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Jassmin Ali

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**“Local urban planning documents and climate change; towards concrete actions to protect vulnerable groups of people”. Context of small and medium-sized cities in the south of France.**

Jassmin Ali

Master Thesis to obtain the Master degree in International Cooperation in Urban Planning

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## **Abstract**

This thesis focuses on giving concrete answers to the problems related to the slow integration of climate issues into local town planning documents. In particular, the analysis focuses on the particularly vulnerable context of southern France, taking into account the specificities that link it with the Mediterranean basin. As a matter of fact, the mere uncontextualized technical response does not favour the speeding up of this transformation process. As well as the numerous guides already created, which are seldom combined with the awareness raising efforts of public and private actors and thus remain an end in themselves.

In addition, the possible negative effects of climate change, in particular overheating which is especially dangerous for the most vulnerable groups of people, require a degree of priority for action. For this reason, special consideration is given to the heat wave issue as well as to urban heat islands (UHI). Therefore, a technical response will be proposed through local urban planning documents, in particular the local urban planning plan “PLU” to improve summer comfort and provide a short and medium term response to the adaptation of cities. Through the possible maneuvers of action offered by this local town planning document (encouragement, obligation and prohibition) recommendations have been developed. The purpose of these recommendations is to provide a rapid response to improve climatic conditions both on the building scale and on the urban scale. Through bioclimatic principles, the inclusion of greenery, the inclusion of refreshing elements, and the prohibition of the use of some low albedo materials, specific standard regulations are proposed.

## Abbreviations

CBS	Coefficient De Biotope Par Surface [Biotope Coefficient Per Area]
EPCI	Établissement Public De Coopération Intercommunale [Public Establishment for Intercommunal Cooperation]
GHGs	Greenhouse Gas
LTECV	Loi Relative À La Transition Énergétique Pour La Croissance Verte [Energy Transition for Green Growth Act]
OPAH	Opération Programmée d'Amélioration de l'Habitat [Programmed Housing Improvement Operation]
PADD	Projet d'Aménagement et de Développement Durable [Planning and Sustainable Development Project]
PCAET	Plan Climat Air-Énergie Territorial [Climate Air-Energy Territorial Plan]
PDU	Plan de Déplacements Urbains [Urban Transport Plan]
PLH	Programme Local de l'Habitat [Local Housing Programme]
PLU	Plan Local de l'Urbanisme [Local Urban Plan]
PLUi	Plan Local de l'Urbanisme intercommunal [Local Inter-municipal Town Planning Plan]
QDM	Bâtiments durables méditerranéens [Mediterranean Sustainable Buildings]
SCoT	Schéma de Cohérence Territoriale [Territorial Coherence Scheme]
SRADDET	Schéma Régional d'Aménagement de Développement Durable et d'Égalité des Territoires [Regional Plan for Sustainable Development and Equality of the Territories]
SRCAE	Schéma Régional Climat Air Énergie [Regional Climate Air Energy Plan]
ZAC	Zone d'Aménagement Concerté [Concerted Development Zone]

## Glossary of terms

Inter-municipal urban planning documents: These documents operate on the intercommunal scale called in French *Établissement public de coopération intercommunale* (EPCI) which include the *Plan Climat Air-Énergie Territorial* (PCAET), *Schéma de cohérence territoriale* (SCoT) as well as the *Plan local d'urbanisme intercommunal* (PLU(i)), the *Programme local de l'habitat* (PLH) and finally the *Plans de déplacements urbains* (PDU)<sup>1</sup>.

Municipal urban planning documents: Includes the *Plan local d'urbanisme* (PLU) and the building permit or also known as the *Zone d'aménagement concerté* (ZAC).

The South of France: also called the *Midi*, is the geographical area that includes New Aquitaine south of Bordeaux, Occitania in the centre, the southern parts of Auvergne-Rhône-Alpes in the north-east, Provence-Alpes-Côte d'Azur in the south-east, as well as the island of Corsica in the south-east (Fig. 1).



**Figure 1.** South of France, based on a limit at the 45th parallel (Author).

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<sup>1</sup> See the list of abbreviations for English translations.



Mitigation: “A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs)” (IPCC, n.d.).

Adaptation: “The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities” (IPCC, n.d.).

Small, medium and large-sized cities: Due to the lack of an unequivocal definition in terms of small, medium and large cities, a specific definition for this research will be considered. In fact, for the INSEE official body in France of statistical definitions, there is no definition of small, medium and large cities (Mainet, 2008). For the sake of simplicity, small and medium-sized cities will be considered as a whole, which includes urban areas with up to 200,000 inhabitants. This generalisation is also made consistently according to the analysis of the category of these cities taken from Taulelle's research of 2017. It comes of itself the generalization of large cities with a number of inhabitants greater than 200,000.

Vulnerable people: The elderly, people with physical and mental disabilities, infants and people with chronic illnesses will be considered as vulnerable people for this study.

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# **1.CHAPTER 1**

## **1.1. Introduction**

Nowadays, cities and their inhabitants are subject to the effects of climate change. Above all, there is a common intention towards enhancing the city's resilience to reduce its vulnerability to different risk factors. Urban planning policies to combat climate change have begun and are taking hold in cities.

Two ways of intervening in human systems arise to deal with unforeseeable and foreseeable events. In particular, these are mitigation policies, aimed at reducing greenhouse gas emissions, and adaptation policies, aimed at moderating possible damage as well as exploiting any potential. Generally, these policies undertaken by cities follow urban planning strategies that have technical responses as a common thread.

Consider the example of green roofs which help both in the sequestration of CO<sub>2</sub>, mitigating the effects of global warming (Hirano et al., 2015), and in air cleanliness, thanks to their ability to filter air pollutants as well as carbon dioxide, which reduce asthma-related problems (Rowe, 2010). On the other hand, however, these responses must be accompanied by a specific analysis of the territory to identify any specificity, not only climatic but also cultural and social, aimed at responding to functional needs as well as to be accepted by the final user of the urban space, i.e. the inhabitant.

This thesis analyses the cities within the French context, in particular the south of France, with particular attention to adaptation policies to moderate possible negative effects on the health of the most vulnerable groups of people.

Specifically, this first introductory chapter aims to give an overview of the situation today regarding climate change in cities and the current debate. Subsequently, a brief analysis of the French situation identifies the problem on which the thesis focuses. In addition, sections are introduced to identify the significance of the study as well as the research question, the research methodology and finally a short description of how the thesis is divided according to the different chapters.

## 1.2. Background

As already mentioned in the introduction, this section aims to give an overview of the current debate on climate change experienced by cities. A general analysis of the current situation is first undertaken globally, followed by a European scale, and finally briefly addressing the French context.

The population growth in urban areas carries with it a second growth in terms of vulnerability of human environments. Indeed, the urban environment vulnerability to climate change effects is strictly linked with anthropogenic actions and the lack of mitigation and adaptation policies (Leone and Rave, 2018). To mention some of the main threats, cities are facing risks in terms of people, including health stress, economic and ecosystem, and assets. While rural areas suffer more issues of water availability and distribution, infrastructure and agricultural revenues and food security (IPCC, 2014). The variety of signed protocols, from the Rio Summit in 1992, through Kyoto in 1997 until the last one in Europe called the Green Paper in 2007, contribute in the acceptance of the idea that human activities are contributing to climate change (Lambert-Habib, et al., 2013).

As a preliminary remark, one can state that cities have a primary role in fighting the effects of climate change due to anthropogenic actions. Indeed, urbanized areas of the world are not only responsible for up to 70% of total greenhouse gas emissions (World Cities Report, 2016), but are also “essentially responsible for many environmental problems humankind is facing” (Aalborg charter, 1994). Actions taken in urban systems are considered essential for the global success of climate change adaptation policies (Revi et al., 2014).

Both mitigation and adaptation policies have started to take place in European countries. Although more mitigation policies are present against fewer adaptation actions, in addition, no city has an adaptation plan without a mitigation plan (Reckien, 2014). Route (2019) highlights a lack of existing projects compared to a wide variety of studies that have been done. Moreover, the issue of adverse effects of climate change in cities is touching, particularly, not only the field of urban climatology, which is very active in the prevention stage (Route, 2019) but also the field of urban planners, oblige nowadays to expand the range of knowledge towards a multidisciplinary and multi-scale perspective (Leone and Rave, 2018).

As regards the French territory, the study on climate change in the 20th century showed a more pronounced increase in temperature than the IPCC world prediction (Moisselin et al., 2002). Furthermore, for what concerns the Mediterranean basin, France ranks second after Italy, with one of the most vulnerable environments in terms of climate change and exposure to natural disasters

(Dinda, 2015). These elements raise the awareness of urban planners, a collective objective of sustainable development is taking place among French municipalities; the need to meet actual and future climate change challenges, through the protection of urban and natural systems, emerges.

Generally speaking, it is useful to analyse the French context in its urban planning laws and documents. Therefore, the next section analyses the laws issued as well as the actions at the national level. What are the weak points of this transition process against climate change in cities? Are there any useful points in improving the effectiveness of some actions or possibly taking new ones? The next section attempts to have a clearer view and to highlight the problem that leads to this study.

### **1.3. Problem statement and research objective**

In recent decades, several changes occurred in the French urban planning legislative system linked to climate change problems. The POPE law (2005), the Grenelle law (2010) and the Energy Transition Act (2015) are the main measures taken until today to fight against climate change in the French context. As a result, one can notice an increase of energy and environmental issues into urban planning policies. Article L. 101-2 of the French *Town Planning Code* establishes the observance of sustainable development objectives. These objectives of sustainable development include the preservation of air quality as well as soil and subsoil water quality of natural resources, biodiversity, ecosystems, and areas of ecological continuity (Urban planning code, 2020). These latter goals constitute key elements in the fight against climate change and especially for climate adaptation. The energy transition documents are also supported by numerous guides, which are more pedagogical as regards to their approach. Indeed, these guides provide hands-on recommendations on "how to do well". Thus, local authorities benefit directly from these guidelines to put into practice these objectives.

Numerous strategic planning documents functioning on a global scale were created for territorial communities. Nevertheless, that does not preclude individual municipalities setting themselves some objectives. The reality, however, is more complex: the number of practical actions taken by municipalities does not seem to be developed as much as the theoretical ones (Route, 2019; Richard et al., 2019). Consequently, not only there is an imbalance towards theoretical actions, but also a tendency to favour mitigation goals over adaptation goals occurs. Indeed, little measures have been taken to improve actions such as the notion of comfort and the fight against urban heat islands (Richard et al., 2019). In addition, laws introduced to date, such as documents and specific guides, are fairly recent tools that are being introduced within an experimental context. In the same

way some urban planning documents such as PLU (*Plan local d'urbanisme*), PLU(s) (*Plan local d'urbanisme intercommunal*) and especially the SCoT (*Schéma de cohérence territoriale*), still form part of this testing context. Therefore the integration of objectives in the fight against climate change follows slowly within the above mentioned documents (Richard et al., 2019).

