		1		Water streams/aquifers sustainable management
255	Guimarães	Promoting water reuse systems	1	1		Water saving
256	Guimarães	Creating stormwater retention systems in urban areas and conserving existing systems	1	1		Flood prevention
257	Guimarães	Improvement of water runoff conditions in critical areas	1	1		Flood prevention
258	Guimarães	Improving municipal spatial plans with specific flood zone rules			1	Flood prevention
259	Guimarães	Operationalization of the PMDFCI			1	Forest fire prevention/recovery

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			Grey	Green	Soft	
260	Guimarães	Developing the sustainable development plan			1	Policy development/reviewing/implementation
261	Guimarães	Promote (re)forestation actions with autochthonous species		1		Agroforestry practices
262	Guimarães	Creating "forest gardens"		1		Agroforestry practices
263	Guimarães	Promoting invasive species control		1		Invasive species/pests management
264	Guimarães	Use of forest biomass		1		Energy efficiency improvement
265	Guimarães	Classified areas management		1		Policy development/reviewing/implementation
266	Guimarães	Natural resource planning and management		1		Ecosystem protection
267	Guimarães	Promoting new agricultural species		1		Agroforestry practices
268	Guimarães	Specific heat wave contingency plan			1	Heat wave management
269	Guimarães	Warning system for heat waves and high solar radiation			1	Heat wave management
270	Guimarães	Pest and disease control		1		Invasive species/pests management
271	Guimarães	Promoting the cultivation of abandoned land		1		Agroforestry practices
272	Guimarães	Strengthen the importance of insurance companies and banks in financing against climate events			1	Economic capacitation
273	Ílhavo	Preparation of a municipal climate change adaptation plan that includes monitoring and revision of objectives and risks			1	Monitoring
274	Ílhavo	Artificial sediment transport and dune reinforcement	1			Coastal management
275	Ílhavo	Building a breakwater in Praia da Barra	1			Coastal management
276	Ílhavo	Extension of ripraps	1			Coastal management
277	Ílhavo	Building a detached breakwater	1			Coastal management
278	Ílhavo	Implementation of the bypassing process to feed the Praia da Barra beach	1			Coastal management
279	Ílhavo	Renaturalisation of dunes with autochthonous species		1		Coastal management
280	Ílhavo	Implementation of "emergency sand deposits"		1		Coastal management
281	Ílhavo	Implementation of a warning and prevention system for meteorological storm surge			1	Disaster preparedness

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			Grey	Green	Soft	
282	Ílhavo	Implementation of a municipal monitoring system for extreme weather phenomena			1	Monitoring
283	Ílhavo	Introduction of the concept of safeguard area in the local coastal planning/management instruments			1	Coastal management
284	Ílhavo	Recovery of the banks of Ria de Aveiro (Caminho do Praião (Gafanha da Encarnação to Vagueira); Costa Nova/Vagueira; Rua da Riamar/Praia da Barra; Cais dos Bacalhoiros/Gafanha da Nazaré; Rua do Sul (between Gafanha de Aquém and Gafanha da Boavista); Esteiro da Medela (Coutada – Aveiro) - with increase in altitude and ripraps)	1			Coastal management
285	Ílhavo	Requalification/recovery of fishing centres on the banks of Ria de Aveiro - Costa Nova; Ílhavo (Malhada, Gafanha de Aquém)	1			Land use planning
286	Ílhavo	Creation of retention basins	1			Flood prevention
287	Ílhavo	Introducing a new way of environmental education: climate change adaptation education			1	Awareness-raising (general public)
288	Ílhavo	Implementation of an action plan to clean the banks and channels of Ria de Aveiro		1		Water streams/aquifers sustainable management
289	Ílhavo	Study about the selection of crops and species that can best adapt to climate change			1	Agroforestry practices
290	Ílhavo	Water management action plan			1	Water saving
291	Ílhavo	Saline intrusion control action pan with (re)activation of tidal valves	1		1	Coastal management
292	Ílhavo	Creating terrestrial and aquatic biodiversity monitoring programs at local and regional level			1	Monitoring
293	Ílhavo	Study to identify the forest species that can best adapt to climate projections			1	Agroforestry practices
294	Ílhavo	Study to identify the main invasive species			1	Invasive species/pests management
295	Ílhavo	Study to identify less water demanding crops. Increasing the efficiency of irrigation water use (listing and disseminating more efficient irrigation techniques)			1	Agroforestry practices

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			Grey	Green	Soft	
296	Ílhavo	Wastewater use		1		Water saving
297	Ílhavo	Training and dissemination of soil conservation techniques			1	Awareness-raising (general public)
298	Ílhavo	Restrict type and size of buildings in high-risk zones			1	Coastal management
299	Ílhavo	Anticipating and minimizing possible effects of heat islands		1		Heat wave management
300	Ílhavo	Implementation of green roofs and walls		1		Green areas improvement/increase
301	Ílhavo	Implementation of different shading mechanisms in buildings	1			Urban design improvements
302	Ílhavo	Evaluation and quantification study of water use by sector in the municipality			1	Water saving
303	Ílhavo	Implementation of mandatory use of water efficiency devices in public and private buildings			1	Water saving
304	Ílhavo	Implementing plans and programmes to improve air quality, consisting of concrete implementation measures		1		Policy development/reviewing/implementation
305	Ílhavo	Promote “Eco-Urbanism” practices for the balance of urban design			1	Urban design improvements
306	Ílhavo	Implementation of dredging in the Ria		1		Water streams/aquifers sustainable management
307	Leiria	Monitor the EMAAC (continuous update of the PIC-L, revision of objectives and risks)			1	Monitoring
308	Leiria	Developing a climate change education, awareness-raising and public information program, which reaches the different sectors			1	Awareness-raising (general public)
309	Leiria	Promote awareness-raising actions to adopt more energy-efficient behaviours			1	Awareness-raising (general public)
310	Leiria	Incorporating new climate change adaptation criteria into municipal regulations, plans and projects			1	Policy development/reviewing/implementation
311	Leiria	Defining climate change adaptation measures for urban conservation and rehabilitation, as part of the elaboration of detailed plans and/or municipal regulations			1	Urban design improvements

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			Grey	Green	Soft	
312	Leiria	Creating climate change monitoring indicators. Using Leiria's PDM's strategic environmental assessment indicators for climate change			1	Monitoring
313	Leiria	Creating a fire risk reduction programme			1	Forest fire prevention/recovery
314	Leiria	Creating a municipal efficient water use programme	1		1	Water saving
315	Leiria	Creating a flood risk management plan	1		1	Flood prevention
316	Leiria	Promoting sustainable agricultural practices		1	1	Agroforestry practices
317	Leiria	Promoting the valorisation, planning and management of Vale do Lis			1	Land use planning
318	Leiria	Promoting water stream protection: municipal Green and Blue Lines	1	1		Water streams/aquifers sustainable management
319	Leiria	Contributing to sustainable coastal management, particularly by integrating the specific rules to safeguard the coastline into the municipal planning instruments		1	1	Coastal management
320	Leiria	Implementing coastal defence structures, possibly submerged (to avoid increased coastal erosion)	1			Coastal management
321	Leiria	Include monitoring, forecasting and response identification systems in Municipal Emergency Plans			1	Monitoring
322	Leiria	Preparing and disseminating reports on the quantity and quality of water for public consumption			1	Knowledge promotion (municipality officials and agents)
323	Leiria	Creating a municipal sustainable mobility plan	1		1	Sustainable mobility improvement
324	Leiria	Encouraging the use of renewable energy sources	1	1	1	Energy efficiency improvement
325	Leiria	Make hydraulic and hydrological studies for the most pressured urban zones and heavily sealed areas			1	Knowledge promotion (municipality officials and agents)
326	Leiria	Creating a working group (with several entities, including the regional directorate for agriculture and fishing of the centre) on the theme of livestock farms with the purpose of developing specific municipal regulations			1	Knowledge promotion (municipality officials and agents)
327	Leiria	Implementing the PAYT system - Pay As You Throw	1	1	1	Policy development/reviewing/implementation

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			Grey	Green	Soft	
328	Leiria	Defining a legal and economic model for possible coastal retreat measures			1	Coastal management
329	Leiria	Developing an environmental fund recycling policy in the municipality			1	Economic capacitation
330	Leiria	Begin efforts to stabilize the primary dune	1	1		Coastal management
331	Leiria	Promoting the elaboration of the municipal forestry registry to ICNF			1	Agroforestry practices
332	Leiria	Preparing a study about viable species for the municipal territory of Leiria			1	Agroforestry practices
333	Leiria	Streamlining the area and promoting the protection of peat bogs: Salinas da Junqueira	1	1		Ecosystem protection
334	Leiria	Influencing seasonality through the application to European Capital of Culture			1	Tourism promotion
335	Lisboa	Communicate with the metropolitan area in order to integrate adaptation into planning and management tools			1	Policy development/reviewing/implementation
336	Lisboa	Mapping hydrogeological resources, including a registry of underground structures			1	Water streams/aquifers sustainable management
337	Lisboa	Thermally photographing the city			1	Knowledge promotion (municipality officials and agents)
338	Lisboa	Studying the effects of extreme weather events - cold and heat waves, etc. - on different groups			1	Heat wave management
339	Lisboa	Assessing the costs of non-adaptation: cost-benefit analysis			1	Knowledge promotion (municipality officials and agents)
340	Lisboa	Studying storm surge / tide rise events			1	Coastal management
341	Lisboa	Reassessing risk exposure map taking into account the occurrence of cascading events			1	Knowledge promotion (municipality officials and agents)
342	Lisboa	Adding autonomous rainwater retention systems in the buildings and public space	1	1		Flood prevention
343	Lisboa	Introducing measures to increase the new and restored buildings' passive resilience through bioclimatic design	1	1		Urban design improvements

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			Grey	Green	Soft	
344	Lisboa	Deepening the knowledge about renewable energies that are adapted to the territory and urban morphology. Examples: harnessing geothermal energy, etc.			1	Energy efficiency improvement
345	Lisboa	Integrating technologies for harnessing solar potential through traditional ceramic tile roofs according to the "views system" (PDM).	1			Energy efficiency improvement
346	Lisboa	Integrate the sustainable urban mobility model into the various planning scales	1	1	1	Sustainable mobility improvement
347	Lisboa	Adopting land-use policies that highlight ecological potential. Example: increasing street permeability; conversion of built areas to be demolished according to the ecological structure, etc.	1	1		Green areas improvement/increase
348	Lisboa	Management of green structure adapted to the new climate scenarios: biodiversity meadows in large green areas, adapted plant species (high resistance to heat, drought, pests and diseases), adapted network and model for horticultural areas management, etc.		1		Green areas improvement/increase
349	Lisboa	Adapting public space management to the water cycle. For example: controlling the infiltration of rainwater in public space	1	1		Water saving
350	Lisboa	Reviewing regulation for the occupation of public roads (intensification of heavy rain and strong wind)			1	Flood prevention
351	Lisboa	Adapting precarious structures, street furniture and signage to strong wind	1			Urban design improvements
352	Lisboa	Promoting the municipal buildings' resilience in new construction and restoration: a) against floods (basements and ground floors); (b) by increasing passive energy efficiency; c) with the introduction of renewable energy	1			Urban design improvements
353	Lisboa	Ensuring the ease of access to information in the municipality, through the articulation of databases and dematerialization of communication			1	Knowledge promotion (municipality officials and agents)

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			Grey	Green	Soft	
354	Lisboa	Articulating data collection and registration with external entities. Examples: creating Network of Meteorological Stations shared with external entities (IPMA, FCT, etc.); optimising the warning system to the population			1	Disaster preparedness
355	Lisboa	Managing land use in order to increase occupation by naturalized spaces. Examples: conversion of building areas that are to be demolished, ensuring permeability of public places, etc.	1	1		Green areas improvement/increase
356	Lisboa	Complementing the municipal budget with external financing funds. Examples: Horizon 2020, Life Program, private entities, etc.			1	Economic capacitation
357	Lisboa	Promoting dissemination and awareness-raising actions to: accept water, prepare for heat and shelter from the wind. Target Audience: general population, parish councils, schools, etc.			1	Awareness-raising (general public)
358	Lisboa	Organising programmes for the involvement of stakeholders, especially Parish Councils, in the implementation of an integrated management model			1	Awareness-raising (general public)
359	Lisboa	Empowering the community to prevent and respond to extreme climate events.			1	Awareness-raising (general public)
360	Lisboa	Organising awareness-raising campaigns for concrete actions: cleaning of drains and downspouts; collection and reuse of rainwater in buildings, adapted urban agriculture, etc.			1	Awareness-raising (general public)
361	Lisboa	Encouraging interaction and technical exchange among the Lisbon metropolitan area municipalities			1	Knowledge promotion (municipality officials and agents)
362	Lisboa	Encouraging interaction and technical exchange across the municipality entities			1	Knowledge promotion (municipality officials and agents)
363	Lisboa	Operationalising programmes/actions to encourage adaptation. Examples: rewarding good practices, designing financing lines, tax advantages; creating the Resilience Certificate for buildings)			1	Economic capacitation

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			Grey	Green	Soft	
364	Lisboa	Promoting and providing technical support to increase the buildings' resilience (new and restored): a) against floods (basements and ground floors); b) by increasing passive energy efficiency; c) with the introduction of renewable energy			1	Urban design improvements
365	Lisboa	Implementing technical training for action through tools with SMART technology			1	Knowledge promotion (municipality officials and agents)
366	Lisboa	Encouraging/raising awareness of sustainable mobility at the Lisbon metropolitan area level.			1	Sustainable mobility improvement
367	Loulé	Developing and implementing a climate change environmental education program at the environmental centre			1	Awareness-raising (general public)
368	Loulé	Developing and implementing a climate change education, awareness-raising and public information program			1	Awareness-raising (general public)
369	Loulé	Creating the Environment Observatory			1	Awareness-raising (general public)
370	Loulé	Periodically updating the PIC-L			1	Monitoring
371	Loulé	Extending the Integrated Management System (mainly the Environmental Management System) to as many municipal services and sectors as possible.	1	1	1	Knowledge promotion (municipality officials and agents)
372	Loulé	Adjusting/tailoring the local prediction, information and alerting system (for different types of events)			1	Disaster preparedness
373	Loulé	Strengthening green spaces and promoting environmental sustainability solutions/initiatives		1		Green areas improvement/increase
374	Loulé	Extending the urban gardens project to other urban areas in the municipality		1		Agroforestry practices
375	Loulé	Defining and implementing the green seal/sustainable seal project			1	Policy development/reviewing/implementation
376	Loulé	Developing and implementing a municipal programme for the efficient use of water	1	1	1	Water saving
377	Loulé	Developing and implementing a municipal contingency plan for drought periods			1	Water saving
378	Loulé	Supporting, promoting and collaborating on climate change research projects			1	Knowledge promotion (municipality officials and agents)