It is, therefore, necessary to analyse the reasons for this current slow evolution in a climate scenario where the speed of action taken by cities may have the potential to make a difference. It is worth highlighting the negative climate scenarios in case no adaptation or mitigation practices are implemented (DataLAB, 2020). What are the difficulties cities face when dealing with climate change issues in urban planning? How can these new objectives be integrated into local planning documents? And what should the process involve for these documents to be effective and produce real change? In a context under the pressure of climate change which puts human health at risk (SOUTH GREC, 2019), not only global but especially local actions by urban planners are required.

#### **1.4. Research limitations and scope**

The objective of the research is to understand what actions should be taken in the various local urban planning legal tools to tackle the adverse health effects of climate change on the most vulnerable groups. Furthermore, the intention is to understand what to do for these documents to be used to their full potential and if the integration of other actions should be required. To achieve this objective, the research aims to provide some recommendations for climate change mitigation and adaptation in cities to reduce the vulnerability of those most at risk. This study is aimed at small and medium-sized municipalities in the south of France.

First of all, the recommendations can be a helpful tool that can be used by small and medium-sized municipalities in the south of France. Secondly, public actors will be able to translate the challenges proposed by global documents into local urban planning documents, through a universal and inclusive approach. Finally, the inclusion of some specific recommendations that take into account the climate as well as additional characteristic elements of the context can help the integration process on a local scale.

The research is limited as it is a purely qualitative study that only takes into account secondary data and personal recommendations resulting from the analysis of underestimated or missing elements for the development of recommendations. This holistic approach will give flexible guidelines and personal points of view, turning it into a specific study. Thus, the type of research method is difficult to generalize for different contexts. For this reason, this research is proposed as a study closely linked to the Mediterranean climate of southern France and the urban legal tools currently available. Moreover, the limited period time and the exceptional 2020 pandemic situation make it



difficult to collect primary data as well as to validate recommendations with a practical case study, by following its post-application response.

## **1.5. Significance of the study**

The study is relevant not only because it highlights the most significant actions that have been taken so far in inter-municipal and municipal planning documents, but also because it examines the ability of these legal instruments to trigger changes at the local level to mitigate the effects of climate change and adapt cities to it. In addition, it is essential to assess which actors and to what extent must be included to encompass any limitations related to urban planning policies and urban planning documents.

Due to the particular complexity of urban phenomena characterized by climate change, a compulsory step of the study is its contextualization. Therefore, the context of small and medium-sized cities in southern France is selected in order to remain consistent with the author's internship mission, pursued during the master's degree.

Moreover, the issue of urban climate is rarely taken into account in urban planning documents (Oke, 2006), especially from the population groups most at risk such as the elderly, children, people with disabilities and so on. One possible reason for this gap may also be the recent introduction of climate change issues through the PCAE (Plan Climat Air-Énergie) in 2010, which adapts local planning documents; a little-known field and a context still for exploration. For this reason, the thesis aims to shed light on the main constraints as well as the levers that surround cities during the introduction of practical actions to combat climate change concerning the greatest vulnerabilities of human health. Finally, this study aims to bridge this gap with the creation of some recommendations which can be used by municipalities to guarantee their cities' resilience.

## **1.6. Research question**

The research revolves around the following main question:

How to integrate sustainable development objectives in urban planning local documents in order to have concrete actions, under the pressure of climate change and related health risks in small and medium-sized cities in the south of France?

The following sub-questions arise:

1. To what extent does climate change have specific impacts on small and medium-sized towns in the south of France compared to small and medium-sized towns in the rest of France?
2. To what extent are climate change effects affecting human health of small and medium-sized towns in the south of France and what actions might limit its negative effects, particularly for people in vulnerable situations?
3. What is the potential of urban planning documents for climate change mitigation and adaptation of cities in southern France? And what are the reasons for the current slow evolution in a climate scenario where the speed of action taken by cities may have the potential to make a difference?

### *1.6.1. Hypotheses*

The first hypothesis raised concerns the impact of the climate change phenomenon as well as mitigation and adaptation actions in the various urban planning documents which will be studied according to the size of the city. Considering the multiple variables that affect the actions taken by cities in the fight against climate change, the first hypothesis has been formulated in order to simplify the sampling criteria.

Subsequently, it is considered that the effects of climate change have and will have specific impacts on human health in small and medium-sized towns in the south of France and it is, therefore, necessary to carry out adaptation studies to avoid negative consequences adapted to the specific context, particularly on the most vulnerable populations.

The last hypothesis regards urban planning documents at the inter-municipal and municipal scale which might contribute not only to mitigate the effects of climate change but also, through adaptation, to the reduction of health risks in small and medium-sized french cities.

### *1.6.2. Assumption*

This study contains three main assumptions. The first concerns the future intention of municipalities to integrate the objectives of mitigation and adaptation practices to combat climate change in the various local urban planning documents.

The second assumption relates to the effects of climate change on small and medium-sized towns in southern France, considered damaging for the health of the most vulnerable groups of people.

Finally, one considers the assumption that small and medium-sized French cities will continue to refer to municipal and inter-municipal urban planning documents to address climate change mitigation and adaptation issues.

### *1.6.3. Limits*

Although the study analyses some future scenarios related to climate change, this study will only aim to know the effects of climate change in the near future. Eventually, thanks to this analysis, the study will be able to develop in greater detail on those elements that put cities and their inhabitants in a highly vulnerable situation.

In addition, part of the study analyses some actions undertaken by municipal and inter-municipal urban planning documents as well as the potential for the action of these documents. Nevertheless, the study does not aim to assess the quality of the legal tools of urban planning as well as the actions taken so far by French municipalities.

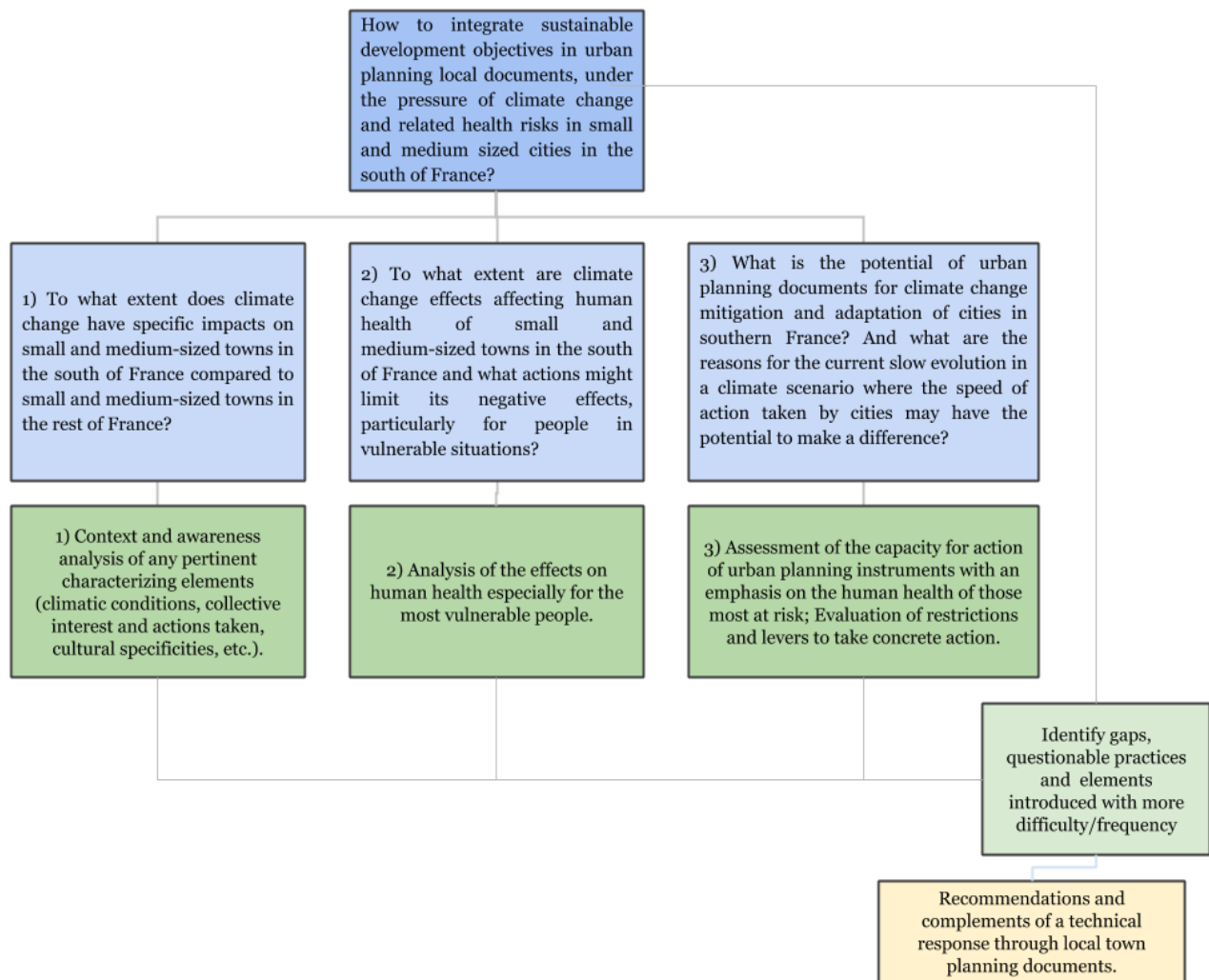
Finally, the study will be limited to the consideration of small and medium-sized towns in the south of France. This study is considered as relevant for southern France since the territory is characterised by cities with the highest temperatures ever recorded in France (“Absolute record: 45.9°C”, 2019) thus placing southern cities among the most at risk in terms of heatwaves.

## **1.7. Research methodology**

Due to the recent interest in the adaptation of local urban planning tools to climate change challenges, this research will be based mainly on the few but indispensable studies carried out so far.

Below (Table 1) illustrates the research method, which is divided into three distinct stages. The first step represents the interrogation process, highlighted by the blue tone scheme. In the second half, highlighted by the green tones chart, the process of acquisition of information takes place for possible answers and awareness of gaps.

The final objective of the research goes beyond answering the questions by giving some recommendations that can be useful to municipalities and that can be used as a reference for their transformation process concerning climate change and urban planning documents.



**Table 1.** Conceptual scheme of the research process (Author).

*Primary research question*

In order to understand what measures have already been taken to counter the effects of climate change in cities, it is necessary to analyse not only the review of academic literature but also the practical cases of the introduction of these measures. Indeed, the collection and analysis of non-academic data is an essential step in empirically understanding what are the most difficult objectives to integrate into the urban planning local process. The literature review will include books, articles and peer-reviewed articles, while the non-academic data will include official and technical documents, inter-municipal and municipal planning documents and reports.

*Secondary research question*

The sub-questions will be answered in chronological order, from understanding the context through specific attention to the negative health effects of the most vulnerable till the definition of best practices.

First, the research will focus on secondary data through the collection and analysis of academic and

non-academic literature. This data will include books, articles, peer-reviewed articles; news, reports, inter-municipal and municipal urban planning tools. The objective is to contextualize the research and to take into consideration any significant differences. In fact, factors such as climatic conditions, the people' degree of awareness may have a significant influence on whether some actions are successful or not (Colobert, 2008; P. Lauriola 2013).

Secondly, to understand the extent to which climate change is affecting human health, especially for vulnerable people living in cities in the south of France, secondary data collection and analysis is needed. The literature review will include books, scientific articles, peer-reviewed articles, official documents, reports and news. However, a collection and analysis of empirical data, such as inter-municipal and municipal urban planning documents and actions, etc., is also needed.

Finally, it is necessary to investigate some strategies implemented by cities through local urban planning documents to make some proposals through recommendations. Through the analysis of local urban planning documents will be necessary to identify any complementary actions needed to be put into practice to ensure the full success of municipal strategies and integration process of these goals. Particular attention will be given to summer comfort and its effects on human health of the most vulnerable people.

## **1.8. Structure of the study/description of the thesis's chapters**

Chapter one is intended to give a general overview of the research topic. Specifically, it includes an introduction of the thesis field, a broad background on the adaptation of urban planning to the new challenges of climate change, the problem statement and research objectives, the research limitation and scope, the significance of the study, the research assumption, the research question, the research methodology and finally the structure of the study with a brief description of each chapter.

At the beginning of the second chapter, the topic of climate change problems is examined from a general point of view. The current debates concerning French urban planning documents are also highlighted. The analysis continues on a scale that focuses on the context of the city, particularly with respect to its geographical location. Therefore, the various phenomena present at urban climate level such as urban heat islands, greenhouse gas emissions as well as elements such as water management and so on are studied. The chapter then follows with an analysis of the effects of climate change in cities on human health with attention to the most vulnerable groups such as elderly, children, people with disabilities and so on. Finally, using the above criteria, some practices and studies are taken into account in order to measure the capacity for action of urban planning

documents.

The third chapter analyses the specificities to be taken into consideration for small and medium-sized towns in the south of France. Therefore, the relevant theme of urban heat islands is analysed, as well as the effectiveness of possible adaptation and mitigation measures.

The fourth chapter is proposed to respond to the gaps identified through the literature review through the proposition of recommendation for small and medium-sized municipalities.

In particular, it focuses on the elements of greatest vulnerability and summer comfort as well as on the possible specificities of small and medium-sized towns in the south of France. The aim is to understand not only how to integrate some recommendations into local urban planning documents but to highlight what this latter process should include in order to give concrete results.

The fifth and final chapter is proposed as a concluding chapter in which is highlighted especially the missing in the existing literature and the recommendations by the author. In addition, proposals can be made by the author to make full use of the recommendations and to foresee possible supplementary studies.

## **2. CHAPTER 2**

### **2.1. Insights on climate change**

First of all, as a basis, it is essential to have an a priori understanding of the context of climate change and therefore of the debate itself, with an eye to cities. It is essential to understand who is involved in this debate and what information is available today to have a comprehensive knowledge of the relevant issue.

The following section attempts to give a general understanding of the climate change debate with particular regard to the role and responsibilities of cities in this process. In detail, it will frame the level of progress of this transition process of cities through the short introduction of the various international protocols introduced to date.

The process of climate change is an irreversible process (IPCC, 2007) which is showing its effects both on natural environments (environments untouched by human activities) as well as on human systems. This complex process, which affects many features such as water, soil, air, biodiversity and so on is not a silent change. Nowadays, many natural disasters have already brought attention to issues related to climate change and especially on the dramatic consequences that this can bring to the heart. For this reason, present and future generations are becoming more and more aware of these vulnerability systems and the urgent need of being resilient as the only effective solution. Especially for what concerns the urban system, many issues such as urban heat islands and so on, are affecting everyday life, with important effects on health. Furthermore, due to anthropogenic influence and a lack of politics of mitigation and adaptation, cities are more and more vulnerable to climate change effects (Leone and Raven, 2018).

In particular, cities and towns took responsibility for these events (Aalborg Charter, 1994) and a new global movement was raised in order to improve the resilience of the theme. The aim is to face climate change through the ability by cities and towns to mitigate its effect and the environment adaptation. Due to this collective goal, many mitigation strategies have already taken place in hundreds of cities around the globe.

The actors involved are multiple which indeed include inhabitants, national and local administrations. On the one hand, public administrations are not the only ones to move on this front. Other stakeholders are changing their interest in order to have an active role in the fight against climate change from the side of cities and urban systems (Shalaby, 2017). The variety of signed protocols, from the Rio Summit, through Kyoto in 1997 until the last one in Europe, called the Green Paper in 2007, contribute to the acceptance of the idea that human activities are changing the climate (Lambert-Habib, et al., 2013). On the other hand, due to its relatively new

appearance, practical actions by cities are still a long way from producing discernible results. As a matter of fact, Raute (2019) points out a lack in the numbers of projects present nowadays, compared to a wide variety of existing studies. The problematic of negative effects of climate change in cities is touching particularly not only the field of urban climatology, which is very active in the prevention stage (Raute, 2019) but also the field of urban planners, oblige nowadays to expand the range of knowledge towards a multidisciplinary and multi-scale perspective (Leone and Raven, 2018).

A new stage of the design process including citizens and professionals is needed to act properly with facts rather than just theory (Raute, 2019). Not only, but co-design can also help to avoid negative effects such as gentrification through a more smooth urban renovation rather than a radical change (Leone and Raven, 2018).

### *2.1.1 Climate change in Mediterranean Europe*

The paragraph aims to introduce a general overview of the climatic characteristics of Mediterranean Europe, through the definition of the Mediterranean climate according to the Köppen climate classification, the European countries covered by this area, and of its particular and common climate as well as its common traits. The intention is to cover the knowledge of the large-scale context to be able to focus the study in the next paragraph in which the context of the South of France will be examined in detail. Subsequently, the study examines small and medium-sized towns and vulnerable people in even more detail. The purpose is to have a general overview of the literature review in order to address the first sub-question of the thesis concerning the particular impact of climate change in small and medium-sized cities in the south of France.

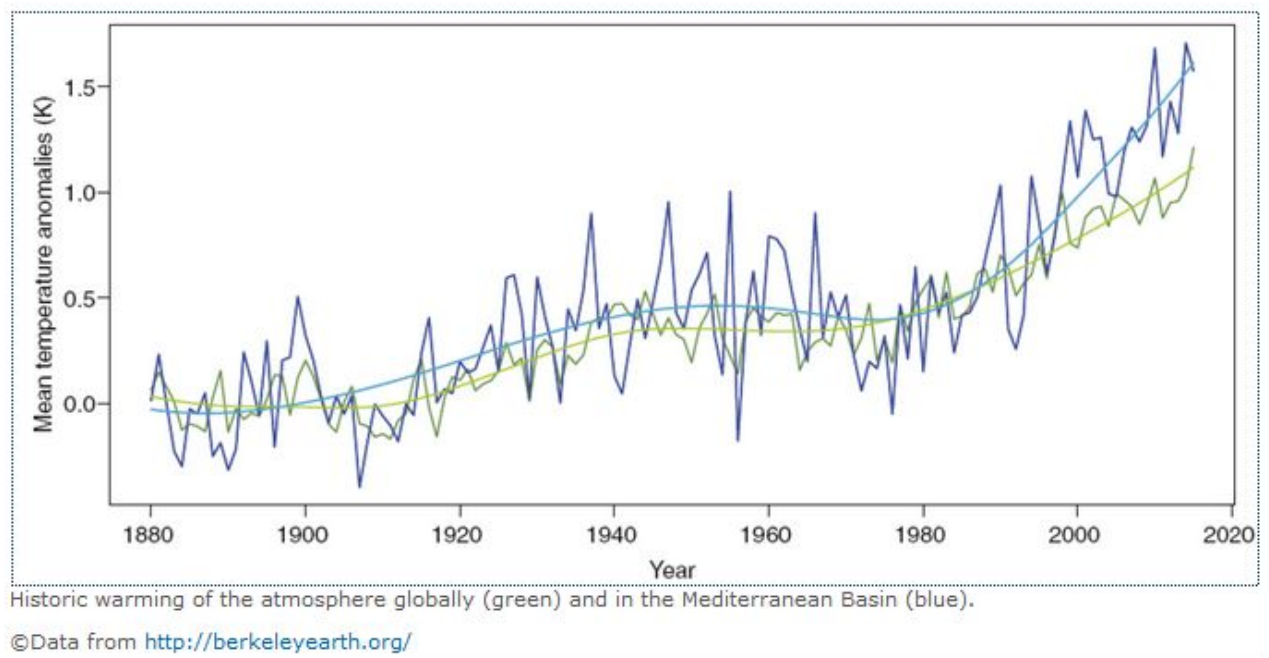
The Mediterranean climate is characterised by hot, dry summers and cool, wet winters. In the climate classification of Köppen, these climates which are classified as Csa and Csb are often referred to as 'Mediterranean' (The Editors of Encyclopaedia Britannica, 2019). For what concern Europe's countries included in the Mediterranean basin are the following: Spain; France; Italy and Greece. Notably, there are some common features in the Mediterranean basin beyond the climate. For instance, Dinda (2015) introduced these common features, including ecology as the landscape, a shared environmental responsibility, a common history, a distinctive Mediterranean economy and a relatively homogeneous culture.

As regards its common climatic characteristics, due to the range of latitudes it covers, the Mediterranean region is a transitional area under the influence of both the temperate climate of medium latitude and the warmer and drier North African climate. In addition, the region is characterized by an almost enclosed sea, surrounded by highly urbanized coastlines and mountains



with numerous springs. Hence, this results in interactions and feedback between ocean-atmosphere-earth processes which play a key role in climate and hydrological cycle, including the high-impact meteorological events that frequently affect the region (AllEnvi, 2016).

The Mediterranean region is one of the world's most vulnerable to global warming impacts (IPCC, 2013), and one of the most sensitive to climate change (AllEnvi, 2016). Indeed, the average temperatures (Fig. 2) in this region have risen  $0.4^{\circ}$  more than the global average, for a total of  $1.4^{\circ}$ , since the average benchmark of the pre-industrial era (Cramer et al., 2018).