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			Grey	Green	Soft	
379	Loulé	Ensuring compliance/implementation of measures set out in the PMDFCI and ensuring their review and monitoring		1	1	Forest fire prevention/recovery
380	Loulé	Developing and implementing a municipal sustainable energy action plan	1	1	1	Energy efficiency improvement
381	Loulé	Incorporating climate change adaptation criteria into municipal regulations, plans and projects			1	Policy development/reviewing/implementation
382	Loulé	Promoting panels and training sessions to raise awareness towards new and more efficient agricultural and forestry practices			1	Agroforestry practices
383	Loulé	Developing and implementing a municipal contingency plan for heat waves			1	Heat wave management
384	Loulé	Implementing and monitoring coastal area safeguard measures			1	Coastal management
385	Loulé	Implementing specific flood risk management measures	1	1	1	Flood prevention
386	Loulé	Creating, promoting and implementing innovative urban sustainability strategies	1	1	1	Policy development/reviewing/implementation
387	Loulé	Preparing a climate change adaptation plan focused on the protected areas managed by the municipality: protected landscapes of Rocha da Pena and Fonte Benémola			1	Ecosystem protection
388	Loulé	Developing and implementing a municipal plan for sustainable tourism			1	Tourism promotion
389	Loulé	Developing and implementing a municipal plan for the prevention, fight and treatment of pests and diseases in tree species			1	Invasive species/pests management
390	Loulé	Creating or supporting the creation of the sea resources observatory			1	Awareness-raising (general public)
391	Loulé	Defining and implementing a programme about the impacts of climate change on human health			1	Policy development/reviewing/implementation
392	Loulé	Including criteria that address climate change issues in public procurement procedures			1	Policy development/reviewing/implementation
393	Loulé	Rehabilitating water streams and associated riparian areas		1	1	Water streams/aquifers sustainable management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
394	Loulé	Promoting sustainable mobility in the municipality	1	1	1	Sustainable mobility improvement
395	Mafra	Annual review of the EMAAC, with the addition, if necessary, of strategy monitoring and risk management indicators			1	Monitoring
396	Mafra	Developing the awareness-raising, communication and Information sharing plan among the different agents and dissemination of the climate change problem in the various areas of municipal action			1	Awareness-raising (general public)
397	Mafra	Inclusion of climate risks into planning instruments with specific regulation			1	Policy development/reviewing/implementation
398	Mafra	Recovery of coastal and riparian areas: strengthening of dune systems and riparian areas, as well as gradual retreat in the most vulnerable coastal areas	1			Coastal management
399	Mafra	Implementation of extreme weather warning systems with emergency communication (e.g. forest defence plan, contingency plans for extreme weather)			1	Disaster preparedness
400	Mafra	Implementation of the municipal water management plan, which includes flood management through the creation or re-establishment of areas that increase retention capacity while supporting habitat and biodiversity conservation objectives			1	Flood prevention
401	Mafra	Urban planning of public spaces to improve their response to climate events: implementation of retention basins and green structures	1	1	1	Flood prevention
402	Mafra	Retreat of infrastructures located in vulnerable areas. When that is not possible, reducing flood damage by using water-resistant materials (floors, walls, window frames, etc.) and placing sensitive materials at higher altitude	1		1	Coastal management
403	Mafra	protecting agricultural and forestry spaces, which provide goods and services that contribute to the sustainable development of the municipality (e.g. preventive forestry, controlled fire, opening of traffic routes).	1	1	1	Agroforestry practices
404	Mafra	Operationalization of the plan against forest fires			1	Forest fire prevention/recovery

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
405	Mafra	Improving efficient water use (type and time of watering) with reduced water losses (maintenance and distribution)	1		1	Water saving
406	Mafra	Implementation of regulatory measures to protect against erosion through tree plantation			1	Land degradation prevention
407	Mafra	Monitoring the implementation of the PDM (creation of additional indicators)			1	Monitoring
408	Mafra	Implementing the urban ecological structure			1	Green areas improvement/increase
409	Montalegre	Environmental education and awareness-raising - prevention due to Montalegre's climate events. Climate change adaptation for the school community.			1	Awareness-raising (general public)
410	Montalegre	Awareness-raising actions for the general public			1	Awareness-raising (general public)
411	Montalegre	Monitoring, evaluation and surveillance of the main inventoried impacts			1	Monitoring
412	Montalegre	Green infrastructure / urban afforestation		1		Green areas improvement/increase
413	Montalegre	Sustainable forest management		1		Agroforestry practices
414	Montalegre	PMDFCI operationalization			1	Forest fire prevention/recovery
415	Montalegre	Use of forest biomass		1		Energy efficiency improvement
416	Montalegre	Planning and management of water stream resources		1		Water streams/aquifers sustainable management
417	Montalegre	Promoting the introduction of new forest and agricultural species		1		Agroforestry practices
418	Montalegre	Specific heat wave contingency plan			1	Heat wave management
419	Montalegre	Pest and agroforestry diseases control		1		Invasive species/pests management
420	Montalegre	Enhancing the cultivation/use of abandoned land		1		Agroforestry practices
421	Montalegre	Heat wave and high solar radiation warning systems			1	Heat wave management
422	Montalegre	Fighting the appearance of species (insects) and the consequent increase of their life cycles caused by heatwaves		1		Invasive species/pests management
423	Montalegre	Determining heat thresholds based on local climate and health data			1	Heat wave management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
424	Montalegre	Recovery and maintenance of the water supply infrastructure	1			Water saving
425	Montalegre	Adoption of an efficient water use tariff			1	Water saving
426	Montalegre	Identification of urban areas that are more likely to be affected by periods of heavy precipitation			1	Flood prevention
427	Montalegre	Improvement of run-off conditions in critical areas	1			Flood prevention
428	Montalegre	Forest fire fighting plan			1	Forest fire prevention/recovery
429	Montalegre	Creation of new groves		1		Green areas improvement/increase
430	Montalegre	Improving water use efficiency in agroforestry activities and reducing losses		1		Water saving
431	Montalegre	Production and promotion of new regional products			1	Agroforestry practices
432	Montalegre	Creating water supply alternatives	1			Water saving
433	Montalegre	Identifying new tourist activities taking into consideration the projected climate change			1	Tourism promotion
434	Montalegre	Create new tourism products for the newly identified opportunities			1	Tourism promotion
435	Montalegre	Reduction of losses in water distribution through investment in infrastructure recovery and maintenance	1			Water saving
436	Montalegre	Creation and monitoring of study areas to research specific species		1	1	Knowledge promotion (municipality officials and agents)
437	Montalegre	Protection of botanical/biodiversity-rich areas that have been little disturbed by fires and invasive plants		1	1	Ecosystem protection
438	Montalegre	Develop databases, strengthen monitoring, prevention of forest pests and diseases		1	1	Invasive species/pests management
439	Montalegre	Study the introduction of agricultural species according to projected changes		1		Agroforestry practices
440	Montalegre	Monitoring the invasion by exotic species of areas with great ecological value that were affected by a fire		1		Invasive species/pests management
441	Montalegre	Establishing a schedule for the control and removal of invasive species through various methods - physical, chemical...		1		Invasive species/pests management

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			Grey	Green	Soft	
442	Montalegre	Ensure proper air conditioning of the health centre and nursing homes	1		1	Heat wave management
443	Montalegre	Awareness-raising for good dietary, hygienic and solar-protection practices			1	Awareness-raising (general public)
444	Montalegre	Reducing the risk of fire		1	1	Forest fire prevention/recovery
445	Montalegre	Promoting forest management			1	Agroforestry practices
446	Montalegre	Promoting the control of invasive plants		1		Invasive species/pests management
447	Montalegre	Erosion protection		1		Land degradation prevention
448	Montalegre	Rehabilitation of streams, riparian areas and wetlands		1		Water streams/aquifers sustainable management
449	Montalegre	Improvement of energy efficiency in municipal buildings/equipment (e.g. municipal swimming pools)	1			Energy efficiency improvement
450	Montalegre	Defining and implementing a strategy to improve street lighting efficiency			1	Energy efficiency improvement
451	Odemira	Continuous identification and monitoring of climate change risks and impacts			1	Monitoring
452	Odemira	Improving the robustness and integration of knowledge in planning instruments			1	Knowledge promotion (municipality officials and agents)
453	Odemira	Decreasing losses in water transportation and supply	1			Water saving
454	Odemira	Resize and adapt infrastructures, making them more robust	1			Urban design improvements
455	Odemira	Consolidation of unstable slopes and cliffs		1		Coastal management
456	Odemira	Enhance biodiversity habitats and agro-silvo-pastoral spaces by increasing water retention capacity in soils, thus reducing the risk of desertification and the occurrence of fires and floods		1		Ecosystem protection
457	Odemira	Promoting communication between entities to optimize the hydrographic area's infrastructures			1	Knowledge promotion (municipality officials and agents)
458	Odemira	Promoting good practices for construction and urban design, improving resilience and energy/environmental sustainability		1		Energy efficiency improvement
459	Odemira	Introducing gradual retreat in the most vulnerable coastal areas	1			Coastal management

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			Grey	Green	Soft	
460	Odemira	Promoting the diversification of the local economy by highlighting local resources			1	Policy development/reviewing/implementation
461	Porto	Limiting the occupation of the most vulnerable coastal areas through the design and implementation of incentive and compensation conditions for retreating and/or seasonal moving. This reduction in urban pressure will reduce vulnerability and improve the seafront.			1	Coastal management
462	Porto	Developing and implementing a Spatial Plan of the Coastal Zone (under preparation by the Portuguese Environment Agency)			1	Coastal management
463	Porto	Developing a coastal protection and defence plan to deal with sea level rise and the increased frequency of coastal overtopping	1			Coastal management
464	Porto	Limiting the occupation of the most vulnerable riverside areas through the design and implementation of incentive and compensation conditions for the gradual retreating of at-risk structures. This reduction in urban pressure will reduce vulnerability and improve the water streams			1	Water streams/aquifers sustainable management
465	Porto	Limiting urban occupation in areas at risk of landslides			1	Land use planning
466	Porto	Developing and updating the Municipal Ecological Structure (to integrate in the next PDM) to ensure: i) conservation and creation of greater connectivity between ecological structures; ii) reducing the distances of citizens to green spaces for recreation and leisure; iii) promotion of vertical gardens and green solutions in height (roofs and facades); iv) creation of partnerships to transform private spaces into leisure facilities that can be accessed by the population; v) conversion and permeabilization of squares or pocket gardens			1	Green areas improvement/increase
467	Porto	Developing and implementing strategic plans of water supply and drainage (domestic wastewater, stormwater, streams and beaches) for hydraulic adaptation to climate change and	1			Flood prevention

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
		improvement of structural and runoff conditions in critical areas (bridges, aqueducts) and other bottlenecks)				
468	Porto	Developing and implementing the Porto water streams recovery and rehabilitation plan using the best natural engineering practices	1			Water streams/aquifers sustainable management
469	Porto	Developing a water sensitive urban design good practice guide, encouraging the use of infrastructures and practices that combine towards a naturalized perspective of the urban water cycle (increased permeable surfaces, creation of retention basins, urban afforestation, green roofs, bioretention, biofiltration and raingardens) and implementing incentive and compensation measures - green economy - at the public and private level		1		Knowledge promotion (municipality officials and agents)
470	Porto	Developing a drainage network maintenance and operation plan (domestic wastewater, rainwater and water streams)	1			Flood prevention
471	Porto	Developing a technology platform to monitor the urban water cycle	1			Monitoring
472	Porto	Promoting the visual and landscape requalification of the escarpment landscape - tourist business card			1	Coastal management
473	Porto	Integrating a groundwater usage programme into the municipal management operations (cleaning and irrigation) using wells	1			Water saving
474	Porto	Developing a plan for rainwater use and treated wastewater reuse for multiple uses (irrigation, garden cleaning)	1			Water saving
475	Porto	Implementing a programme for the automation of irrigation systems in order to reduce water consumption	1			Water saving
476	Porto	Keep a gravitational water supply system in the city of Porto (Porto Gravitic Project)	1			Energy efficiency improvement
477	Porto	Keep the unbilled water reduction plan	1			Water saving
478	Porto	Adopt a tariff system that encourages water-efficiency			1	Water saving

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
479	Porto	Increasing the permeable surface area of the municipality (through a riparian ecosystem renaturalisation programme, raingardens, drainage paving solutions, etc.)		1		Flood prevention
480	Porto	Implementing a tree-planting, blue infrastructure programme to reduce CO ₂ concentration and minimize the heat island phenomena		1		Heat wave management
481	Porto	Implementing a native vegetation expansion programme in selected urban areas (Porto green belt and Porto Biolab / autochthonous grove in Quinta de Salgueiros)		1		Agroforestry practices
482	Porto	Extending the network of community gardens as a way of ensuring the gradual permeabilization of the land		1		Agroforestry practices
483	Porto	Mapping climatic phenomena at the municipal level, particularly the "heat islands"			1	Monitoring
484	Porto	Developing diagnose study and control plan for invasive/exotic species			1	Invasive species/pests management
485	Porto	Developing a special natural hazard emergency plan for the protection of people, assets and natural heritage, producing risk mapping (most vulnerable trees, urban flooding, coastal overtopping, landslides in slopes, heat/cold waves)			1	Knowledge promotion (municipality officials and agents)
486	Porto	Promoting the clarification of the responsibilities and area of action of each of the entities in an emergency context, under the coordination of municipal Civil Protection services, through the elaboration of intervention plans for different risk situations in adverse weather conditions			1	Knowledge promotion (municipality officials and agents)
487	Porto	Investing in an autonomous weather forecasting and monitoring network to increase the reliability of forecasting of extreme weather events at local scale, in collaboration with other entities (e.g. IPMA)			1	Monitoring
488	Porto	Developing a contingency plan to cope with extreme temperatures – heat waves and cold waves			1	Heat wave management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
489	Porto	Implementing a programme to monitor and evaluate the evolution of each of the extreme events; this will be done by each of the entities involved, in order to define warnings			1	Disaster preparedness
490	Porto	Supporting and improving formal and informal assistance networks for the population that is most vulnerable to extreme events (homeless and isolated elderly people)			1	Disaster preparedness
491	Porto	Developing a control and monitoring plan of the phytosanitary state of the city's trees			1	Monitoring
492	Porto	Implementing a programme for improving thermal comfort in hospitals, nursing homes and nurseries	1			Energy efficiency improvement
493	Porto	Ensuring response readiness in hospitals and complementary social support network, in order to cope with the high demand of emergency services due to extreme events			1	Disaster preparedness
494	Porto	Promoting the study of the potential increase in vector-borne disease/outbreaks (mosquitoes, sand-flies, ticks and fleas) or others that are enhanced by climate change			1	Knowledge promotion (municipality officials and agents)
495	Porto	Implementing a prevention and/or contingency program to address vector-borne disease/outbreaks (mosquitoes, sand-flies, ticks and fleas) or others that are enhanced by climate change			1	Invasive species/pests management
496	Porto	Integrating energy sustainability measures and building adaptation strategies in municipal plans; through the use of incentive systems/binding regulations and positive hierarchy/discrimination over the most vulnerable buildings			1	Energy efficiency improvement
497	Porto	Mapping "thermal behaviour", "adaptive capacity", "potential impact", "current and future vulnerability" indicators for buildings at statistical subsection scale			1	Knowledge promotion (municipality officials and agents)
498	Porto	Creating a municipal guide with information on measures/recommendations/incentive system/binding regulation			1	Awareness-raising (general public)
499	Porto	Ensuring that new or rehabilitated municipal buildings (services and social housing) are examples of energy	1			Energy efficiency improvement