**Figure 2.** Average temperatures of the atmosphere globally (green) and the Mediterranean Basin (blue). Source: Cramer et al. (2018).

Projections from the global and regional climate model indicate that warming and drying are expected to continue to increase and that the magnitude of the changes after 2050 will depend heavily on the emissions scenario (AllEnvi, 2016).

In Dinda's research (2015) an interesting comparison of environmental vulnerability between countries within the Mediterranean basin is made. Indeed, France and Italy are the most vulnerable European countries in terms of biodiversity, meanwhile, in terms of vulnerability to climate change and exposure to natural disasters France ranks after Italy, followed by Greece and Spain. For what concerns water, agriculture and fisheries and human health aspect vulnerabilities France is positioned last and second to last.

A further significant aspect that is useful to deal with is the general actions conducted within the European Mediterranean basin in order to have a global picture of the current situation in terms of

adaptation and mitigation plans.

Reckiental et al. (2018) have carried out a representative study on two hundred European cities in order to assess the response of urban areas to climate change. Two scales of cities are considered; medium-sized cities, between 50,000 and 250,000 inhabitants, and large cities with up to 250,000 inhabitants. The study showed that 6.5 out of 10 cities have a mitigation plan and only 3.5 have also an adaptation plan. Among these cities a big disparity depending on the country is highlighted, to mention one the 43% of France cities have a mitigation plan compared to 93% in the UK. Finally, the study concludes that there is an accentuation on the variation of cities' response to climate change in the direction North-South (Reckien al et al., 2018).

In conclusion, the Mediterranean basin is a particularly vulnerable area. Therefore, the impact of climate change in this region should be studied to avoid being unprepared for present and future problems. Consequently, mitigation and adaptation plans are needed to reduce gas emissions and reduce levels of vulnerability.

#### *2.1.1.1. Focus on the south of France*

A diagnosis of the territory is the first indispensable step to lead the development of recommendations in terms of adaptation to deal with climate change.

In the next paragraph, the context of the South of France with its specific characteristics in terms of climate evolutions, vulnerability, social awareness to climate change etc. is analysed. This section aims to understand to what extent climate change observed in the South of France has specificities that make it different from the rest of France

First, it is necessary to understand the climate context and the most recent major phenomenon that have affected these regions. The presence of a particular vulnerability in terms of climate, demography and so on, or a difference in terms of inhabitants awareness is important to better analyze the urban planning documents and future adaptation strategies within their context. Finally, this analysis is indispensable during the study of legal documents and strategies adaptation in order to understand if any significant relationship arises.

The vulnerability of the territory to the effects of climate change is, therefore, a delicate issue to grasp. This requires the analysis of potential impacts in cross-cutting areas and in a context which is still marked by uncertainties: the major trends in climate change are known, but the scenarios for its evolution are variable, and some of its aspects, as well as the details of its local impacts, still need to be refined. The consequences of climate change at the territorial level will therefore be multiple and interdependent, and some of them can already be identified. At the global level, some

of the impacts associated with a warming of 1 to 5°C are already integrated into several areas. Tourism, agriculture, natural risks, biodiversity, health are all sectors that will be strongly impacted on a local scale if nothing is anticipated today (Diagnostic CoVe, 2018).

This study's analysis refers to the south of France, in particular the geographical area called Midi. This area comprises the New Aquitaine south of Bordeaux, the Occitan region, the southern part of Auvergne-Rhône-Alpes in the north-east, Provence-Alpes-Côte d'Azur in the south-east, as well as the island of Corsica in the south-east. Another more restrictive definition places the south of France as the southern part of the 45th parallel. All the regions mentioned are composed of urban, peri-urban or rural areas.

Regions facing the sea are catalogued according to the Köppen climate classification, and as already mentioned in the previous section, with a Mediterranean climate described with hot and dry summers and cold and wet winters (Fig.3). As regards the regions and in general the northernmost parts in the south of France are defined by the acronym "Cfb" which means West Coast Marine Climate ("France and its climate", n.d.).

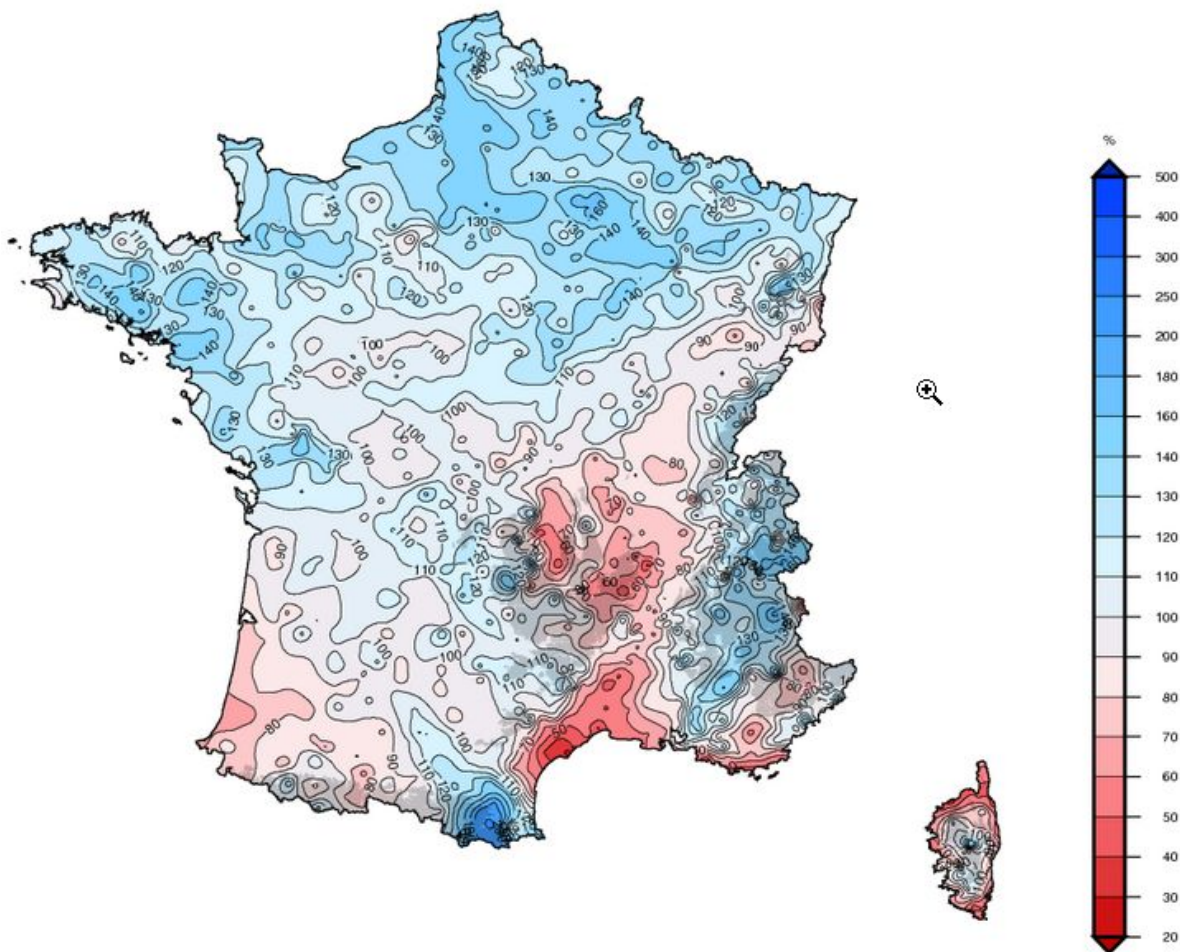


**Figure 3.** Köppen climate classification for the french country. Source: “La France et son climat [France and its

climate]”, n.d. *Meteo contact*.

Météo-France noted the different trends since 1900 at the national level. In metropolitan France, the effects of climate change are mainly reflected in the increase in average temperatures. Since 1900, warming has reached about 1.4°C, which is higher than the global average, estimated at +0.9°C over the period 1901-2012 (IPCC, 2013). Meanwhile, based on more recent trends, more anomalous phenomena were recorded since 1950. First, the evolution of precipitation varies according to regions and seasons, as well as the random frequency of thunderstorms and extreme rainfall events. Secondly, the increase in the frequency of heatwaves, as well as the reduction in the duration of snow cover in mid-mountain areas. Finally, phenomena such as soil drought and increased drought intensity was highlighted.

Over the period 1959 - 2009, the cumulative annual rainfall (Fig. 4) did not show any significant change at the French level, even if regional differences do appear. There is generally an increase in rainfall over the northern half of the country, especially the north-eastern quarter, and a decrease over the southern regions, especially the French Riviera departments and Corsica. However, outside these regions, the trends observed are often not statistically robust and may change over the period considered.



**Figure 4.** Relative to the 1981-2010 seasonal reference average of cumulative precipitation. Source: “Bilan climatique de l’hiver 2019 - 2020 [Climate assessment of winter 2019 - 2020]”. (2020). *Meteo France*.

Multiple scenarios have been studied till today and a common state of fact raised; heat waves in France will be more and more frequent, longer and intense in the further years (IPCC, 2013). The study carried out by Moisselin et al. (2012) state a more important rising of temperatures during the 20 century in France compared to the predicted form IPCC (2014). Météo France's latest climate report (2020) showed winter temperatures 2°C above average in December 2019 and January 2020 and even 3°C in February 2020. Many records of meekness were recorded in February 2020, especially in the south of France with peaks sometimes above 20°C. Moreover, according to the weather report it is estimated that the last winter had an average temperature of 8.2°C that is 2.7°C above the norm, making 2019-2020 the warmest winter of the period 1900-2000. In particular, the highest temperature recorded in February 2020 was again reached in the south - municipality of Oloron-Sainte-Marie in the department of the Atlantic Pyrenees - with a temperature of 28.3°C.

The past year in France was the highest temperature ever recorded in some cities, especially in the south of France. For instance, in the Meteorological Vigilance Chart Météo France (Fig. 5) of 27 and 28 June 2019 below four departments of Vaucluse, Gard, Hérault and Bouches-du-Rhone were

placed on the highest level of alert (“France Records All-time Highest Temperature Of 45.9c”, 2019).