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
		sustainability and tend to be autonomous. Buildings should surpass what is required by legislation and meet future challenges				
500	Porto	Converting the municipal fleet of cars with up to 70% of electric vehicles			1	Energy efficiency improvement
501	Porto	Implementing mobility programme to prioritize access for emergency vehicles			1	Disaster preparedness
502	Porto	Pedestrianize streets	1			Sustainable mobility improvement
503	Porto	Expanding the cycling network	1			Sustainable mobility improvement
504	Porto	Increasing thermal comfort in the most vulnerable residential areas by minimizing the use of conventional energy sources	1			Energy efficiency improvement
505	Porto	Implementing an Information and awareness-raising programme for the prevention of vector-borne diseases (mosquitoes, sand-flies, ticks and fleas)			1	Invasive species/pests management
506	Porto	Implementing an information and awareness-raising programme for the prevention of allergies			1	Awareness-raising (general public)
507	Porto	Implementing an information and awareness-raising programme for the prevention of sunlight exposure and melanomas			1	Heat wave management
508	Porto	Continuing the information and awareness-raising programme to promote tap water consumption			1	Water saving
509	Porto	Implementing an Information and awareness-raising programme for introducing climate change into the educational process of the school community, focusing on water education (urban water cycle)			1	Water saving
510	Porto	Implementing an Information and awareness-raising programme about sectoral emergency plans			1	Awareness-raising (general public)
511	Porto	Implementing an Information and awareness-raising programme for identification of invasive species and prevention of the release of exotic animals into the wild			1	Invasive species/pests management

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			Grey	Green	Soft	
512	Porto	Implementing an Information and awareness-raising programme for the plantation of native species in private gardens by offering trees			1	Agroforestry practices
513	São João da Pesqueira	Creating stormwater retention systems in urban areas (e.g. retention basins)	1			Flood prevention
514	São João da Pesqueira	Restoring the municipal sanitation system: construction of separative system and restoration of WWTP	1			Flood prevention
515	São João da Pesqueira	Restoration of water supply network	1			Water saving
516	São João da Pesqueira	Planning and management of water stream systems (e.g. conservation of fishery resources and their ecosystems)			1	Water streams/aquifers sustainable management
517	São João da Pesqueira	Bicycle path and pedestrian path along the Douro river: implementation of a cycling network in the municipality, prioritising the connections between the main leisure areas, sports equipment and riverside area	1			Sustainable mobility improvement
518	São João da Pesqueira	Creating shading outside buildings (e.g. planting trees, shade covers between buildings)	1	1		Heat wave management
519	São João da Pesqueira	Planning new urban areas, taking into account the orientation/morphology of buildings and streets (for solar radiation control and promotion of passive ventilation)			1	Energy efficiency improvement
520	São João da Pesqueira	Improvements in buildings (e.g. social buildings): reflective materials on roofs and facades to avoid temperature increases in the warm season	1			Energy efficiency improvement
521	São João da Pesqueira	Improvements in buildings (e.g. social buildings): Insulation of walls, roofs, floors, windows and window frames to reduce energy losses in the cold season.	1			Energy efficiency improvement
522	São João da Pesqueira	Increasing green spaces (e.g. creating "green corridors")		1		Green areas improvement/increase
523	São João da Pesqueira	Cleaning and conservation of water streams and requalification of riparian areas		1		Water streams/aquifers sustainable management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
524	São João da Pesqueira	Reorganization/planning of the agricultural area			1	Agroforestry practices
525	São João da Pesqueira	Operationalization of the PMDFCI		1		Forest fire prevention/recovery
526	São João da Pesqueira	Soil protection against erosion (e.g. increased vegetation cover)		1		Land degradation prevention
527	São João da Pesqueira	Recovery and restoration of ecosystems after fires		1		Forest fire prevention/recovery
528	São João da Pesqueira	Increasing the continuity of naturalized areas in the urban context; implementation of the ecological structure (PDM) as proposed by the local action plan for biodiversity		1		Green areas improvement/increase
529	São João da Pesqueira	Education and awareness-raising of the citizens regarding climate change			1	Awareness-raising (general public)
530	São João da Pesqueira	Heat wave contingency plan (including a heat wave and high radiation warning system)			1	Heat wave management
531	São João da Pesqueira	Dissemination of reports on the quantity and quality of water for public supply, particularly in drought situations where its use should be limited (e.g. for agricultural purposes)			1	Water saving
532	São João da Pesqueira	Improvement of the water resource planning and management processes in urban, agricultural, forestry, industrial and touristic areas			1	Water streams/aquifers sustainable management
533	São João da Pesqueira	Introducing adaptation measures in the urban conservation and restoration sector, within the scope of municipal regulations			1	Urban design improvements
534	São João da Pesqueira	Developing GIS for environmental monitoring in the municipality (e.g. urban vegetation)			1	Monitoring
535	São João da Pesqueira	Implementation of a shared weather station network			1	Monitoring
536	São João da Pesqueira	Studying and controlling invasive species (e.g. pest disinfestation)			1	Invasive species/pests management
537	São João da Pesqueira	Integration of the EMAAC in the planning instruments at the time of the PDM revision			1	Policy development/reviewing/implementation

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			Grey	Green	Soft	
538	São João da Pesqueira	Mapping risk			1	Knowledge promotion (municipality officials and agents)
539	São João da Pesqueira	Monitoring and fighting disease transmission vectors			1	Invasive species/pests management
540	São João da Pesqueira	Promoting the renovation of dwellings (neighbourhoods and blocks) through incentives and collaboration with stakeholders			1	Urban design improvements
541	São João da Pesqueira	Creating municipal guides with information on, for example, bioclimatic measures and building adaptation strategies			1	Urban design improvements
542	Seia	Increasing the resilience to forest fires. Building and managing mandatory fuel management zones	1			Forest fire prevention/recovery
543	Seia	Increasing the resilience to forest fires. Forest road network management	1			Forest fire prevention/recovery
544	Seia	Increasing the resilience to forest fires. Improving forest fire surveillance and detection			1	Forest fire prevention/recovery
545	Seia	Increasing the resilience to forest fires. Developing fire fighting process	1			Forest fire prevention/recovery
546	Seia	Increasing the resistance and resilience of forest areas to fires. Forest species pattern recomposition		1		Forest fire prevention/recovery
547	Seia	Increasing the resistance and resilience of forest areas to fires. Rural land management (streamlining the agro-silvo-pastoral landscape matrix)		1		Forest fire prevention/recovery
548	Seia	Supporting research and land use management practices that are appropriate for the local climate change conditions (agricultural, forestry), seizing the opportunities		1		Agroforestry practices
549	Seia	Improving the efficiency of agricultural irrigation systems	1			Water saving
550	Seia	Improving the efficiency of water supply and sanitation systems	1			Water saving
551	Seia	Increasing the efficiency of irrigation systems in urban green areas (includes changing the species composition)	1	1		Water saving
552	Seia	Actively protecting riparian ecosystems		1		Water streams/aquifers sustainable management

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			Grey	Green	Soft	
553	Seia	Developing and implementing a monitoring and control plan for invasive species and pests		1	1	Invasive species/pests management
554	Seia	Developing and implementing a building thermal comfort plan - Public buildings	1	1	1	Heat wave management
555	Seia	Developing and implementing a building thermal comfort plan - Dwellings	1	1	1	Heat wave management
556	Seia	Developing and implementing a plan for the development of thermal comfort solutions in non-built public urban spaces	1	1	1	Heat wave management
557	Seia	Implementing a road restoration plan regarding drainage (collector system dimensioning) and slope stabilization. Characterization, diagnosis, requalification and maintenance	1			Flood prevention
558	Seia	Developing and implementing a tourist image redefinition plan related to snow			1	Tourism promotion
559	Seia	Creating a municipal structure for climate change knowledge and dissemination: Climate House			1	Awareness-raising (general public)
560	Seia	Developing and implementing a climate change awareness-raising dissemination plan			1	Awareness-raising (general public)
561	Seia	Installing a network of local weather stations			1	Monitoring
562	Tomar	Developing an environmental education programme on climate change			1	Awareness-raising (general public)
563	Tomar	Improve the environmental interpretation centre's action regarding awareness-raising about climate change among citizens			1	Awareness-raising (general public)
564	Tomar	Creation and maintenance of a database of extreme weather events/impacts of the municipality			1	Monitoring
565	Tomar	Strengthening the municipality's green structure		1		Green areas improvement/increase
566	Tomar	Creating an "urban gardens" project		1		Agroforestry practices
567	Tomar	Management plan for the efficient use of water			1	Water saving
568	Tomar	Municipal drought contingency plan	1		1	Water saving

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
569	Tomar	Heat waves Municipal Plan		1	1	Heat wave management
570	Tomar	Strengthening of the PMDFCI		1	1	Forest fire prevention/recovery
571	Tomar	Elaboration of management plans for the Rio Nabão dams		1	1	Water streams/aquifers sustainable management
572	Tomar	Preparation of an energy efficiency plan	1		1	Energy efficiency improvement
573	Tomar	Rainwater drainage network resizing	1			Flood prevention
574	Tomar	Continuous training and updating of officials on climate change issues			1	Knowledge promotion (municipality officials and agents)
575	Tondela	Inclusion of climate change in municipal regulations, plans and projects			1	Policy development/reviewing/implementation
576	Tondela	Adoption of local policies and processes in the municipality to adapt to climate change			1	Policy development/reviewing/implementation
577	Tondela	PIC-L annual update, systematization of all information			1	Monitoring
578	Tondela	Improving communication between all stakeholders involved in land management and planning			1	Knowledge promotion (municipality officials and agents)
579	Tondela	Creation of a municipal emergency plan, with monitoring, forecasting and response systems			1	Monitoring
580	Tondela	Enhancing the implementation of a municipal plan through GIS			1	Policy development/reviewing/implementation
581	Tondela	Strengthening/operationalization of the PMDFCI, incorporating appropriate responses to climate change impacts			1	Forest fire prevention/recovery
582	Tondela	Increasing resilience to forest fires			1	Forest fire prevention/recovery
583	Tondela	Risk mapping			1	Knowledge promotion (municipality officials and agents)
584	Tondela	Strengthening of the tools and mechanisms to improve environmental management and reduce abandonment			1	Land use planning
585	Tondela	Developing fire prevention actions through inspection of fuel management zones			1	Forest fire prevention/recovery
586	Tondela	Flood risk management plan			1	Flood prevention

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
587	Tondela	Reduction of impermeable areas		1		Flood prevention
588	Tondela	Protection of water streams, namely those classified as a national ecological reserve			1	Water streams/aquifers sustainable management
589	Tondela	Creation of water retention infrastructures, namely retention basins for agriculture and forestry			1	Flood prevention
590	Tondela	Developing a climate change education, awareness-raising and information programme for all sectors			1	Awareness-raising (general public)
591	Tondela	Improve/increase planning towards response effectiveness			1	Policy development/reviewing/implementation
592	Tondela	Information/forecasting and warning systems			1	Disaster preparedness
593	Torres Vedras	Identifying and scheduling retreat of built areas that are exposed to sea level rise and floods			1	Coastal management
594	Torres Vedras	Reducing the risk for the built areas that are to be kept	1			Coastal management
595	Torres Vedras	Incorporating risk into planning instruments to ensure gradual compatibility between uses and risk factors			1	Policy development/reviewing/implementation
596	Torres Vedras	Planning relocation and building techniques for infrastructure and equipment located in vulnerable areas such as the coastline	1			Coastal management
597	Torres Vedras	Improving the responsiveness of urban public spaces to climate events by incorporating adaptive solutions in the design		1		Urban design improvements
598	Torres Vedras	Strengthening the importance and operating conditions of the green corridors, especially those that integrate urban systems		1		Green areas improvement/increase
599	Torres Vedras	Creating a fund or insurance that covers uses and activities whose location involves additional maintenance costs due to risk			1	Economic capacitation
600	Torres Vedras	Increasing the resilience and/or adaptive capacity of buildings and structures related to economic activities (such as greenhouses and livestock), through technical and building solutions	1			Urban design improvements
601	Torres Vedras	Strengthening the resilience of dune systems to ensure coastal protection		1		Coastal management
602	Torres Vedras	Producing a drainage plan for the city of Torres Vedras	1	1		Flood prevention

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			Grey	Green	Soft	
603	Torres Vedras	Implementing a municipal risk warning system for extreme weather events			1	Disaster preparedness
604	Torres Vedras	Implementing PMDFCI measures and actions to increase fire risk resilience		1	1	Forest fire prevention/recovery
605	Torres Vedras	Diversifying agricultural and forestry production based on climate change and the resulting soil conditions		1		Agroforestry practices
606	Torres Vedras	Enhancing the tourism opportunities in the municipality due to the increase in temperature, reducing the effects of seasonality and diversifying the supply			1	Tourism promotion
607	Torres Vedras	Implementing a climate change awareness-raising and communication plan, including the possibility of one extracurricular activity in the 1st cycle being about climate change			1	Awareness-raising (general public)
608	Torres Vedras	Creating autonomous emergency communications system			1	Disaster preparedness
609	Torres Vedras	Creating local energy production and storage solutions to cope with outages due to extreme events	1			Energy efficiency improvement
610	Torres Vedras	Implementing municipal water management plan			1	Water saving
611	Torres Vedras	Developing a municipal strategy for nature protection and biodiversity promotion			1	Ecosystem protection
612	Torres Vedras	Promoting the integration of climate change issues in the different areas of municipal action			1	Knowledge promotion (municipality officials and agents)
613	Viana do Castelo	Creating an information, awareness-raising and training plan			1	Awareness-raising (general public)
614	Viana do Castelo	Adopting local policies and processes that promote climate change adaptation in the municipality			1	Knowledge promotion (municipality officials and agents)
615	Viana do Castelo	Monitoring and evaluating key impacts by defining indicators and methodology			1	Monitoring
616	Viana do Castelo	Restricting certain uses, occupation and transformation of the coastal area			1	Coastal management
617	Viana do Castelo	Monitoring and preserving infrastructures for coastal defence and protection	1			Coastal management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
618	Viana do Castelo	Study sedimentary movements and sand replacement. Desilting rivers and estuaries	1			Water streams/aquifers sustainable management
619	Viana do Castelo	Restore and preserve dune systems, their fauna and flora		1		Coastal management
620	Viana do Castelo	Promoting, maintaining and creating beach accessibility alternatives (bike path, walkways, buses, etc.), limiting parking and using more appropriate materials		1		Sustainable mobility improvement
621	Viana do Castelo	Improving riparian areas, wetlands and riverbanks. Clean and clear water lines (Rio Lima)		1		Water streams/aquifers sustainable management
622	Viana do Castelo	Promoting efficient water use, reducing losses and using recycled water through distribution systems for less demanding uses		1	1	Water saving
623	Viana do Castelo	Promoting water supply alternatives (e.g. rainwater retention) and recovery, improvement and conservation of water retention infrastructures, including for agricultural irrigation		1		Water saving
624	Viana do Castelo	Improving runoff conditions in critical areas	1	1		Flood prevention
625	Viana do Castelo	Creating specific rules for potential flooding and high winds areas (licensing)			1	Flood prevention
626	Viana do Castelo	Promoting the implementation of permeable areas		1		Flood prevention
627	Viana do Castelo	Operationalising the PMDFCI		1		Forest fire prevention/recovery
628	Viana do Castelo	Promoting forest management			1	Agroforestry practices
629	Viana do Castelo	Promoting the planting of autochthonous (more adapted and less combustible) species, generating species diversity and fuel management mosaics		1		Forest fire prevention/recovery
630	Viana do Castelo	Promote invasive species control		1		Invasive species/pests management

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
631	Viana do Castelo	Using forest biomass		1		Energy efficiency improvement
632	Viana do Castelo	Promoting the management of protected and classified areas		1		Policy development/reviewing/implementation
633	Viana do Castelo	Studying the viability of new fishing, floral and agricultural species (new opportunities)		1		Agroforestry practices
634	Viana do Castelo	Controlling pests and diseases		1		Invasive species/pests management
635	Viana do Castelo	Recovering burnt areas and preventing soil erosion in forest areas		1		Forest fire prevention/recovery
636	Viana do Castelo	Developing a sustainable mobility plan			1	Sustainable mobility improvement
637	Viana do Castelo	Implementing a cycling path network in urban and surrounding areas		1		Sustainable mobility improvement
638	Viana do Castelo	Adapting public and private buildings to renewable energy. Promoting energy efficiency of buildings	1	1		Energy efficiency improvement
639	Viana do Castelo	Adapting tourism promotion to climate change, enhancing local produce and landscapes			1	Tourism promotion
640	Viana do Castelo	Implementation of a study of Human Phenomenology due to the impacts of climate change			1	Knowledge promotion (municipality officials and agents)
641	Viana do Castelo	Contingency plans - Identifying older and more vulnerable people			1	Disaster preparedness
642	Viana do Castelo	Improving energy efficiency in street lighting	1	1		Energy efficiency improvement
643	Vila Franca do Campo	Slope monitoring			1	Monitoring
644	Vila Franca do Campo	Restructuring of rainwater drainage networks	1			Flood prevention
645	Vila Franca do Campo	Reduction of the effects of flood water flow	1			Flood prevention

#	Municipality	Adaptation option (translated to English)	Category			Adaptation option (cluster)
			Grey	Green	Soft	
646	Vila Franca do Campo	Creation of measures for the promotion and protection of natural retention, regulating runoff and promoting infiltration		1		Flood prevention
647	Vila Franca do Campo	Creation of adaptation measures in the agricultural sector		1		Agroforestry practices
648	Vila Franca do Campo	Promoting tourism in order to enhance the opportunities created by climate change			1	Tourism promotion
649	Vila Franca do Campo	Improving bathing water quality			1	Coastal management
650	Vila Franca do Campo	Promoting aquaculture as a means of minimizing climate change impacts on fisheries and the canning industry	1			Aquaculture choices adaptation
651	Vila Franca do Campo	Public awareness-raising about the EMAAC			1	Awareness-raising (general public)
652	Vila Franca do Campo	EMAAC revision/reviewing			1	Monitoring
653	Vila Franca do Campo	Building and urbanization			1	Urban design improvements

Annex III

List of 653 adaptation options identified by the 27 municipalities, listed by the adaptation option cluster they were integrated in.

Adaptation option (cluster)	#	Adaptation option (translated to English)
Agroforestry practices	12	Promoting the planting of autochthonous species
	44	Analysis and definition of a group of tree and shrub species to be preferentially used in both municipal and private projects, in the context of the elaboration of the Good Practices Manual
	63	Promoting forest management - giving priority to autochthonous species, creating mosaics, placing water points, etc.
	66	Promoting cultivation of alternative agricultural species adapted to climate change
	67	Promoting an increase in the area of worked (not abandoned) agricultural land
	76	Promoting forest management
	79	Adaptation of subsistence agriculture and farms to prolonged dry climate
	93	Promoting and dissemination of good agricultural and forestry cultivation practices
	109	Promoting the use of vegetation species with lower water use needs in the municipality's green spaces
	148	Local implementation of the adaptation measures defined in the [National] Climate and Agriculture Adaptation Strategy
	154	Strengthening the mechanisms and instruments needed to improve forest management and reduce abandonment
	177	Adequacy of soil management in gardens and similar areas
	178	Adequacy of planted species
	201	Social/school gardens
	213	Reorganization of the agricultural area
	226	Urban garden creation
	230	Promoting the land available in the municipality to increase the use of abandoned land
	232	Reorganisation of public spaces, with the introduction of autochthonous and adapted plant species, less demanding in water consumption
	233	Introduction of good practices in public tree planning and management
	261	Promote (re)forestation actions with autochthonous species
262	Creating "forest gardens"	
267	Promoting new agricultural species	
271	Promoting the cultivation of abandoned land	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Agroforestry practices	289	Study about the selection of crops and species that can best adapt to climate change
	293	Study to identify the forest species that can best adapt to climate projections
	295	Study to identify less water demanding crops. Increasing the efficiency of irrigation water use (listing and disseminating more efficient irrigation techniques)
	316	Promoting sustainable agricultural practices
	331	Promoting the elaboration of the municipal forestry registry to ICNF
	332	Preparing a study about viable species for the municipal territory of Leiria
	374	Extending the urban gardens project to other urban areas in the municipality
	382	Promoting panels and training sessions to raise awareness towards new and more efficient agricultural and forestry practices
	403	protecting agricultural and forestry spaces, which provide goods and services that contribute to the sustainable development of the municipality (e.g. preventive forestry, controlled fire, opening of traffic routes).
	413	Sustainable forest management
	417	Promoting the introduction of new forest and agricultural species
	420	Enhancing the cultivation/use of abandoned land
	431	Production and promotion of new regional products
	439	Study the introduction of agricultural species according to projected changes
	445	Promoting forest management
	481	Implementing a native vegetation expansion programme in selected urban areas (Porto green belt and Porto Biolab / Autochthonous grove in Quinta de Salgueiros)
	482	Extending the network of community gardens as a way of ensuring the gradual permeabilization of the land
	512	Implementing an Information and awareness-raising programme for the plantation of native species in private gardens by offering trees
	524	Reorganization/planning of the agricultural area
	548	Supporting research and land use management practices that are appropriate for the local climate change conditions (agricultural, forestry), seizing the opportunities
566	Creating a "urban gardens" project	
605	Diversifying agricultural and forestry production based on climate change and the resulting soil conditions	
628	Promoting forest management	
633	Studying the viability of new fishing, floral and agricultural species (new opportunities)	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Agroforestry practices	647	Creation of adaptation measures in the agricultural sector
Aquaculture choices adaptation	650	Promoting aquaculture as a means of minimizing climate change impacts on fisheries and the canning industry
Awareness-raising (general public)	1	Raising awareness to the population by encouraging behavioural change, disseminating measures and clarifying good management practices
	9	Creating Best Practice Guide
	21	Education and awareness raising on climate change adaptation in schools and for the general population
	46	Implementation of an annual training and awareness-raising plan
	68	Develop and implement an annual plan of education, awareness-raising and training of the population
	87	Implementation of a climate change/adaptation awareness-raising information programme
	104	Information, education and awareness-raising
	146	Knowledge, information and awareness raising; promotion of participation in activities to promote and disseminate good practices; setting up an information sharing network and developing guides on climate change adaptation measures
	157	Promotion of the Cork Oak and Cork Observatory, giving it a fundamental role to promote the transfer of knowledge between science and forest practice
	189	Development of an information platform for the dissemination of available information on climate change adaptation measures to various areas and sectors
	190	Inclusion of climate change information in municipal services
	191	Dissemination and awareness-raising regarding efficient water use in public and domestic systems, tourism, industry, agriculture and forests
	192	Reinforcement of forest fire awareness-raising actions
	195	Develop an environmental education plan on climate change at the Centre for Environmental Education of Gasparões
	216	Awareness-raising for the introduction of good agricultural/forestry practices
	221	Promote training/awareness-raising sessions (within the scope of climate change adaptation options and related risks) to the population, the municipality and institutions
	244	Raise awareness and regulate to avoid/prevent construction or reconstruction in critical areas
	245	Developing a strategic and tactical plan to disseminate and communicate the EMAAC
246	Creating an annual information, awareness-raising and training plan	
287	Introducing a new way of environmental education: climate change adaptation education	
297	Training and dissemination of soil conservation techniques	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Awareness-raising (general public)	308	Developing a climate change education, awareness-raising and public information program, which reaches the different sectors
	309	Promote awareness-raising actions to adopt more energy-efficient behaviours
	357	Promoting dissemination and awareness-raising actions to: accept water, prepare for heat and shelter from the wind. Target Audience: general population, parish councils, schools, etc.
	358	Organising programmes for the involvement of stakeholders, especially Parish Councils, in the implementation of an integrated management model
	359	Empowering the community to prevent and respond to extreme climate events.
	360	Organising awareness-raising campaigns for concrete actions: cleaning of drains and downspouts; collection and reuse of rainwater in buildings, adapted urban agriculture, etc.
	367	Developing and implementing a climate change environmental education program at the environmental centre
	368	Developing and implementing a climate change education, awareness-raising and public information program
	369	Creating the Environment Observatory
	390	Creating or supporting the creation of the sea resources observatory
	396	Developing the awareness-raising, communication and Information sharing plan among the different agents and dissemination of the climate change problem in the various areas of municipal action
	409	Environmental education and awareness-raising - prevention due to Montalegre's climate events. Climate change adaptation for the school community.
	410	Awareness-raising actions for the general public
	443	Awareness-raising for good dietary, hygienic and solar-protection practices
	498	Creating a municipal guide with information on measures / recommendations / incentive system / binding regulation
	506	Implementing an information and awareness-raising programme for the prevention of allergies
	510	Implementing an Information and awareness-raising programme about sectoral emergency plans
	529	Education and awareness-raising of the citizens regarding climate change
	559	Creating a municipal structure for climate change knowledge and dissemination: Climate House
	560	Developing and implementing a climate change awareness-raising dissemination plan
562	Developing an environmental education programme on climate change	
563	Improve the environmental interpretation centre's action regarding awareness-raising about climate change among citizens	
590	Developing a climate change education, awareness-raising and information programme for all sectors	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Awareness-raising (general public)	607	Implementing a climate change awareness-raising and communication plan, including the possibility of one extracurricular activity in the 1st cycle being about climate change
	613	Creating an information, awareness-raising and training plan
	651	Public awareness-raising about the EMAAC
Coastal management	24	Coastal protection systems to prevent the progressive sea level rise, consistent with the projected risks
	218	Artificial feeding of the southern beaches of the county through the desilting of the Mondego River in Figueira da Foz port channel
	219	Introduce progressive retreat in coastal areas considering criteria such as low altitude to justify and define <i>non aedificandi</i> areas
	274	Artificial sediment transport and dune reinforcement
	275	Building a breakwater in Praia da Barra
	276	Extension of ripraps
	277	Building a detached breakwater
	278	Implementation of the bypassing process to feed the Praia da Barra beach
	279	Renaturalisation of dunes with autochthonous species
	280	Implementation of "emergency sand deposits"
	283	Introduction of the concept of safeguard area in the local coastal planning/management instruments
	284	Recovery of the banks of Ria de Aveiro (Caminho do Praião (Gafanha da Encarnação to Vagueira); Costa Nova/Vagueira; Rua da Riamar/Praia da Barra; Cais dos Bacalhoeiros/Gafanha da Nazaré; Rua do Sul (between Gafanha de Aquém and Gafanha da Boavista); Esteiro da Medela (Coutada – Aveiro) - with increase in altitude and ripraps)
	291	Saline intrusion control action pan with (re)activation of tidal valves
	298	Restrict type and size of buildings in high-risk zones
	319	Contributing to sustainable coastal management, particularly by integrating the specific rules to safeguard the coastline into the municipal planning instruments
	320	Implementing coastal defence structures, possibly submerged (to avoid increased coastal erosion)
	328	Defining a legal and economic model for possible coastal retreat measures
330	Begin efforts to stabilize the primary dune	
340	Studying storm surge / tide rise events	
384	Implementing and monitoring coastal area safeguard measures	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Coastal management	398	Recovery of coastal and riparian areas: strengthening of dune systems and riparian areas, as well as gradual retreat in the most vulnerable coastal areas
	402	Retreat of infrastructures located in vulnerable areas. When that is not possible, reducing flood damage by using water resistant materials (floors, walls, window frames, etc.) and placing sensitive materials at higher altitude
	455	Consolidation of unstable slopes and cliffs
	459	Introducing gradual retreat in the most vulnerable coastal areas
	461	Limiting the occupation of the most vulnerable coastal areas through the design and implementation of incentive and compensation conditions for retreating and/or seasonal moving. This reduction in urban pressure will reduce vulnerability and improve the seafront.
	462	Developing and implementing a Spatial Plan of the Coastal Zone (under preparation by the Portuguese Environment Agency)
	463	Developing a coastal protection and defence plan to deal with sea level rise and the increased frequency of coastal overtopping
	472	Promoting the visual and landscape requalification of the escarpment landscape - tourist business card
	593	Identifying and scheduling retreat of built areas that are exposed to sea level rise and floods
	594	Reducing the risk for the built areas that are to be kept
	596	Planning relocation and building techniques for infrastructure and equipments located in vulnerable areas such as the coastline
	601	Strengthening the resilience of dune systems to ensure coastal protection
	616	Restricting certain uses, occupation and transformation of the coastal area
	617	Monitoring and preserving infrastructures for coastal defence and protection
	619	Restore and preserve dune systems, their fauna and flora
649	Improving bathing water quality	
Cold spell management	80	Choosing snow and ice resistant pavements
	81	Acquisition of means of forecasting, signalling and responding to weather events such as snow or ice
Disaster preparedness	7	Flood risk management plan and heatwave management plan
	136	Articulation between the municipality, the national guard and the health administration in order to trigger measures to protect the elderly in case of extreme phenomena
	137	Strengthening emergency teams with appropriate human resources and technical equipment
	281	Implementation of a warning and prevention system for meteorological storm surge