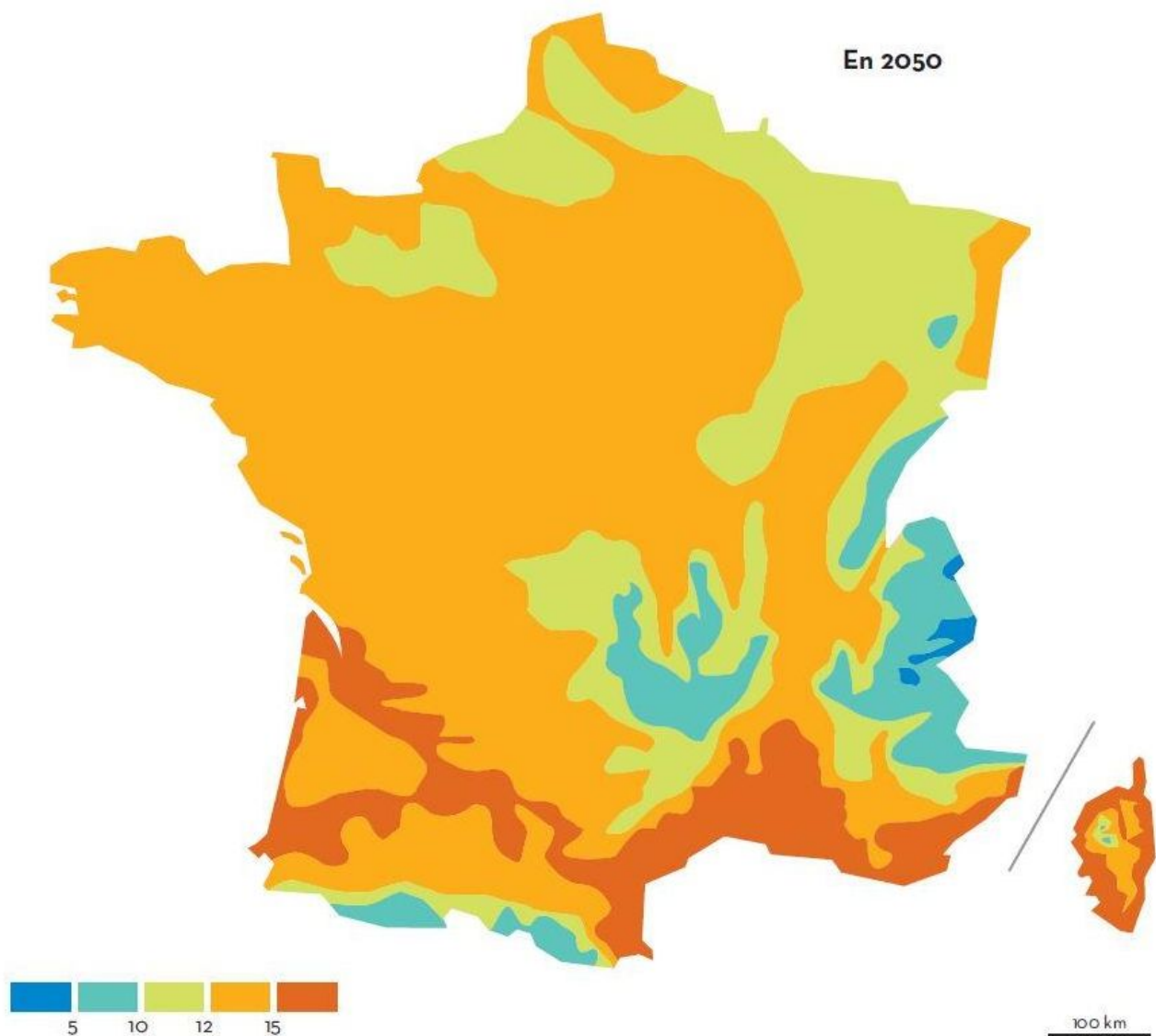
**Figure 5.** Meteorological Vigilance Chart Météo France of 27 and 28 June 2019. Source: “Weather Warning Map” (2019).

More than 50 cities in France were touched by ever recorded temperature during the summer heatwave of 2019, especially on the 25 of July. More of these previous temperatures were recorded during the heatwave of 2003 (“Heat wave: 41.5 °C in Lille”, 2019). The maximum temperature recorded was in Gallargues-le-Montueux in the Gard (Occitania region, south of France) with 45.9°C at 4.20 pm the 28 June 2019, the first time a temperature exceeded 45°C in France (“France records”, 2019).

Other vulnerabilities presented by the DataLAB studies (2020) show how the south of France is one of the most endangered areas of the country. Not only a vulnerability due to severe heat waves

that usually hit these southern regions hardest but also due to shrink-swell soil<sup>2</sup>. Data from the study also shows that urban, peri-urban municipalities, as well as rural areas close to cities, have 1.3 inhabitants and artificial areas above the national average. Moreover, the density of some areas is exacerbated by the fact that the highest concentration of populations settles near watercourses, thus increasing flood risk. Besides, the buildings are especially low-lying, which makes it difficult to provide shelter on higher floors in the event of flooding. Last but not least is the particular vulnerability regarding fires in the large forest massifs of the south-east and even more widespread are the south-west massifs (DataLAB, 2020).

Regarding heating, a future scenario (Fig. 6) is accentuated by extremely high temperatures, notably in the regions to the south of the country.



**Figure 6.** Rise in average temperatures over the next 50 years. Source: Bernard & Caldini, (n.d.).

<sup>2</sup> Shrink/swell potential is the relative change in volume that can be expected with changes in moisture content, i.e. the extent to which the soil shrinks when it dries out or swells when it gets wet.

Below, a scheme showing past constant climate change (Table 2) is followed by a second scheme that highlights 21st-century trends in climate change (Table 3). Both diagrams provide a comparison of the situation in metropolitan France and more specifically all the regions taken into account in the research.

	<b>Average temperatures rise since 1900</b>	<b>Increase in warming</b>	<b>Greater warming</b>	<b>Precipitation Trends</b>	<b>Heatwave frequency</b>	<b>Storm frequency</b>	<b>Duration of snow cover in medium mountains</b>	<b>Intensity of droughts</b>
<i>Metropolitan France</i>	1.4°C	over the last 3 decades Sensitive accentuation	-	different according to regions and seasons	increased	no significant trend	decreased	increased
<i>New Aquitaine south of Bordeaux *</i>	0.2 to 0.3°C per decade over the period 1959-2009	-	spring and summer	no significant changes; more intense and more frequent in the southeast	-	-	-	increased
<i>Occitania</i>	0.3°C per decade over the period 1959-2009	increased warming since the 1980s	spring and summer	no significant changes (Midi-Pyrénées); Increased (Languedoc-Roussillon).	-	-	decreased	increased
<i>southern parts of Auvergne-Rhône-Alpes*</i>	from 0.3 to 0.4°C per decade over the period 1959-2009	increased warming since the 1980s	spring and summer	no significant changes	-	-	decreased	increased
<i>Provence-Alpes-Côte d'Azur</i>	0.3°C per decade over the period 1959-2009	increased warming since the 1980s	spring and summer	a decrease in rainfall over the period 1959-2009	-	-	no significant	increased
<i>Corsica</i>	0.2°C per decade over the period 1959-2009	Increased warming since the 1980s	Summer	a decrease in rainfall over the period 1959-2009	-	-	-	no significant



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\*(data for the whole region)

**Table 2.** Comparative table of the different past climatic phenomena made by the author. Data source: Observations des températures depuis 1900 [Temperature observations since 1900]. (n.d.). Meteo France. Retrieved from <http://www.meteofrance.fr/climat-passe-et-futur/climathd>.

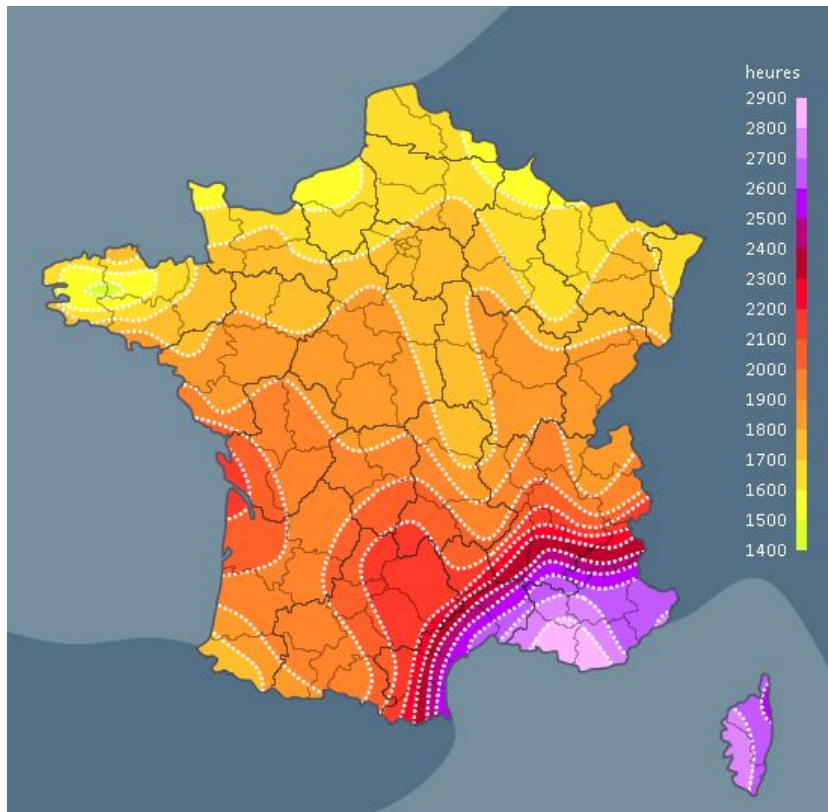
	<b>Warming horizon 2071-2100 compared to the period 1976-2005</b>	<b>warming</b>	<b>hot days</b>	<b>Precipitation Trends</b>	<b>heatwave frequency</b>	<b>Drying of the soil</b>
<i>Metropolitan France</i>	can reach 4°C	continued warming during the 21st century in metropolitan France, regardless of the scenario	continued decrease in the number of frost days and an increase in the number of hot days under all scenarios	little change in annual precipitation in the 21st century, but seasonal and regional contrasts	increasingly frequent and intense heat waves	drainage of soils increasingly pronounced during the 21st century in all seasons
<i>New Aquitaine south of Bordeaux*</i>	can reach 4°C	continued warming during the 21st, regardless of the scenario	continued decrease in the number of frost days and an increase in the number of hot days under all scenarios.	no significant changes	-	drainage of soils increasingly pronounced during the 21st century in all seasons
<i>Occitania</i>	can reach 4°C	continued warming during the 21st century, regardless of the scenario	continued decrease in the number of frost days and an increase in the number of hot days under all scenarios.	little change in annual precipitation in the 21st century, but seasonal and regional contrasts	-	drainage of soils increasingly pronounced during the 21st century in all seasons
<i>southern parts of Auvergne-Rhône-Alpes*</i>	according to the scenario without climate policy, warming could exceed 4°C	continued warming during the 21st century, regardless of the scenario	continued decrease in the number of frost days and an increase in the number of hot days under all scenarios.	no significant changes	-	drainage of soils increasingly pronounced during the 1st century in all seasons
<i>Provence-Alpes-Côte d'Azur</i>	could exceed 4°C, regardless of the scenario	continued warming during the 21st century, regardless of the scenario	continued decrease in the number of frost days and an increase in the number of	no significant changes	-	drainage of soils increasingly pronounced during the 21st century

			hot days under all scenarios.			in all seasons
<i>Corsica</i>	according to the scenario without climate policy, warming could exceed 4°C	continued warming during the 21st century, regardless of the scenario	continued decrease in the number of frost days and an increase in the number of hot days under all scenarios.	no significant changes	-	drying of soils during the 21st century except in summer.