Adaptation option (cluster)	#	Adaptation option (translated to English)
Disaster preparedness	354	Articulating data collection and registration with external entities. Examples: creating Network of Meteorological Stations shared with external entities (IPMA, FCT, etc.); optimising the warning system to the population
	372	Adjusting/tailoring the local prediction, information and alerting system (for different types of events)
	399	Implementation of extreme weather warning systems with emergency communication (e.g. forest defence plan, contingency plans for extreme weather)
	489	Implementing a programme to monitor and evaluate the evolution of each of the extreme events; this will be done by each of the entities involved, in order to define warnings
	490	Supporting and improving formal and informal assistance networks for the population that is most vulnerable to extreme events (homeless and isolated elderly people)
	493	Ensuring response readiness in hospitals and complementary social support network, in order to cope with high demand of emergency services due to extreme events
	501	Implementing mobility programme to prioritize access for emergency vehicles
	592	Information/forecasting and warning systems
	603	Implementing municipal risk warning system for extreme weather events
	608	Creating autonomous emergency communications system
	641	Contingency plans - Identifying older and more vulnerable people
Economic capacitation	38	Strengthen the importance of insurance companies and banks in financing against the impacts of climate events
	193	Promoting the development of sustainable economic activities
	272	Strengthen the importance of insurance companies and banks in financing against climate events
	329	Developing an environmental fund recycling policy in the municipality
	356	Complementing the municipal budget with external financing funds. Examples: Horizon 2020, Life Program, private entities, etc.
	363	Operationalising programmes/actions to encourage adaptation. Examples: rewarding good practices, designing financing lines, tax advantages; creating the Resilience Certificate for buildings)
	599	Creating a fund or insurance that covers uses and activities whose location involves additional maintenance costs due to risk
Ecosystem protection	113	Preservation of natural resources (water and soil), particularly areas of high soil permeability
	147	Montado ecosystem protection
	164	Management of the cork oak and holm oak grove in the municipality
	165	Promoting the maintenance of habitats and species of flora and fauna associated with waterlines and wetlands
	266	Natural resource planning and management

Adaptation option (cluster)	#	Adaptation option (translated to English)
Ecosystem protection	333	Streamlining the area and promoting the protection of peat bogs: Salinas da Junqueira
	387	Preparing a climate change adaptation plan focused on the protected areas managed by the municipality: protected landscapes of Rocha da Pena and Fonte Benémola
	437	Protection of botanical/biodiversity rich areas that have been little disturbed by fires and invasive plants
	456	Enhance biodiversity habitats and agro-silvo-pastoral spaces by increasing water retention capacity in soils, thus reducing the risk of desertification and the occurrence of fires and floods
	611	Developing a municipal strategy for nature protection and biodiversity promotion
Energy efficiency improvement	8	Promoting the discarding of leftovers without burning
	10	Create Municipal Guides with information on bioclimatic measures and adaptation strategies for buildings (public and private)
	16	Implementing measures to promote energy efficiency
	17	Promoting the use of environmentally friendly energy sources (solar, wind and hydric)
	32	Creating guides with information on bioclimatic measures and adaptation strategies in public and private buildings
	58	Promoting bioclimatic and energy efficient construction
	62	Promoting the use of forest biomass (water heating, pellets, etc.)
	89	Creation of the Municipal Program for the efficient use and exploitation of renewable energy
	92	Promoting the use of forest biomass
	111	Promote the improvement of the building's energy efficiency
	121	Planning of residential areas, equipments, transports and communication systems and economic activities that reduce exposure and improve energy efficiency, taking into account the orientation and morphology of buildings and streets
	122	Defining climate change adaptation measures for conservation and rehabilitation works, in the framework of the elaboration of urban rehabilitation detailed plans or municipal regulations, promoting the implementation of cold roofs and the use of light colours
	124	Introduction of climate change adaptation measures in the Municipal Program for "supporting the improvement of housing comfort"
	138	Harnessing solar energy
	140	Reduction of energy requirements for climatization through rehabilitation of glazed surfaces and efficient insulation
141	Tax benefits for A or A+ class buildings in order to increase the number of buildings with a higher level of energy performance	
142	Decarbonization and implementation of energy efficiency measures in public buildings	
143	Implementation of energy efficiency measures in the municipality's social solidarity institutions	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Energy efficiency improvement	144	Implementation of energy efficiency measures in industries
	145	Promotion of awareness-raising actions to adopt more energy-efficient behaviours and use of high-efficiency heating and cooling equipment.
	168	Adoption of incentive mechanisms for the use of sustainable building measures
	199	Elaboration of a housing thermal intervention plan
	203	Developing a municipal sustainable energy plan
	215	Promote the use of forest biomass
	225	Implementation of good practices for energy efficiency
	229	Harnessing alternative energies: solar, wind and tidal
	264	Use of forest biomass
	324	Encouraging the use of renewable energy sources
	344	Deepening the knowledge about renewable energies that are adapted to the territory and urban morphology. Examples: harnessing geothermal energy, etc.
	345	Integrating technologies for harnessing solar potential through traditional ceramic tile roofs according to the "views system" (PDM).
	380	Developing and implementing a municipal sustainable energy action plan
	415	Use of forest biomass
	449	Improvement of energy efficiency in municipal buildings/equipment (e.g. municipal swimming pools)
	450	Defining and implementing a strategy to improve street lighting efficiency
	458	Promoting good practices for construction and urban design, improving resilience and energy/environmental sustainability
	476	Keep a gravitational water supply system in the city of Porto (Porto Gravitic Project)
	492	Implementing a programme for improving thermal comfort in hospitals, nursing homes and nurseries
	496	Integrating energy sustainability measures and building adaptation strategies in municipal plans; through the use of incentive systems/binding regulations and positive hierarchy/discrimination over the most vulnerable buildings
499	Ensuring that new or rehabilitated municipal buildings (services and social housing) are examples of energy sustainability and tend to be autonomous. Buildings should surpass what is required by legislation and meet future challenges	
500	Converting the municipal fleet of cars with up to 70% of electric vehicles	
504	Increasing thermal comfort in the most vulnerable residential areas by minimizing the use of conventional energy sources	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Energy efficiency improvement	519	Planning new urban areas, taking into account the orientation/morphology of buildings and streets (for solar radiation control and promotion of passive ventilation)
	520	Improvements in buildings (e.g. social buildings): reflective materials on roofs and facades to avoid temperature increases in the warm season
	521	Improvements in buildings (e.g. social buildings): Insulation of walls, roofs, floors, windows and window frames to reduce energy losses in the cold season.
	572	Preparation of an energy efficiency plan
	609	Creating local energy production and storage solutions to cope with outages due to extreme events
	631	Using forest biomass
	638	Adapting public and private buildings to renewable energy. Promoting energy efficiency of buildings
	642	Improving energy efficiency in street lighting
Flood prevention	14	Creating mechanisms for the municipality and the general population to highlight the importance of rainwater harvesting and drainage systems, in the natural environment, in surface and buried networks; through awareness, inspection, registration, maintenance, design and expansion scaled for the future
	22	Water retention basin systems (rural areas / dispersed housing)
	23	Urban stormwater control systems
	26	Flood prevention in the Ribeira de Coia basin
	40	Creation of a monitoring system for the streams of rivers and areas that might be flooded (tunnels)
	47	Creating retention basins upstream of the city (Sete Fontes Park; Rio Este Valley), Rio Torto (Real, Dume and Frossos)
	50	Integration between the sustainable drainage systems (bio-gutters or others) and the existing or planned rainwater drainage network
	51	Promoting the development of urban design options: creation of infiltration gardens / retention basins / conversion of waterproof pavements
	74	Improvement of run-off conditions in critical areas and creation of specific rules for potential flood areas and high winds
	91	Rehabilitation/extension of natural and artificial drainage systems in rural and urban areas
	99	Cartography elaboration, identifying the areas with the highest degree of flood risk
	100	Restrict the installation of infrastructure in areas with high degree of flood risk
	101	Replacement/widening of the culvert located on Mercado Street, for the transportation of the Ameixoeira stream in Póvoa e Meadas
	102	Adaptation/resizing of rainwater collectors

Adaptation option (cluster)	#	Adaptation option (translated to English)
Flood prevention	106	Preparation of contingency plan for flooding scenarios
	169	Progressive increase in the extension of the separative urban drainage network
	170	Implementation of sustainable urban drainage systems
	185	Improvement of flood prediction and warning systems
	186	Duct resizing
	196	Improvement of the Sanitation System of the municipality: construction of separative network and improvement of WWTP
	210	Improvement of the urban rainwater drainage system in critical areas
	211	Specific municipal regulation for potential flood and coastal erosion areas
	234	Building flood protection infrastructure
	242	Restructuring rainwater drainage networks
	249	Minimize soil sealing, or when necessary, objectively assess its effects and carefully size the stormwater drainage network taking into account the capacity of the receiving water stream
	250	Restrain construction near water streams
	251	Monitoring and preservation of flood protection and defence infrastructures
	256	Creating stormwater retention systems in urban areas and conserving existing systems
	257	Improvement of water runoff conditions in critical areas
	258	Improving municipal spatial plans with specific flood zone rules
	286	Creation of retention basins
	315	Creating a flood risk management plan
	342	Adding autonomous rainwater retention systems in the buildings and public space
	350	Reviewing regulation for the occupation of public roads (intensification of heavy rain and strong wind)
	385	Implementing specific flood risk management measures
400	Implementation of the municipal water management plan, which includes flood management through the creation or re-establishment of areas that increase retention capacity while supporting habitat and biodiversity conservation objectives	
401	Urban planning of public spaces to improve their response to climate events: implementation of retention basins and green structures	
426	Identification of urban areas that are more likely to be affected by periods of heavy precipitation	
427	Improvement of run-off conditions in critical areas	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Flood prevention	467	Developing and implementing strategic plans of water supply and drainage (domestic wastewater, stormwater, streams and beaches) for hydraulic adaptation to climate change and improvement of structural and runoff conditions in critical areas (bridges, aqueducts) and other bottlenecks)
	470	Developing a drainage network maintenance and operation plan (domestic wastewater, rainwater and water streams)
	479	Increasing the permeable surface area of the municipality (through a riparian ecosystem renaturalisation programme, raingardens, drainage paving solutions, etc.)
	513	Creating stormwater retention systems in urban areas (e.g. retention basins)
	514	Restoring the municipal sanitation system: construction of separative system and restoration of WWTP
	557	Implementing a road restoration plan regarding drainage (collector system dimensioning) and slope stabilization. Characterization, diagnosis, requalification and maintenance
	573	Rainwater drainage network resizing
	586	Flood risk management plan
	587	Reduction of impermeable areas
	589	Creation of water retention infrastructures, namely retention basins for agriculture and forestry
	602	Producing drainage plan for the city of Torres Vedras
	624	Improving runoff conditions in critical areas
	625	Creating specific rules for potential flooding and high winds areas (licensing)
	626	Promoting the implementation of permeable areas
	Forest fire prevention/recovery	75
77		Promoting plantation with autochthonous (more adapted and less combustible) species, creating species diversity and fuel management mosaics
84		Restructuring of the PMDFCI
98		Restrict the installation of infrastructures in areas with fire hazard equal to or higher than that stated in current legislation.
105		Preparation of contingency plan for forest fires
110		Promoting the plantation of autochthonous forest species, adapted to the season and resistant to forest fires, in the areas with the highest fire risk in the municipality

Adaptation option (cluster)	#	Adaptation option (translated to English)
Forest fire prevention/recovery	150	Increase the forest's resistance and resilience to fires
	155	Incorporate appropriate responses to potential climate change impacts into the PMDFCI revision
	156	Development of fire prevention actions, namely the execution and inspection of mandatory fuel management zones
	188	Strengthening of municipal resources for the implementation of forest fire prevention and control measures
	214	Increasing forest resistance and resilience to forest fires and adapting the PMDFCI
	241	Rehabilitate and restore ecosystems after a fire through a forest management plan
	259	Operationalization of the PMDFCI
	313	Creating a fire risk reduction programme
	379	Ensuring compliance/implementation of measures set out in the PMDFCI and ensuring their review and monitoring
	404	Operationalization of the plan against forest fires
	414	PMDFCI operationalization
	428	Forest fire fighting plan
	444	Reducing the risk of fire
	525	Operationalization of the PMDFCI
	527	Recovery and restoration of ecosystems after fires
	542	Increasing the resilience to forest fires. Building and managing mandatory fuel management zones
	543	Increasing the resilience to forest fires. Forest road network management
	544	Increasing the resilience to forest fires. Improving forest fire surveillance and detection
	545	Increasing the resilience to forest fires. Developing fire fighting process
	546	Increasing the resistance and resilience of forest areas to fires. Forest species pattern recomposition
	547	Increasing the resistance and resilience of forest areas to fires. Rural land management (streamlining the agrosilvopastoral landscape matrix)
	570	Strengthening of the PMDFCI
	581	Strengthening/operationalization of the PMDFCI, incorporating appropriate responses to climate change impacts
582	Increasing resilience to forest fires	
585	Developing fire prevention actions through inspection of fuel management zones	
604	Implementing PMDFCI measures and actions to increase fire risk resilience	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Forest fire prevention/recovery	627	Operationalising the PMDFCI
	629	Promoting the planting of autochthonous (more adapted and less combustible) species, generating species diversity and fuel management mosaics
	635	Recovering burnt areas and preventing soil erosion in forest areas
Green areas improvement/increase	4	Rehabilitating and implementing green corridors
	15	Creating more green spaces in and around rustic soils
	27	Green infrastructures "green corridors"
	28	Urban forestation
	29	Sustainable forest management (Machada National Forest)
	53	Addition of vegetation-based shading elements into the most open and busy streets
	54	Promoting the increase and diversification of green spaces, including vertical gardens and green roofs
	90	Creation/expansion of green spaces and urban gardens
	253	Creation, regeneration and restoration of green corridors
	300	Implementation of green roofs and walls
	347	Adopting land-use policies that highlight ecological potential. Example: increasing street permeability; conversion of built areas to be demolished according to the ecological structure, etc.
	348	Management of green structure adapted to the new climate scenarios: biodiversity meadows in large green areas, adapted plant species (high resistance to heat, drought, pests and diseases), adapted network and model for horticultural areas management, etc.
	355	Managing land use in order to increase occupation by naturalized spaces. Examples: conversion of building areas that are to be demolished, ensuring permeability of public places, etc.
	373	Strengthening green spaces and promoting environmental sustainability solutions/initiatives
	408	Implementing the urban ecological structure
412	Green infrastructure / urban afforestation	
429	Creation of new groves	
466	Developing and updating the Municipal Ecological Structure (to integrate in the next PDM) to ensure: i) conservation and creation of greater connectivity between ecological structures; ii) reducing the distances of citizens to green spaces for recreation and leisure; iii) promotion of vertical gardens and green solutions in height (roofs and facades); iv) creation of partnerships to transform private spaces into leisure facilities that can be accessed by the population; v) conversion and permeabilization of squares or pocket gardens	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Green areas improvement/increase	522	Increasing green spaces (e.g. creating "green corridors")
	528	Increasing the continuity of naturalized areas in the urban context; implementation of the ecological structure (PDM) as proposed by the local action plan for biodiversity
	565	Strengthening the municipality's green structure
	598	Strengthening the importance and operating conditions of the green corridors, especially those that integrate urban systems
Heatwave management	33	Heatwave contingency plan
	34	Creation of specific urban spaces to reduce the impact of heatwaves
	35	Heatwave and high solar radiation warning system
	55	Promotion of shading areas, in artificial structures built in critical areas
	56	Addition of evaporative cooling solutions (such as sprinklers and water mirrors) in green spaces and open public areas
	119	Promotion of favourable conditions for atmospheric circulation and air temperature control, especially in urban areas, through the use of green elements on roofs and facades and shading outside buildings (narrow streets and trees)
	212	Increased water points for human consumption in the urban public area, namely areas with a higher population concentration
	268	Specific heatwave contingency plan
	269	Warning system for heatwaves and high solar radiation
	299	Anticipating and minimizing possible effects of heat islands
	338	Studying the effects of extreme weather events - cold and heatwaves, etc. - on different groups
	383	Developing and implementing a municipal contingency plan for heatwaves
	418	Specific heatwave contingency plan
	421	Heatwave and high solar radiation warning systems
	423	Determining heat thresholds based on local climate and health data
	442	Ensure proper air conditioning of the health centre and nursing homes
	480	Implementing a tree-planting, blue infrastructure programme to reduce CO ₂ concentration and minimize the heat island phenomena
488	Developing a contingency plan to cope with extreme temperatures - heatwaves and cold waves	
507	Implementing an information and awareness-raising programme for the prevention of sunlight exposure and melanomas	
518	Creating shading outside buildings (e.g. planting trees, shade covers between buildings)	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Heatwave management	530	Heatwave contingency plan (including a heatwave and high radiation warning system)
	554	Developing and implementing a building thermal comfort plan - Public buildings
	555	Developing and implementing a building thermal comfort plan - Dwellings
	556	Developing and implementing a plan for the development of thermal comfort solutions in non-built public urban spaces
	569	Heatwaves Municipal Plan
Invasive species/pests management	13	Invasive species eradication plan
	36	Pest disinfection plan
	37	Fighting the appearing of species (insects) and the increase in their life cycles caused by heatwaves
	64	Promoting control of invasive species, pests and diseases
	151	Increase the forest's resistance and resilience to biotic agents
	236	Monitor and fight emerging disease transmission vectors
	237	Develop a contingency plan for vector-borne disease outbreaks
	263	Promoting invasive species control
	270	Pest and disease control
	294	Study to identify the main invasive species
	389	Developing and implementing a municipal plan for the prevention, fight and treatment of pests and diseases in tree species
	419	Pest and agroforestry diseases control
	422	Fighting the appearance of species (insects) and the consequent increase of their life cycles caused by heatwaves
	438	Develop databases, strengthen monitoring, prevention of forest pests and diseases
	440	Monitoring the invasion by exotic species of areas with great ecological value that were affected by fire
	441	Establishing a schedule for the control and removal of invasive species through various methods - physical, chemical...
	446	Promoting the control of invasive plants
	484	Developing diagnose study and control plan for invasive/exotic species
495	Implementing a prevention and/or contingency program to address vector-borne disease / outbreaks (mosquitoes, ticks and fleas) or others that are enhanced by climate change	
505	Implementing an Information and awareness-raising programme for the prevention of vector-borne diseases (mosquitoes, sand-flies, ticks and fleas)	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Invasive species/pests management	511	Implementing an Information and awareness-raising programme for identification of invasive species and prevention of the release of exotic animals into the wild
	536	Studying and controlling invasive species (e.g. pest disinfestation)
	539	Monitoring and fighting disease transmission vectors
	553	Developing and implementing a monitoring and control plan for invasive species and pests
	630	Promote invasive species control
	634	Controlling pests and diseases
Knowledge promotion (municipality officials and agents)	3	Developing new functionalities on the GIS
	6	Creating a multidisciplinary team in order to improve environmental performance
	25	Studying the impact of the projected sea level rise (above the current altitude of Barreiro's outskirts territory)
	39	Creation of a municipal civil protection centre
	43	Production of a municipal good practice manual
	45	Elaboration of a 'Climate Change Susceptibility map' in GIS for the municipality
	69	Adoption of local policies and processes in the municipality to adapt to climate change
	95	Implementation of a study of Human Phenomenology due to the impacts of climate change
	97	Creation of an EMAAC municipal monitoring council
	125	Improved communication between entities involved in land management and planning
	133	Improved communication between entities involved in water resources management
	149	Development of genetics scientific studies to increase the resistance of species (cork oak and others)
	158	Development of studies and research projects at Herdade dos Concelhos
	159	Elaboration of the study for stabilization of the Encosta do Castelo / rainwater drainage
	182	Assessment of the municipality's susceptibility to the occurrence of floods due to drainage systems overload and lack of planning, which has led to the last recorded floods
	183	Quantification of risk factors associated with the projected increase in precipitation frequency and intensity [Dissertation author's note: precipitation frequency is not projected to increase]
	204	Research regarding climate change and its impacts on the municipality
222	Setting up a multidisciplinary team to study/plan strategies regarding climate change and related risks	
224	Improving knowledge about vulnerable groups	
322	Preparing and disseminating reports on the quantity and quality of water for public consumption	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Knowledge promotion (municipality officials and agents)	325	Make hydraulic and hydrological studies for the most pressured urban zones and heavily sealed areas
	326	Creating a working group (with several entities, including the regional directorate for agriculture and fishing of the centre) on the theme of livestock farms with the purpose of developing specific municipal regulations
	337	Thermally photographing the city
	339	Assessing the costs of non-adaptation: cost-benefit analysis
	341	Reassessing risk exposure map taking into account the occurrence of cascading events
	353	Ensuring the ease of access to information in the municipality, through the articulation of databases and dematerialization of communication
	361	Encouraging interaction and technical exchange among the Lisbon metropolitan area municipalities
	362	Encouraging interaction and technical exchange across the municipality entities
	365	Implementing technical training for action through tools with SMART technology
	371	Extending the Integrated Management System (mainly the Environmental Management System) to as many municipal services and sectors as possible.
	378	Supporting, promoting and collaborating on climate change research projects
	436	Creation and monitoring of study areas to research specific species
	452	Improving the robustness and integration of knowledge in planning instruments
	457	Promoting communication between entities to optimize the hydrographic area's infrastructures
	469	Developing a water sensitive urban design good practice guide, encouraging the use of infrastructures and practices that combine towards a naturalized perspective of the urban water cycle (increased permeable surfaces, creation of retention basins, urban afforestation, green roofs, bioretention, biofiltration and raingardens) and implementing incentive and compensation measures - green economy - at the public and private level
	485	Developing a special natural hazard emergency plan for the protection of people, assets and natural heritage, producing risk mapping (most vulnerable trees, urban flooding, coastal overtopping, land slides in slopes, heat/cold waves)
	486	Promoting the clarification of the responsibilities and area of action of each of the entities in an emergency context, under the coordination of municipal Civil Protection services, through the elaboration of intervention plans for different risk situations in adverse weather conditions
	494	Promoting the study of the potential increase in vector-borne disease / outbreaks (mosquitoes, sand-flies, ticks and fleas) or others that are enhanced by climate change
	497	Mapping "thermal behaviour", "adaptive capacity", "potential impact", "current and future vulnerability" indicators for buildings at statistical subsection scale
	538	Mapping risk
574	Continuous training and updating of officials on climate change issues	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Knowledge promotion (municipality officials and agents)	578	Improving communication between all stakeholders involved in land management and planning
	583	Risk mapping
	612	Promoting the integration of climate change issues in the different areas of municipal action
	614	Adopting local policies and processes that promote climate change adaptation in the municipality
	640	Implementation of a study of Human Phenomenology due to the impacts of climate change
Land degradation prevention	52	Creation of areas of bushes on slopes that are more susceptible to hydric erosion
	172	Erosion and transport control of sediment contaminated with fertilizers and pesticides from agriculture
	217	Forestation to prevent soil erosion in areas at risk of hydric erosion and slope instability
	406	Implementation of regulatory measures to protect against erosion through tree plantation
	447	Erosion protection
	526	Soil protection against erosion (e.g. increased vegetation cover)
Land use planning	112	Sustainable and rational land use, minimizing GHG emissions and intensifying their removal by sinks
	166	Maintaining rural multifunctionality
	184	Adequate management of occupation of higher risk areas
	285	Requalification/recovery of fishing centres on the banks of Ria de Aveiro - Costa Nova; Ílhavo (Malhada, Gafanha de Aquém)
	317	Promoting the valorisation, planning and management of Vale do Lis
	465	Limiting urban occupation in areas at risk of land slides
	584	Strengthening of the tools and mechanisms to improve environmental management and reduce abandonment
Monitoring	19	Developing indicators for monitoring, reviewing and risk prevention in the context of EMAAC
	41	Monitoring of air quality (O ₃) and weather parameters
	42	Tree health monitoring
	70	Preparation and Implementation of a plan for monitoring, evaluating and surveilling the main inventoried impacts
	82	EMAAC monitoring, including review of objectives and risks
	96	Implementation of a database system of weather events, their effects and causes in the municipal territory (PIC-L)
	116	Development of indicators for monitoring climate change adaptation options under the PDM revision
	117	Creation of a monitoring, forecasting and response system - early warning and warning systems in the municipal emergency plan

Adaptation option (cluster)	#	Adaptation option (translated to English)
Monitoring	202	Maintaining and periodically updating the PIC-L
	220	Creation of a municipal detection and management system for climate events
	227	Creation of an observatory of coastal zone evolution
	235	Developing monitoring plans to deal with risk of extreme phenomena such as floods, heatwaves and droughts.
	238	Monitor slopes
	248	Monitoring, evaluation and surveillance of the main listed impacts
	273	Preparation of a municipal climate change adaptation plan that includes monitoring and revision of objectives and risks
	282	Implementation of a municipal monitoring system for extreme weather phenomena
	292	Creating terrestrial and aquatic biodiversity monitoring programs at local and regional level
	307	Monitor the EMAAC (continuous update of the PIC-L, revision of objectives and risks)
	312	Creating climate change monitoring indicators. Using Leiria's PDM's strategic environmental assessment indicators for climate change
	321	Include monitoring, forecasting and response identification systems in Municipal Emergency Plans
	370	Periodically updating the PIC-L
	395	Annual review of the EMAAC, with the addition, if necessary, of strategy monitoring and risk management indicators
	407	Monitoring the implementation of the PDM (creation of additional indicators)
	411	Monitoring, evaluation and surveillance of the main inventoried impacts
	451	Continuous identification and monitoring of climate change risks and impacts
	471	Developing a technology platform to monitor the urban water cycle
	483	Mapping climatic phenomena at the municipal level, particularly the "heat islands"
	487	Investing in an autonomous weather forecasting and monitoring network to increase the reliability of forecasting of extreme weather events at local scale, in collaboration with other entities (eg IPMA)
	491	Developing a control and monitoring plan of the phytosanitary state of the city's trees
	534	Developing GIS for environmental monitoring in the municipality (e.g. urban vegetation)
535	Implementation of a shared weather station network	
561	Installing a network of local weather stations	
564	Creation and maintenance of a database of extreme weather events / impacts of the municipality	
577	PIC-L annual update, systematization of all information	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Monitoring	579	Creation of a municipal emergency plan, with monitoring, forecasting and response systems
	615	Monitoring and evaluating key impacts by defining indicators and methodology
	643	Slope monitoring
	652	EMAAC revision/reviewing
Policy development/reviewing/ implementation	78	Management of protected and classified areas
	83	PDM review, taking into account the integration of EMAAC
	85	Revision of special plans
	86	Adaptation of the Castelo Branco Municipal Civil Protection Emergency Plan
	94	Consolidation of protected and classified areas
	114	EMAAC integration in planning documents, notably in the PDM revision
	115	Integration of Climate Change in the strategic environmental evaluation of Coruche's PDM revision
	135	Improved planning for response effectiveness
	153	Strengthening the climate change adaptation component in planning documents, notably the PDM
	194	Develop a municipal health education plan
	206	Elaboration of a management plan for the Morraceira island
	228	Defend and promote protected and classified areas
	231	Creation of a rural land register
	247	Adoption of local policies and processes in the municipality to adapt to climate change
	260	Developing the sustainable development plan
	265	Classified areas management
	304	Implementing plans and programmes to improve air quality, consisting of concrete implementation measures
	310	Incorporating new climate change adaptation criteria into municipal regulations, plans and projects
	327	Implementing the PAYT system - Pay As You Throw
	335	Communicate with the metropolitan area in order to integrate adaptation into planning and management tools
375	Defining and implementing the green seal/sustainable seal project	
381	Incorporating climate change adaptation criteria into municipal regulations, plans and projects	
386	Creating, promoting and implementing innovative urban sustainability strategies	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Policy development/reviewing/ implementation	391	Defining and implementing a programme about the impacts of climate change on human health
	392	Including criteria that address climate change issues in public procurement procedures
	397	Inclusion of climate risks into planning instruments with specific regulation
	460	Promoting the diversification of the local economy by highlighting local resources
	537	Integration of the EMAAC in the planning instruments at the time of the PDM revision
	575	Inclusion of climate change in municipal regulations, plans and projects
	576	Adoption of local policies and processes in the municipality to adapt to climate change
	580	Enhancing the implementation of a municipal plan through GIS
	591	Improve/increase planning towards response effectiveness
	595	Incorporating risk into planning instruments to ensure gradual compatibility between uses and risk factors
	632	Promoting the management of protected and classified areas
	Sustainable mobility improvement	2
11		Promoting the dissemination and exchange of experiences regarding sustainable mobility, such as the “Do The Right Mix” campaigns and the European Mobility Week
18		Creating parking lots on the outskirts
65		Implementation of an integrated mobility plan to effectively reduce the use of individual motorized transportation, promoting commuting in public transports and soft mobility (cycling and walking)
120		Regeneration and revitalization of urban centres taking into account sustainability criteria, namely through the implementation of the Sustainable Urban Mobility Plan
200		Creating a pedestrian path
223		Promoting soft mobility in urban areas through networks of cycling and walking paths
240		Develop a mobility plan that reduces traffic impact and road conditioning
323		Creating a municipal sustainable mobility plan
346		Integrate the sustainable urban mobility model into the various planning scales
366		Encouraging/raising awareness of sustainable mobility at the Lisbon metropolitan area level.
394		Promoting sustainable mobility in the municipality
502		Pedestrianize streets
503		Expanding the cycling network