\*(data for the whole region)

**Table 3.** Comparative table of the different future climatic phenomena. Data source: Les tendances des évolutions du climat au XXI<sup>e</sup> siècle [Climate change trends in the 21st century]. (n.d.). Meteo France. Retrieved from <http://www.meteofrance.fr/climat-passe-et-futur/climathd>.

To conclude, given the latest temperatures recorded in 2019 and the various studies present, several scenarios highlight how climate change vulnerability is difficult to generalize within a broad geographical context. Indeed, some areas present climatic peculiarities uncommon to the region as a whole. However, it appears that specific phenomena occur more in southern France than in the rest of the country. As a matter of fact, the highest winter and summer temperature peaks have recently been recorded in the south of France. In addition, some studies show scenarios in which the highest temperatures will affect, although not uniformly in the territory, mainly the southern regions (Bernard & Caldini, n.d.). This phenomenon may be aggravated by greater sun exposure in some locations, which have more hours of sunshine than the rest of the country (Fig. 7). Therefore, the sunniest regions include Gironde and Charente-Maritime (south-west of France). For example, La Rochelle in the region of Aquitaine, is the sunniest west city, counting an average of 2100 hours of sunshine.



**Figure 7.** Average annual sunshine map in France. Source: Ensoleillement annuel [Annual sunshine]. (n.d.). Météo Express.

Even more hours of sunshine are received in the Provence-Alpes-Cote d'Azur region and near coastal areas in the Occitan region. The record is set by the Bouches-du-Rhône area within the Provence-Alpes-Côte d'Azur region with 2900 days of sunshine per year (“Annual Sunshine”, n.d.). One of the major consequences of the phenomena analyzed which characterize some areas of high heat is to cause summer discomfort. Besides, some groups of people may become more vulnerable as they are more intensely exposed to high temperatures. Therefore, special attention must be paid to artificial environments, which in turn are exposed to phenomena that can increase the vulnerability of populations such as urban heat islands.

#### 2.1.1.2. Context of small medium-sized cities in the south of France

Further, every city is unique with respect to its geographical location and setting, cultural history and architectural expression. This diversity, that makes travel so interesting, makes urban climate comparison especially challenging (Oke, 2006).

Cities have a primary role in fighting the effects of climate change due to anthropogenic actions due to their high emission of greenhouse. For this reason, they play an important part in the effects of climate change.

Due to the particular complexity of urban phenomena characterized by climate change, a compulsory step of the study is its contextualization. One of the hypotheses of this research is that the impact of climate change phenomena as well as mitigation and adaptation by urban planning documents differs according to the size of the city. Given the ambiguous categorisation of small, medium, and large cities in France, this research must draw up an ad hoc definition. The conjecture made by the author aims to simplify the study concerning the number of variables to be considered.

On the one hand, the author is aware that this definition is restrictive for the research itself as it does not include concrete aspects that could significantly influence the climate of urban systems, such as urban density, surfaces, green spaces and so on. On the other hand, not only the city's number of inhabitants is a recurring sampling criterion among similar studies (Taulelle, 2017), but also this aspect tends to define some other common characteristics, e.g. infrastructure or services.

The issue of urban climate is rarely taken into account in urban planning documents (Oke, 2006), especially from the population groups most at risk such as the elderly, children, people with disabilities and so on. In particular, another significant gap in the literature review concerns the study of UHIs for medium-sized cities, these between 50,000 to 500,000 inhabitants, in comparison to a wide variety of studies in the same subject for big-sized cities (Amorim et al., 2009 as cited in X. Foissard et al., 2019). For example, the city of Carpentras, a small town of 30,000 inhabitants in the PACA region, has only recently, in 2019, carried out a study to prove that even small towns are subject to UHI phenomenon. This study highlights the importance of taking action for small towns as well as big ones (Personnic, 2019). Therefore, it is important to give greater consideration to small and medium-sized Mediterranean cities (Chaline, 2001).

In cities, the effects of climate change overlap with the local characteristics of the urban climate, describing the changes caused by the weather conditions in the urban environment. Cities experiencing urban heat islands could have serious repercussions in terms of energy demand and public health, especially during heatwaves. Furthermore, heat waves have an impact on air quality

as they enhance the effects of temperature inversion and reduce the washout by dew or mist of aerosols and some types of pollen in the air (Lambert-Habib, 2013).

The main issues of urban systems to date which consider climate change are multiple and interrelated. Indeed, urban systems are experiencing an increasing growth in terms of artificialization of the soil which affects urban spaces as well as peri-urban areas. In addition, this factor is associated with a rise in the mobility of inhabitants, increasing resources, services, and more artificiality. Despite this, urban planning approaches are still not adapted to today's urban challenges with a trend towards fragmentation of space (GREC-PACA, 2017).

#### 2.1.1.3. Vulnerable people

To address the study according to the priority needs of the most vulnerable groups of people, it is important to understand what these vulnerabilities are and which people are subject to them. Therefore, the greatest vulnerability regarding the French and Mediterranean context on which the study focuses is identified.

The word vulnerable, derived from the Latin *vulnerabilis* which means "wounding", describes the possibility of being easily hurt, influenced or attacked physically, emotionally or mentally ("Vulnerability", n.d.). Generally speaking, the vulnerability depends therefore not only on an individual's initial vulnerability but also on his exposure to an event that can damage his or her ability to adapt. The risk is often specific to the type of disaster, or extreme climatic event, and the type of exposure concerning the considered scale.

Climate change is not the only element that can affect health risks. Indeed, cities' vulnerability can also be influenced by economic, cultural and social changes and, of course, by any adaptation and mitigation measures taken to combat climate change. For what concerns public health, the identification of the most vulnerable population groups is essential to take action to reduce the health risk associated with climate change. Consequently, by reducing the vulnerability of communities and if adaptation measures are well taken, both the risk of impact on the community and the exposure to the disaster can be reduced.

Since towns and cities are strongly intentioned "to achieve social justice, sustainable development, and environmental sustainability" (Aalborg Charter, 1994, section I.7), the fight against climate change without taking into consideration vulnerable populations is incoherent regarding these principles. Within the context of cities and towns, people's vulnerability can be affected de facto by several factors.

In the Mediterranean context, climate change impacts the health of the population (Linares et al.,

2020). In particular, studies show specific related impacts in the effects of climate change on health's population. These effects can have indirect consequences in terms of water availability, air and food quality as well as food provisions, while as regards the direct consequences, extreme heat, drought and storms can be observed (Linares et al., 2020; Dinda, 2015). For instance, in urban areas in Europe, the combination of phenomena of heatwave and UHI can lead to large numbers of deaths among elderly, people suffering from chronic diseases, social isolated<sup>3</sup>, and outdoors workers (IPCC, 2012).

In the French context, the heatwave of 2003 particularly affected the country, indeed, researchers consider heat waves as a major mortal risk among the natural hazards caused by Anthropocene. A future global scenario stated that the number of deaths will be highest during the summer hottest days, however, these losses will be compensated by a declining death during severe cold winters ("Health France", n.d.). Although in France, mortality associated with major climate-related risks remains modest, a study carried out by DataLAB (2020) reveals that in 2016, six out of ten French people were already concerned about the risks due to climate change.

In addition, an interesting recent study conducted by Mitchell et al. (2016) aimed to quantify the role of human activity on climate and heat-related mortality during the heatwave that hit Europe in 2003. A wide climate-modelling ensemble has been analysed which "enables a robust attribution of heat-related deaths at local scales to anthropogenic climate change" (Mitchell et al., 2016, page 7) . Results showed that anthropogenic climate change increased the risk of heat-related mortality in Central Paris by ~70% (Mitchell et al., 2016).

As regards the south of France, it emerges that, unlike the rest, all the Mediterranean regions are characterised by an above-average number of elderly people, except for the Rhône-Alpes region. Another peculiarity that places medium-sized and small cities among those with the highest number of elderly people is the fact that retired couples tend to withdraw from large cities in favour of smaller towns (Desplanques, 2005). This means that medium and small cities represent those with a high number of elderly people and therefore particularly vulnerable to some climate change risks such as the UHI and so forth.

The strategies to combat climate change effects on vulnerable populations include mitigation and adaptation plans as essential tools to avoid the adverse scenarios which have been analysed. In addition, a further step towards health prevention plans should be taken with cross-border collaboration (Linares et al., 2020).

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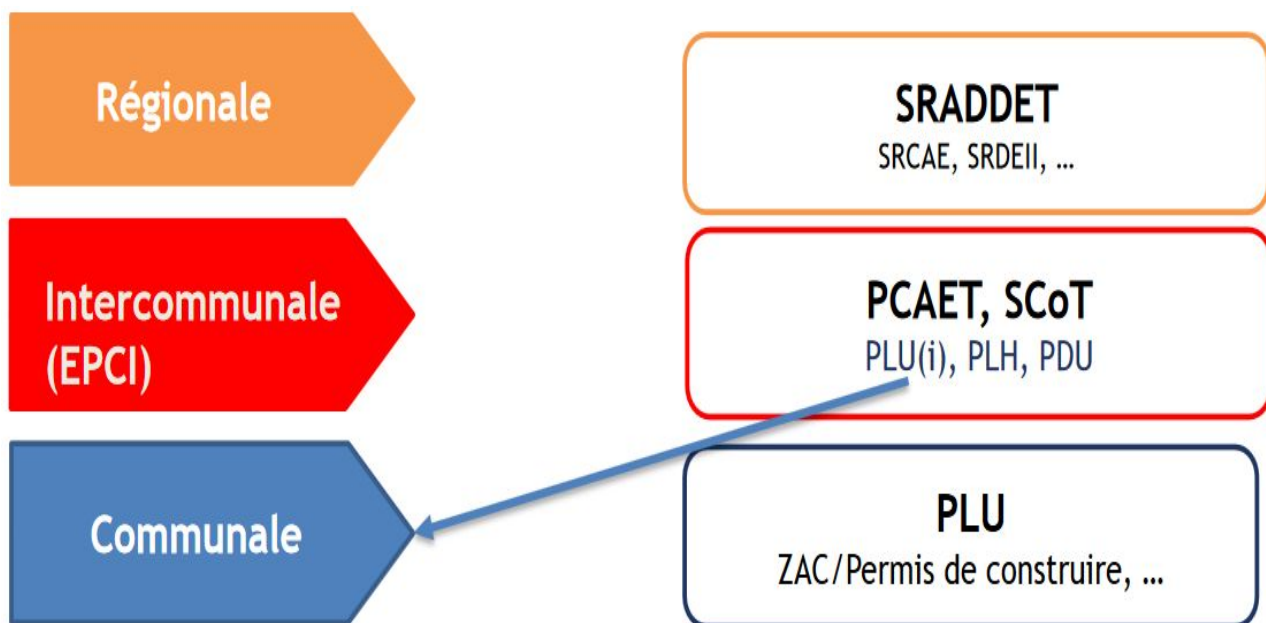
<sup>3</sup> Due to socioeconomic factors including poverty and social isolation, access to and use of cooling, physiological and behavioral adaptation of the population, and urban infrastructure (IPCC, 2012).

### 2.1.2 *Legal tools*

The climate machine is difficult to slow down: the lifespan of GHGs being several tens or hundreds of years. Consequently, even if one succeeds in drastically reducing GHG emissions, the warming of our planet is inevitable. It is, therefore, necessary to adapt to its impacts (La CoVe, 2020). In addition, adaptation plans are valuable for reducing vulnerability and are adopted to a greater extent than mitigation plans, which are primarily used for greenhouse gas emission reductions (Reckien et al., 2018). In the French context, the majority of territorial climate plans focus mainly on energy and its overconsumption, while less attention is put on adaptation to climate change. Regarding the topic of adaptation to climate change, it has been observed that it mainly concerns issues related to the risk of flooding or heat waves rather than those related to city planning and design (Lambert-Habib, 2013).

In France, many actions were taken between 2000 and 2010. First, with the PNLCC national program to fight against climate change (Lambert-Habib, 2013) established in 2000 to reduce greenhouse gas emissions for the period 2000-2010 (“National Programme for the Fight against Climate Change”, n.d.). Followed by the National Plan in 2004 and the objectives “factor 4 to 1” with the aim of reduction of greenhouse gas emission by 2050. A few years later, two acts called “Grenelle” in 2010 are confirming the objectives, applying them at the land planning and the regional development through the PCAETs which is implemented by french regions, departments and municipalities (Lambert-Habib, 2013). Finally, the 2015 LTECV law on energy transition for green growth aims to enable France to contribute more effectively to the fight against climate change and the preservation of the environment, as well as to strengthen its self-sufficiency in energy (Energy Transition Act for Green Growth, 2018). This latter law, allows the PCAET to become more transversal and operative as well as a more prescriptive urban planning in terms of energy. According to this law, the elaboration and implementation of the climate plan are limited to public inter-municipal cooperation establishments (EPCI) of more than 20,000 inhabitants. Therefore, climate plans do not overlap over the same territory, policies to combat climate change and air pollution are generalized on a national scale, and climate and energy spatial planning are limited to a scale of mobility and activity (Ademe, 2016).

The following is a summary of the various current urban planning documents and the relationships between them (Fig. 8).



**Figure 8.** Operation plan of the various documents especially the local ones. In top-down order: regional, inter-municipal (EPCI) and municipal. Source: ADEME & CNFPT. (2019).

Urban planning is therefore conceived on a territorial scale through the SCoT and locally through the PLU and municipal maps. Both work concerning operational planning (ZAC, building permit, etc.). Many documents take the environment into account, however, those that play a central role in urban planning, are the SCoT and the PLU. SCoT and PLU play a key role in the territory and enable municipalities to establish urban developments in the future. In particular, they provide opportunities for environmental, ecological and quality of life developments (Colombert, 2008). The SCoT takes precedence over the PLU at the hierarchical level. The SCoT itself serves as a global management document. It can subsequently be undertaken in detail concerning the territory and its specificities in the PLU document. The latter document applies to any public or private entity for any construction work, implantation and lot creation (B.M. & GLV., 2014). The PLU is useful on a local scale to safeguard and protect the most at-risk areas, to enhance agricultural as well as peri-urban areas and so on. Therefore, regulation of land use directly influences people's lives. On a global scale, the drafting of urban planning documents such as SCoT, PLU, etc. requires a multi-thematic approach which can specify above all the management of issues such as heat islands. Thus, SCoT and PLU must act not only as better tools for the insertion of urban climate-related elements concerning people with greater vulnerability but also regards how to take action and turn these ambitions into reality (Colombert, 2008).

The following sections study in detail the scope of documents such as PLU, SCoT including also those more operational documents such as ZAC and lots.



### *2.1.2.1. SCoT*

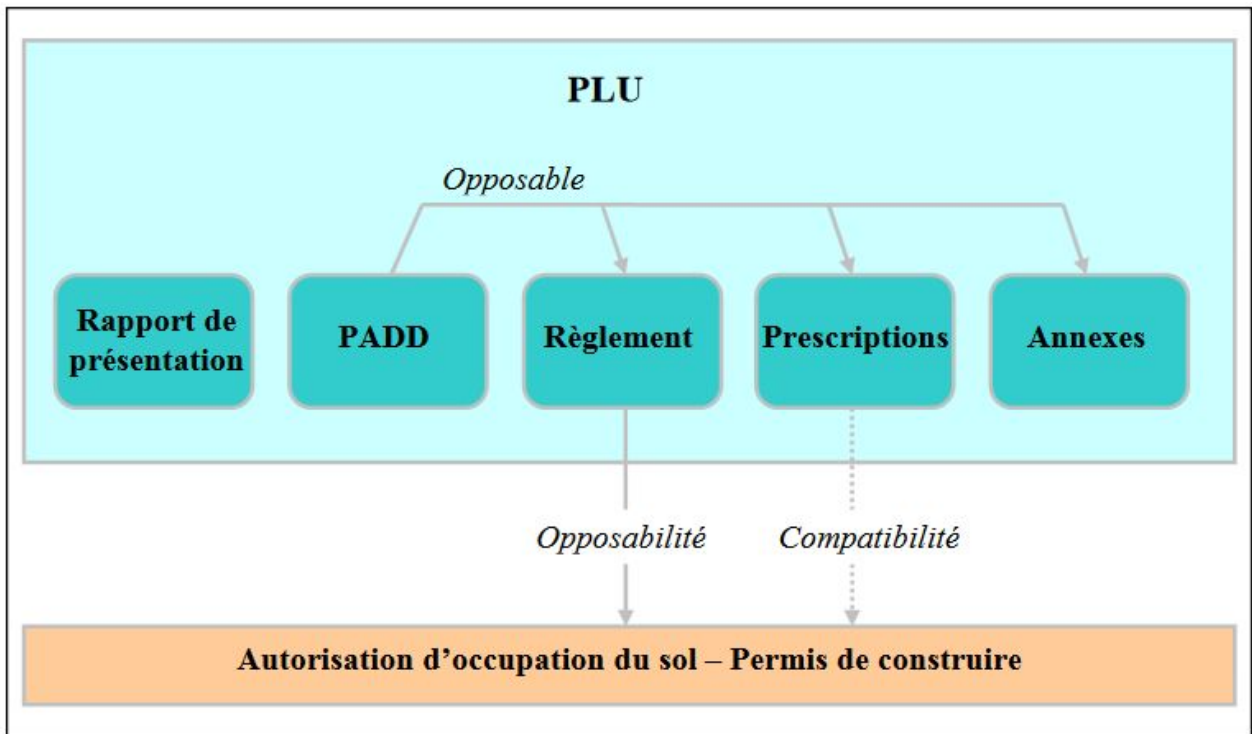
The SCoT represents the best-suited tool for environmental issues and challenges on a global scale. Whereas at the local level, the municipalities have the final say in implementing the ambitions established by major planning schemes such as SCoT (Bertrand et al., 2014).

The territorial coherence scheme (SCoT) serves as a tool to implement planning across one or more inter-municipalities. In 2010, as a result of the National Commitment for the Environment (ENE) law, the SCoT was established as an urban planning tool and determines a project at a territorial scale. The main objectives are to safeguard the environment and to manage the soil economically. The SCoT is accompanied by a presentation report containing a diagnostic and environmental assessment, a planning and sustainable development project (PADD) and an objective orientation document (DOO) (“Territorial Coherence Scheme”, n.d.).

The SCoT exercises influence over the spatial organization both in terms of construction density, green spaces etc. and in the organization of urban spaces as well as their shape. On the other hand, the SCoT does not intervene on buildings, such as urban forms and the composition of buildings or public spaces (forms, geometry, streets, etc.) or the nature of vegetated spaces. On the positive side, it prepares the ground for an eventual territorial climate map as well as proposing general orientation documents. In addition, recommendations can be made on the theme of urban climate (Colombert, 2008).

### *2.1.2.2. PLU*

The PLU, a Local Urbanism Plan, defines general destinations of land which are not specified for the Land Use Plan (POS). Indeed, since the introduction of the SRU, Solidarity Urban Renewal law in 2000, the PLU has replaced the POS document. Features such as shapes of buildings, natural areas to be protected as well as areas to be reserved for new buildings, etc. are included. Several documents are included in the PLU (Fig. 9) as follow: the presentation report; the PADD (Projet d'aménagement et de développement durable); the regulations containing a graphic part (with the four zoning types) and a written part (with the rules for each zone); and finally the OAP (“Local Urban Plan”, n.d.), planning and programming orientations at the level of quartier, which is the main urban planning tools of the PLU (Lambert-Habib, 2013; Lambert, 2016).



**Figure 9.** Documents included in the PLU. Source: Colombert, 2008.

The OAP takes into consideration not only the summer comfort but also the winter comfort (Bertrand, 2014). This document should also set out the intentions of the community in the overall urban planning project or PADD as well as the evolution of the agglomeration for the future. The zoning includes the following four action areas: U the urbanized zones; AU the urbanizing zones; N the natural zones; A the agricultural zones. In addition, for the inter-municipal scale, there is the PLU( i), Plan Local d'Urbanisme intercommunal, containing the same elements. These documents must both be compatible with the SCoT (“Local Urban Plan”, n.d.).

Also if the PLU’s field of action is wide and covers the building, the public space, and the spatial organization scale (Colombert, 2008) a limitation appears at the single building scale. Indeed, the PLU document is not appropriate to define some criteria such as materials, performances, inscriptions in the site and so forth. On the other hand, a restrictive regulation could limit the operating space of bioclimatic projects which have specific necessities depending on the site (Bertrand, 2014). However, through the PADD the PLU provides the possibility to integrate themes related to urban climate for the municipality (Colombert, 2008).