Adaptation option (cluster)	#	Adaptation option (translated to English)
Sustainable mobility improvement	517	Bicycle path and pedestrian path along the Douro river: implementation of a cycling network in the municipality, prioritising the connections between the main leisure areas, sports equipment and riverside area
	620	Promoting, maintaining and creating beach accessibility alternatives (bike path, walkways, buses, etc.), limiting parking and using more appropriate materials
	636	Developing the sustainable mobility plan
	637	Implementing a cycling path network in urban and surrounding areas
Tourism promotion	243	Promoting quality tourism
	334	Influencing seasonality through the application to European Capital of Culture
	388	Developing and implementing a municipal plan for sustainable tourism
	433	Identifying new tourist activities taking into consideration the projected climate change
	434	Create new tourism products for the newly identified opportunities
	558	Developing and implementing a tourist image redefinition plan related to snow
	606	Enhancing the tourist opportunities in the municipality due to the increase in temperature, reducing the effects of seasonality and diversifying the supply
	639	Adapting tourism promotion to climate change, enhancing local produce and landscapes
Urban design improvements	648	Promoting tourism in order to enhance the opportunities created by climate change
	30	Urban planning considering sun exposure and wind predominance
	31	Gradual renovation of public buildings as an example of good practices
	57	Maintenance of natural ventilation corridors (water streams with vegetation, especially along the sides of the main local RELEVOS) and urban ventilation corridors (streets with trees, with prevailing winds North-South and Northwest-Southeast)
	123	Defining standards for building requirements, taking into account the need for protection from extreme weather conditions. For example: insulation of walls, roofs and floors, external sun shades and improved ventilation and natural lighting
	131	Increasing urban space resilience to climate change
	139	Adaptation of public and building space with the introduction of new techniques that improve thermal comfort, namely through the use of reflective materials on roofs and facades, materials that promote the cooling of outdoor pavements and the use of water to cool the urban space
	205	Attribute tax benefits to the reconstruction/construction adapted to climate change
	301	Implementation of different shading mechanisms in buildings
305	Promote “Eco-Urbanism” practices for the balance of urban design	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Urban design improvements	311	Defining climate change adaptation measures for urban conservation and rehabilitation, as part of the elaboration of detailed plans and/or municipal regulations
	343	Introducing measures to increase the new and restored buildings' passive resilience through bioclimatic design
	351	Adapting precarious structures, street furniture and signage to strong wind
	352	Promoting the municipal buildings' resilience in new construction and restoration: a) against floods (basements and ground floors); (b) by increasing passive energy efficiency; c) with the introduction of renewable energy
	364	Promoting and providing technical support to increase the buildings' resilience (new and restored): a) against floods (basements and ground floors); b) by increasing passive energy efficiency; c) with the introduction of renewable energy
	454	Resize and adapt infrastructures, making them more robust
	533	Introducing adaptation measures in the urban conservation and restoration sector, within the scope of municipal regulations
	540	Promoting the renovation of dwellings (neighbourhoods and blocks) through incentives and collaboration with stakeholders
	541	Creating municipal guides with information on, for example, bioclimatic measures and building adaptation strategies
	597	Improving the responsiveness of urban public spaces to climate events by incorporating adaptive solutions in the design
	600	Increasing the resilience and/or adaptive capacity of buildings and structures related to economic activities (such as greenhouses and livestock), through technical and building solutions
	653	Building and urbanization
	Water saving	59
60		Restoration, conservation and extension of water storage infrastructures
61		Reuse of treated water from WWTP for irrigation
73		Improving efficient water use by reducing losses and creating water supply alternatives (eg rainwater retention)
88		Creation of the Municipal Program for the efficient use of water
103		Improvement of water supply system
107		Elaboration of contingency plan for prolonged drought
108		Ensure the operationality of the municipality's strategic water supply reserves
126		Definition of action lines focused on demand control, supply security, protection and promotion of the good condition of water bodies, as well as risk reduction in extreme drought situations
127		Improvement of dam flow management
128		Preparation and dissemination of reports on the quantity and quality of water for public supply, particularly in drought situations, in order to limit its use for agricultural purposes in these situations

Adaptation option (cluster)	#	Adaptation option (translated to English)
Water saving	132	Incentive for the creation of a water efficiency plan for industry, namely the cork industry, which uses large amounts of water in its production process
	134	Promoting awareness towards the efficient use of water as a scarce natural resource
	152	Increasing water availability through irrigation and storage, promoting efficient water use in agriculture
	160	Introduction of more efficient irrigation systems in agriculture
	161	Reuse of WWTP water for irrigation
	167	Regulation of water efficiency criteria in tourism, industry, agriculture and forests
	175	Installation of water meters in all water sources for consumption in the public urban space
	176	Adequacy of irrigation management in gardens and other public green spaces
	179	Replacing or upgrading existing irrigation systems with lower consumption systems
	180	Implementation of rainwater harvesting systems to feed irrigation systems
	181	Implementation of a municipal water loss reduction programme
	197	Develop a municipal plan for efficient water use
	198	Improvement of the water supply network
	207	Optimization and creation of municipal good practices for irrigation systems
	208	Creation and improvement of water retention infrastructures for agricultural irrigation
	209	Creating incentives for sustainable water use
	239	Improve efficient water use and reduce waste
	255	Promoting water reuse systems
	290	Water management action plan
	296	Wastewater use
	302	Evaluation and quantification study of water use by sector in the municipality
	303	Implementation of mandatory use of water efficiency devices in public and private buildings
	314	Creating a municipal efficient water use programme
349	Adapting public space management to the water cycle. For example: controlling the infiltration of rainwater in public space	
376	Developing and implementing a municipal programme for the efficient use of water	
377	Developing and implementing a municipal contingency plan for drought periods	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Water saving	405	Improving efficient water use (type and time of watering) with reduced water losses (maintenance and distribution)
	424	Recovery and maintenance of the water supply infrastructure
	425	Adoption of an efficient water use tariff
	430	Improving water use efficiency in agroforestry activities and reducing losses
	432	Creating water supply alternatives
	435	Reduction of losses in water distribution through investment in infrastructure recovery and maintenance
	453	Decreasing losses in water transportation and supply
	473	Integrating a groundwater usage programme into the municipal management operations (cleaning and irrigation) using wells
	474	Developing a plan for rainwater use and treated wastewater reuse for multiple uses (irrigation, garden cleaning)
	475	Implementing a programme for the automation of irrigation systems in order to reduce water consumption
	477	Keep the unbilled water reduction plan
	478	Adopt a tariff system that encourages water-efficiency
	508	Continuing the information and awareness-raising programme to promote tap water consumption
	509	Implementing an Information and awareness-raising programme for introducing climate change into the educational process of the school community, focusing on water education (urban water cycle)
	515	Restoration of water supply network
	531	Dissemination of reports on the quantity and quality of water for public supply, particularly in drought situations where its use should be limited (e.g. for agricultural purposes)
	549	Improving the efficiency of agricultural irrigation systems
	550	Improving the efficiency of water supply and sanitation systems
	551	Increasing the efficiency of irrigation systems in urban green areas (includes changing the species composition)
	567	Management plan for the efficient use of water
	568	Municipal drought contingency plan
610	Implementing municipal water management plan	
622	Promoting efficient water use, reducing losses and using recycled water through distribution systems for less demanding uses	
623	Promoting water supply alternatives (e.g. rainwater retention) and recovery, improvement and conservation of water retention infrastructures, including for agricultural irrigation	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Water streams/aquifers sustainable management	5	Promoting the cleanliness and regularization of water streams, taking into account the need to keep an adequate riparian vegetation
	20	Monitoring and analysis of the Tejo-Sado aquifer, incorporating the possible impacts of climate change (scenarios of water scarcity and/or contamination - this is he region's only drinking water producer)
	48	Desilting of water streams and optimization of preventive processes in early autumn, regarding the drainage of rainwater: foliage collection, gutter cleaning, etc.
	49	Rehabilitation of riparian galleries
	71	Promoting the cleanliness and regularization of water streams, maintaining adequate riparian vegetation
	72	Rehabilitation of water streams, riparian areas, wetlands and green corridors
	118	Preparation of Monte da Barca and Agolada weirs management plans
	129	Protection of higher level water lines, namely those classified as natural ecologic reserve
	130	Requalification and preservation of riparian zones
	162	Reduction of water contamination by diffuse discharges
	163	Promoting vegetation in areas of maximum infiltration of the aquifer system
	171	Identification and reduction of pollution sources that contribute to the recurrent poor quality of the Monte Novo, Divor and Vigia reservoirs
	173	Restoration of water stream vegetation
	174	Strengthening of the ability to inspect the autonomous effluent treatment systems associated with rural soil uses, especially in the sub-category of the PDM "basin protection zones"
	187	Water stream cleaning
	252	Cleaning and clearing water streams without harming the ecological system while enriching the landscape
	254	Ecological restoration of water lines, bringing the population closer to them
	288	Implementation of an action plan to clean the banks and channels of Ria de Aveiro
	306	Implementation of dredging in the Ria
	318	Promoting water stream protection: municipal Green and Blue Lines
336	Mapping hydrogeological resources, including a registry of underground structures	
393	Rehabilitating water streams and associated riparian areas	
416	Planning and management of water stream resources	
448	Rehabilitation of streams, riparian areas and wetlands	

Adaptation option (cluster)	#	Adaptation option (translated to English)
Water streams/aquifers sustainable management	464	Limiting the occupation of the most vulnerable riverside areas through the design and implementation of incentive and compensation conditions for the gradual retreating of at-risk structures. This reduction in urban pressure will reduce vulnerability and improve the water streams
	468	Developing and implementing the Porto water streams recovery and rehabilitation plan using the best natural engineering practices
	516	Planning and management of water stream systems (e.g. conservation of fishery resources and their ecosystems)
	523	Cleaning and conservation of water streams, and requalification of riparian areas
	532	Improvement of the water resource planning and management processes in urban, agricultural, forestry, industrial and touristic areas
	552	Actively protecting riparian ecosystems
	571	Elaboration of management plans for the Rio Nabão dams
	588	Protection of water streams, namely those classified as national ecological reserve
	618	Study sedimentary movements and sand replacement. Desilting rivers and estuaries
	621	Improving riparian areas, wetlands and river banks. Clean and clear water lines (Rio Lima)

Annex IV

Municipalities' risk analysis for the four climate events selected.

	High temperatures/heat waves			Extreme precipitation/flooding			Sea level rise			Drought		
	Present	Future 2041-2070	Future 2071-2100	Present	Future 2041-2070	Future 2071-2100	Present	Future 2041-2070	Future 2071-2100	Present	Future 2041-2070	Future 2071-2100
Amarante	6	9	9	4	9	9	-	-	-	-	-	-
Barreiro	0	4	6	4	9	9	1	4	9	-	-	-
Braga	2	6	9	4	9	9	-	-	-	-	-	-
Bragança	2	6	6	4	9	9	-	-	-	2	6	6
Castelo Branco	6	9	9	4	6	9	-	-	-	6	9	9
Castelo de Vide	4	6	9	4	6	9	-	-	-	4	6	9
Coruche	4	9	9	2	6	9	-	-	-	4	9	9
Évora	4	9	9	2	6	6	-	-	-	4	9	9
Ferreira do Alentejo	2	6	6	2	6	6	-	-	-	2	6	6
Figueira da Foz	4	9	9	2	6	6	4	9	9	-	-	-
Funchal	2	4	4	6	6	6	2	4	4	-	-	-
Guimarães	2	6	9	6	6	6	-	-	-	-	-	-
Ílhavo	1	4	9	4	9	9	6	9	9	1	4	9
Leiria	4	9	9	4	9	9	4	9	9	-	-	-
Lisboa	2	6	9	4	6	6	-	-	-	-	-	-
Loulé	4	9	9	4	9	9	3	6	9	3	6	9
Mafra	2	6	9	2	6	9	2	4	9	-	-	-
Montalegre	2	6	9	1	2	6	-	-	-	-	-	-
Odemira	2	6	9	2	6	9	-	-	-	2	6	9
Porto	1	4	6	2	6	3	2	6	4	-	-	-
São João da Pesqueira	2	6	9	6	9	9	-	-	-	2	6	6
Seia	1	6	6	2	4	4	-	-	-	4	9	9
Tomar	4	9	9	4	9	9	-	-	-	-	-	-
Tondela	6	9	9	3	3	6	-	-	-	3	6	9
Torres Vedras	1	4	4	4	9	9	4	9	9	1	1	4
Viana do Castelo	6	9	9	4	9	9	3	6	6	-	-	-
Vila Franca do Campo	1	2	4	4	6	9	1	4	4	-	-	-
<i>Mean</i>	2.9	6.6	7.9	3.5	6.9	7.7	2.9	6.4	7.4	2.9	6.4	7.9

Annex V

Climatic data collected from Portal do Clima (IPMA 2019b) and filtered per municipality through ArcGIS (DGT 2019).

Municipality	Aridity Index				Maximum accumulated precipitation in 5 days			
	1971-2000	1971-2100	ANOMALY	VARIATION	1971-2000	2071-2100	ANOMALY	VARIATION
Amarante	1.98921001	1.53990996	-0.449300051	-23%	218.8860016	223.128006	4.242004395	+2%
Barreiro	0.629963994	0.46633101	-0.163632989	-26%	90.23670197	94.40190125	4.16519928	+5%
Braga	2.012700081	1.62758994	-0.38511014	-19%	216.1089935	225.0919952	8.983001709	+4%
Bragança	1.24052	0.976143	-0.264376998	-21%	134.2319946	138.3509979	4.119003296	+3%
Castelo Branco	0.717998981	0.55142498	-0.166574001	-23%	105.5849991	108.5220032	2.937004089	+3%
Castelo de Vide	0.750482023	0.56702697	-0.18345505	-24%	101.362999	104.3990021	3.036003113	+3%
Coruche	0.675664008	0.50852001	-0.167144001	-25%	92.3266983	95.2390976	2.912399292	+3%
Évora	0.580250978	0.425767	-0.154483974	-27%	89.53130341	91.87740326	2.346099854	+3%
Ferreira do Alentejo	0.514662027	0.37537301	-0.139289021	-27%	79.42220306	84.11000061	4.687797546	+6%
Figueira da Foz	1.069599986	0.840904	-0.228695989	-21%	120.1500015	123.6900024	3.540000916	+3%
Guimarães	2.037970066	1.62193	-0.416040063	-20%	221.625	227.3639984	5.738998413	+3%
Ílhavo	1.23593998	0.99204999	-0.243889987	-20%	135.8399963	142.5910034	6.75100708	+5%
Leiria	1.050439954	0.80577898	-0.244660974	-23%	117.5589981	121.9000015	4.341003418	+4%
Lisboa	0.672724009	0.50145698	-0.171267033	-25%	98.38310242	101.5149994	3.131896973	+3%
Loulé	0.608217001	0.41764399	-0.190573007	-31%	118.8170013	108.848999	-9.968002319	-8%
Mafra	0.845100999	0.62541503	-0.219685972	-26%	105.2900009	106.9110031	1.621002197	+2%
Montalegre	2.261420012	1.72566998	-0.535750031	-24%	230.1210022	233.6210022	3.5	+2%
Odemira	0.610141993	0.43189701	-0.178244978	-29%	92.93740082	90.41259766	-2.524803162	-3%
Porto	1.572039962	1.28564	-0.286399961	-18%	166.2489929	175.3390045	9.090011597	+5%
São João da Pesqueira	0.770669997	0.612858	-0.157811999	-20%	95.00350189	98.21260071	3.209098816	+3%
Seia	2.067280054	1.49391997	-0.573360085	-28%	201.3130035	200.1799927	-1.133010864	-1%
Tomar	0.823655009	0.63186401	-0.191790998	-23%	110.038002	114.4599991	4.42199707	+4%
Tondela	1.951179981	1.46202004	-0.489159942	-25%	206.3470001	203.1360016	-3.210998535	-2%
Torres Vedras	0.773144007	0.58116299	-0.191981018	-25%	96.28050232	98.54740143	2.266899109	+2%
Viana do Castelo	1.991569996	1.62611997	-0.365450025	-18%	195.4519958	208.2050018	12.75300598	+7%

Municipality	Maximum temperature			
	1971-2000	2071-2100	ANOMALY	VARIATION
Amarante	16.03219986	20.03720093	4.005001068	+25%
Barreiro	20.08690071	23.5557003	3.468799591	+17%
Braga	17.38409996	21.22669983	3.842599869	+22%
Bragança	14.57839966	18.76919937	4.190799713	+29%
Castelo Branco	19.07990074	23.22640038	4.146499634	+22%
Castelo de Vide	18.92749977	23.06830025	4.140800476	+22%
Coruche	20.78059959	24.65040016	3.869800568	+19%
Évora	20.35199928	24.41320038	4.061201096	+20%
Ferreira do Alentejo	21.62820053	25.57519913	3.946998596	+18%
Figueira da Foz	17.9423008	21.09810066	3.155799866	+18%
Guimarães	17.0177002	20.91049957	3.892799377	+23%
Ílhavo	17.55069923	20.63680077	3.086101532	+18%
Leiria	18.00849915	21.44109917	3.432600021	+19%
Lisboa	19.6406002	23.09029961	3.449699402	+18%
Loulé	20.51499939	24.23200035	3.717000961	+18%
Mafra	18.14150047	21.36529922	3.223798752	+18%
Montalegre	12.64150047	16.76070023	4.119199753	+33%
Odemira	20.39150047	23.94860077	3.557100296	+17%
Porto	17.4137001	20.73259926	3.318899155	+19%
São João da Pesqueira	16.21010017	20.35820007	4.148099899	+26%
Seia	15.06229973	19.21549988	4.15320015	+28%
Tomar	19.35770035	23.22050095	3.862800598	+20%
Tondela	17.15029907	21.11800003	3.967700958	+23%
Torres Vedras	18.31410027	21.52120018	3.207099915	+18%
Viana do Castelo	16.73419952	20.14749908	3.413299561	+20%

Annex VI

Burnt area between 2001 and 2016 and total area of the ClimAdaPT.Local mainland municipalities (DGT 2019; INE 2019).

Municipality	Burnt municipal area (ha)																Municipal area (ha)
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Amarante	662	334	474	441	2698	1301	133	85	1604	1212	208	366	3634	1076	315	805	30100
Barreiro	17	104	4	5	8	5	12	33	8	18	5	11	5	8	4	2	3600
Braga	504	540	192	167	1210	856	42	44	143	243	909	163	417	23	116	601	18300
Bragança	1158	1845	509	1145	2528	125	347	602	2282	30	902	2180	299	100	645	479	117400
Castelo Branco	265	6873	9856	6682	5953	420	115	1168	101	120	612	378	30	68	183	1576	143800
Castelo de Vide	1236	15	9153	12	4	13	49	2	2	3	3	1	2	1	6	4	26500
Coruche	90	69	354	326	28	58	77	14	19	77	38	49	202	11	60	523	111600
Évora	266	499	706	1964	50	385	151	100	56	370	61	79	261	109	190	132	130700
Ferreira do Alentejo	1	20	6	878	7	92	92	75	37	76	80	16	36	35	34	10	64800
Figueira da Foz	12	37	33	49	2286	46	10	13	30	7	12	268	4	2	5	6	37900
Guimaraes	473	494	755	604	1292	320	189	86	625	304	608	320	857	40	520	271	24100
Ílhavo	1	5	2	4	6	5	2	12	1	2	1	2	1	0	5	3	7300
Leiria	34	96	19	114	4980	89	177	23	16	10	29	23	12	6	25	416	56500
Lisboa	6	1	0	0	0	7	6	0	3	0	0	3	17	10	5	6	10000
Loulé	20	9	50	14774	447	32	36	6	11	22	24	40	30	44	39	11	76400
Mafra	533	389	2893	644	635	76	133	112	59	62	280	133	29	10	52	42	29200
Montalegre	1814	1190	1241	760	3809	295	866	264	4164	2903	3431	939	674	154	1402	3244	80500
Odemira	74	39	12468	953	1223	36	26	28	131	38	28	55	73	48	859	30	172100
Porto	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4100
São João da Pesqueira	114	127	83	89	160	143	62	25	347	155	474	117	17	27	106	200	26600
Seia	3978	1408	4257	27	8762	70	149	62	192	9127	167	2746	585	455	49	542	43600
Tomar	164	2543	362	1453	3259	136	279	42	31	28	26	3373	51	22	1633	65	35100
Tondela	26	1146	651	35	1757	89	68	70	57	190	170	364	8387	15	20	8	37100
Torres Vedras	127	242	534	202	120	29	98	56	25	82	208	283	76	34	111	89	40700
Viana do Castelo	1224	1259	453	750	7499	110	57	96	662	4190	772	468	1992	615	656	5758	31900

Annex VII

Relative frequencies of the different clusters of adaptation options within each municipality.

Municipality	Agroforestry choices adaptation	Aquaculture choices adaptation	Awareness-raising (general public)	Coastal management	Cold spell management	Disaster preparedness	Economic capacitation	Ecosystem protection	Energy efficiency improvement	Flood prevention
Amarante	6%	0%	11%	0%	0%	6%	0%	0%	22%	6%
Barreiro	0%	0%	5%	5%	0%	0%	5%	0%	5%	15%
Braga	14%	0%	4%	0%	0%	0%	0%	0%	7%	14%
Bragança	17%	0%	8%	0%	17%	0%	0%	0%	0%	8%
Castelo Branco	7%	0%	7%	0%	0%	0%	0%	0%	13%	7%
Castelo de Vide	7%	0%	7%	0%	0%	0%	0%	0%	7%	33%
Coruche	4%	0%	4%	0%	0%	4%	0%	4%	20%	0%
Évora	6%	0%	13%	0%	0%	0%	3%	6%	3%	13%
Ferreira do Alentejo	8%	0%	8%	0%	0%	0%	0%	0%	17%	8%
Figueira da Foz	19%	0%	7%	7%	0%	0%	0%	0%	11%	7%
Funchal	0%	0%	9%	0%	0%	0%	0%	0%	0%	18%
Guimarães	14%	0%	7%	0%	0%	0%	4%	4%	4%	21%
Ílhavo	9%	0%	6%	32%	0%	3%	0%	0%	0%	3%
Leiria	11%	0%	7%	14%	0%	0%	4%	4%	4%	4%
Lisboa	0%	0%	13%	3%	0%	3%	6%	0%	6%	6%
Loulé	7%	0%	14%	4%	0%	4%	0%	4%	4%	4%
Mafra	8%	0%	8%	15%	0%	8%	0%	0%	0%	15%
Montalegre	15%	0%	7%	0%	0%	0%	0%	2%	7%	5%
Odemira	0%	0%	0%	20%	0%	0%	0%	10%	10%	0%
Porto	6%	0%	6%	8%	0%	8%	0%	0%	12%	6%
São João da Pesqueira	4%	0%	4%	0%	0%	0%	0%	0%	11%	7%
Seia	5%	0%	10%	0%	0%	0%	0%	0%	0%	5%
Tomar	8%	0%	15%	0%	0%	0%	0%	0%	8%	8%
Tondela	0%	0%	6%	0%	0%	6%	0%	0%	0%	17%
Torres Vedras	5%	0%	5%	20%	0%	10%	5%	5%	5%	5%
Viana do Castelo	7%	0%	3%	10%	0%	3%	0%	0%	10%	10%
Vila Franca do Campo	10%	10%	10%	10%	0%	0%	0%	0%	0%	30%

Municipality	Forest fire prevention/recovery	Green areas improvement/increase	Heat wave management	Invasive species/pests management	Knowledge promotion (municipality officials and agents)	Land degradation prevention	Land use planning	Monitoring
Amarante	0%	11%	0%	6%	11%	0%	0%	0%
Barreiro	0%	15%	15%	10%	5%	0%	0%	5%
Braga	0%	7%	7%	4%	11%	4%	0%	7%
Bragança	17%	0%	0%	0%	8%	0%	0%	8%
Castelo Branco	7%	7%	0%	0%	7%	0%	0%	13%
Castelo de Vide	20%	0%	0%	0%	7%	0%	0%	0%
Coruche	6%	0%	2%	2%	10%	0%	2%	4%
Évora	3%	0%	0%	0%	6%	3%	6%	0%
Ferreira do Alentejo	0%	0%	0%	0%	8%	0%	0%	8%
Figueira da Foz	4%	0%	4%	0%	7%	4%	0%	7%
Funchal	9%	0%	0%	18%	0%	0%	0%	18%
Guimarães	4%	4%	7%	7%	0%	0%	0%	4%
Ílhavo	0%	3%	3%	3%	0%	0%	3%	9%
Leiria	4%	0%	0%	0%	11%	0%	4%	11%
Lisboa	0%	9%	3%	0%	22%	0%	0%	0%
Loulé	4%	4%	4%	4%	7%	0%	0%	4%
Mafra	8%	8%	0%	0%	0%	8%	0%	15%
Montalegre	7%	5%	10%	15%	2%	2%	0%	2%
Odemira	0%	0%	0%	0%	20%	0%	0%	10%
Porto	0%	2%	6%	8%	10%	0%	2%	8%
São João da Pesqueira	7%	7%	7%	7%	4%	4%	0%	7%
Seia	30%	0%	15%	5%	0%	0%	0%	5%
Tomar	8%	8%	8%	0%	8%	0%	0%	8%
Tondela	17%	0%	0%	0%	11%	0%	6%	11%
Torres Vedras	5%	5%	0%	0%	5%	0%	0%	0%
Viana do Castelo	10%	0%	0%	7%	7%	0%	0%	3%
Vila Franca do Campo	0%	0%	0%	0%	0%	0%	0%	20%

Municipality	Monitoring	Policy development/ reviewing/ implementation	Sustainable mobility improvement	Tourism promotion	Urban design improvements	Water saving	Water streams/ aquifers sustainable management	TOTAL options in the municipality (all of them)	TOTAL FINAL options in the municipality
Amarante	0%	0%	17%	0%	0%	0%	6%	18	18
Barreiro	5%	0%	0%	0%	10%	0%	5%	20	20
Braga	7%	0%	4%	0%	4%	11%	7%	29	28
Bragança	8%	8%	0%	0%	0%	8%	17%	14	12
Castelo Branco	13%	27%	0%	0%	0%	7%	0%	15	15
Castelo de Vide	0%	0%	0%	0%	0%	20%	0%	15	15
Coruche	4%	8%	2%	0%	6%	16%	6%	50	50
Évora	0%	0%	0%	0%	0%	19%	19%	32	31
Ferreira do Alentejo	8%	8%	8%	0%	8%	17%	0%	12	12
Figueira da Foz	7%	11%	4%	0%	0%	11%	0%	28	27
Funchal	18%	0%	9%	9%	0%	9%	0%	11	11
Guimarães	4%	11%	0%	0%	0%	4%	7%	28	28
Ílhavo	9%	3%	0%	0%	6%	12%	6%	34	34
Leiria	11%	7%	4%	4%	4%	4%	4%	28	28
Lisboa	0%	3%	6%	0%	13%	3%	3%	32	32
Loulé	4%	18%	4%	4%	0%	7%	4%	28	28
Mafra	15%	8%	0%	0%	0%	8%	0%	14	13
Montalegre	2%	0%	0%	5%	0%	12%	5%	42	41
Odemira	10%	10%	0%	0%	10%	10%	0%	10	10
Porto	8%	0%	4%	0%	0%	13%	4%	52	52
São João da Pesqueira	7%	4%	4%	0%	11%	7%	11%	29	28
Seia	5%	0%	0%	5%	0%	15%	5%	20	20
Tomar	8%	0%	0%	0%	0%	15%	8%	13	13
Tondela	11%	22%	0%	0%	0%	0%	6%	18	18
Torres Vedras	0%	5%	0%	5%	10%	5%	0%	20	20
Viana do Castelo	3%	3%	10%	3%	0%	7%	7%	30	30
Vila Franca do Campo	20%	0%	0%	10%	10%	0%	0%	11	10