### 2.1.2.3. ZAC

The ZAC (joint development zone) is a public urban planning operation tool designed to carry out

the development and equipping of urbanizing land to subsequently transfer or concede it to public or private users. These areas may correspond to a single location or several territorially distinct locations (ZAC multi-site). The document includes a presentation report, a status plan, a plan of the perimeter of the areas and an assessment of impacts. The report sets out the objectives, and uses a description of the site and environment in which it is located, indicating the reasons why the project was considered (“The Concerted Planning Area”, n.d.).

Legislative instruments offer few options, whereas in operational terms there is greater flexibility concerning urban planning, as is the case with the ZAC. Indeed, the latter document, compared to the PLU, provides wider opportunities to introduce new criteria on the climate environment especially in terms of summer comfort.

Concerning parcelling out, this is a regulatory urbanism operation which gives both private and public authorities and local authorities the possibility of urbanising part of their property by using private investor resources. Therefore, these regulations have stricter rules than the PLUs.

The advantages of the ZAC is that it imposes stricter regulations than the PLU and allows considerations of elements such as the thermal and radioactive characteristics of buildings. On the other hand, however, the ZAC only acts on limited areas of the territory. As a matter of fact, the scale of action considers not the arrangement of urban spaces as well as their urban profile but only the scale of the building and public space (Colombert, 2008).

#### *2.1.2.4. Conclusion*

From the more global scale of SCoT, to the local scale of PLU, the inter-municipal scale of PLUs, and ZAC, it is possible to address climate issues within the various fields of action. One can intervene at the scale of the spatial organization (density of construction and vegetated spaces, forms and profiles of urban space) along with the scale of public space (streets, nature of vegetated spaces) down to that of the building (forms and composition of buildings).

Unfortunately, however, multiple factors play as real brakes, preventing these instruments from being exploited to their full potential. Some fields of action remain difficult to manage, for instance, it is not possible to force the use of some materials instead of less sustainable ones (Colombert, 2008). The main brakes, however, do not concern the potential of these instruments but a whole series of elements that must be taken into account.

Another limitation is that municipalities tend to act according to the length of their mandate, normally six years, thus restricting them to long-term projects. For instance, many studies confirm that political mandates due to their short duration do not coincide with the long-term horizons of climate issues in local public action, over which economic and labour policies are often preferred. (Richard et al., 2019; Simonet & Leseur, 2018). Similarly, the same happens for the drafting of

some urban planning documents which have a duration of between 10 and 30 years (Colombert, 2008).

According to a comprehensive study conducted by Richard et al. (2019), four major brake categories are identified. In particular, the causes and effects of integrating climate-energy issues into urban planning documents are represented. Therefore, the major brakes concern the contextual and environmental limits; the technical limits and the available municipal means; the political and institutional limits; and the cognitive and cultural limits (Richard et al., 2019).

To conclude, one can state that the planning of sustainable projects and the development of the SCoT and PLU allow a first awareness of the main actors such as politicians, professionals and inhabitants (Colombert, 2008). In addition, it is also important to have a participatory community involvement right from the design concept process. By including communities, awareness-raising is increased, which increases in a continuous motion the actions at the city level (Colombert, 2008; Richard et al., 2019). Secondly, adaptation issues are more bitter, inaccurate, and under-represented. However, the study reveals a further problem: the hypothesis that the present knowledge available is not enough in order to take action. Despite a large number of guides present to date, the information contained within the guides should be shared with a wider audience for the development of a concrete awareness of energy-climatic issues during the elaboration process of urban planning documents (Richard et al., 2019).

### **3. CHAPTER 3**

According to the data collected in the second chapter, cities in southern France are particularly vulnerable to global warming, especially those in the Mediterranean basin. For this reason, the third chapter focuses on the phenomena related to heatwaves with particular attention to urban heat islands. As a matter of fact, these phenomena are particularly dangerous for the human health of the most vulnerable groups and if not tackled they can increase the number of deaths during the heat waves. Linked to the theme of strong heat, a detailed analysis is carried out trying to identify any further morphological specificities that characterize the context. Indeed, these specificities are indispensable for a local response.

Mitigation and adaptation strategies are analyzed and reformulated for the Mediterranean context according to the summer comfort theme. This chapter attempts to understand which components need to be integrated in addition to the technical response of local urban planning documents, in order to enable cities to develop concrete cases of action. Finally, some examples and recommendations within the PLU aim to facilitate this integration process and to decrease health vulnerability in Mediterranean cities. The aim is to give recommendations that can already be implemented by municipalities in the drafting of their local urban planning documents. This translation is intended to reduce the risks associated with the strong heat waves to which the regions of southern France are most exposed and which will become increasingly frequent and intense in the years to come (IPCC, 2014).

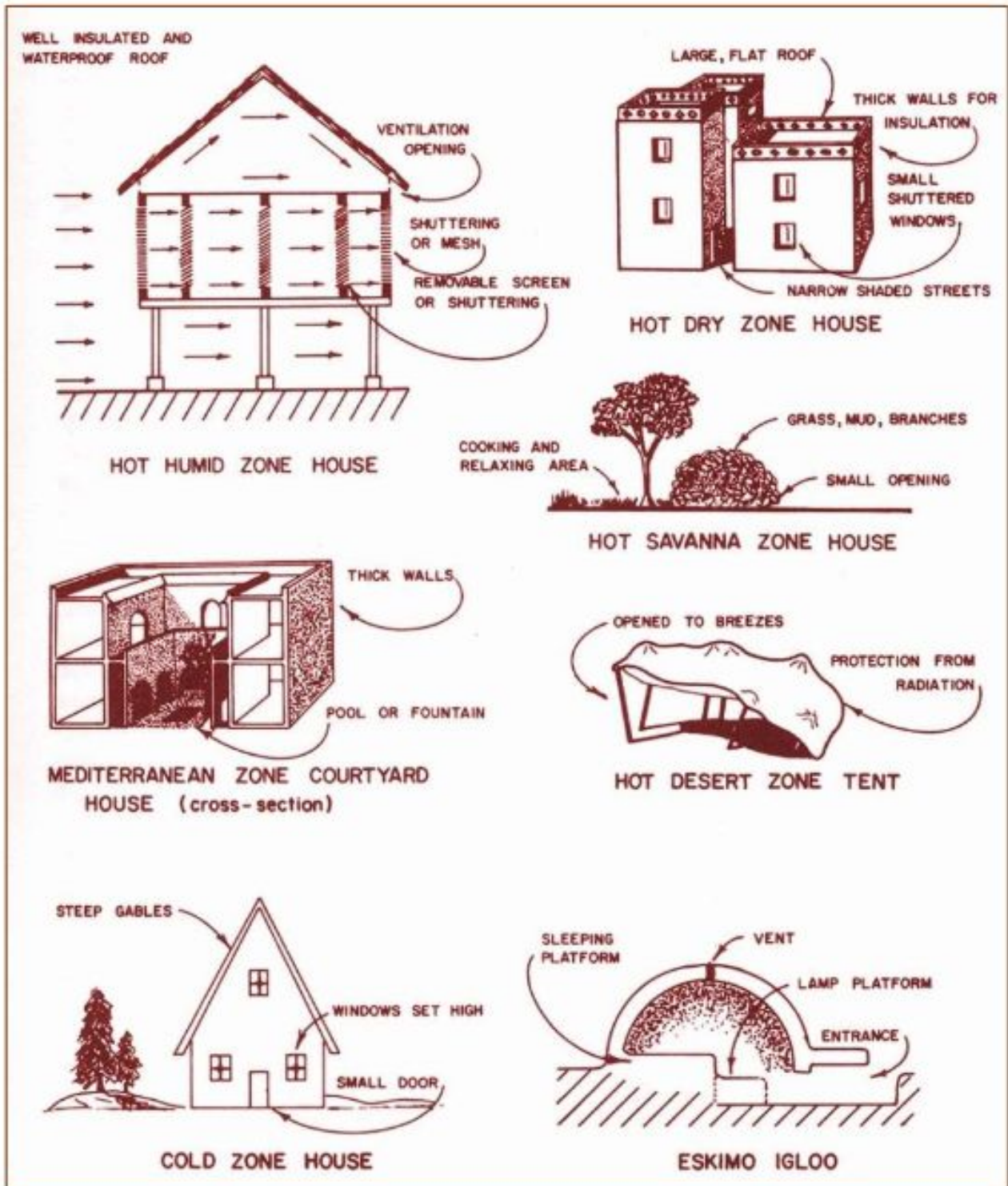
#### **3.1. Specificities to consider on local intervention in Mediterranean cities**

In the previous chapter, the greater specificity of the south of France concerning the climate itself emerged. This climate condition often gives rise to additional characteristics, for instance in terms of the city' morphology. Therefore, summer temperatures in cities and towns are a factor for adaptation, particularly in the building design process. Notably, these are thermal differences occurring late in the day and at night in comparison to nearby rural areas. The Mediterranean regions are also characterised by specific winds such as the Mistral and the Tramontane winds which clear the clouds from the sky, as well as a high percentage of sunny days per year. On the other hand, these winds are refreshing in summer compared to hot south winds such as the Sirocco wind.

An analysis of exemplary eco-neighbourhood projects in the PACA region explores several recurring problems which can be traced back to other regions with similar climates. Among the

main emerging problems are the ageing of the population and the difficulty of rehabilitating old town centres. Moreover, heritage themes play an important role, with significant rehabilitation costs and a supply that does not match demand. The heritage as mentioned in the PACA (2012) region study can be both a stopgap and an opportunity. As specific brakes of small cities, for example, there is a lack of financial means such as investors. Moreover, the fact that politicians are not trained, which leads to difficulties in terms of implementation of the projects themselves. In addition, in small cities, the project scales are usually small with high costs which is a deterrent for private and public owners to intervene. Finally, there is a lack of institutional partnerships as well as technical staff. It is, therefore, necessary to implement specific accompanying programmes for small municipalities (PACA, 2012).

While on the one hand, an acceptance exists of the fact that buildings have climate-friendly specificities on the architectural level in Mediterranean cities (Fig. 10), on the other hand, there are conflicting views regarding urban planning specificities. For what concerns building scale the architectural design for Mediterranean climates presents specific features, as shown for example by Griffiths' studio (1976) by a typical courtyard characterized by a central fountain and thick walls. Conversely, the GREC-PACA (2017) states that although there is a specific impact of climate variables due to the Mediterranean climate, this impact remains independent of the urban planning peculiarities.



**Figure 10.** Vernacular and traditional houses. Source: Griffiths, 1976 as cited in Colombert (2008).

Nowadays, due to several changes over the decades composed by general operations, some cities progressively lost their traditional architectural nature. For instance, the widening of the streets, to meet new mobility needs, have even led to a worsening of the effects of UHIs, especially concerning projects where no green spaces have been foreseen. These latter features are particularly important within a context where an increase in temperature and the absence of shaded spaces are key factors to reduce exposure of people most at risk. In addition, in an environment characterized by many

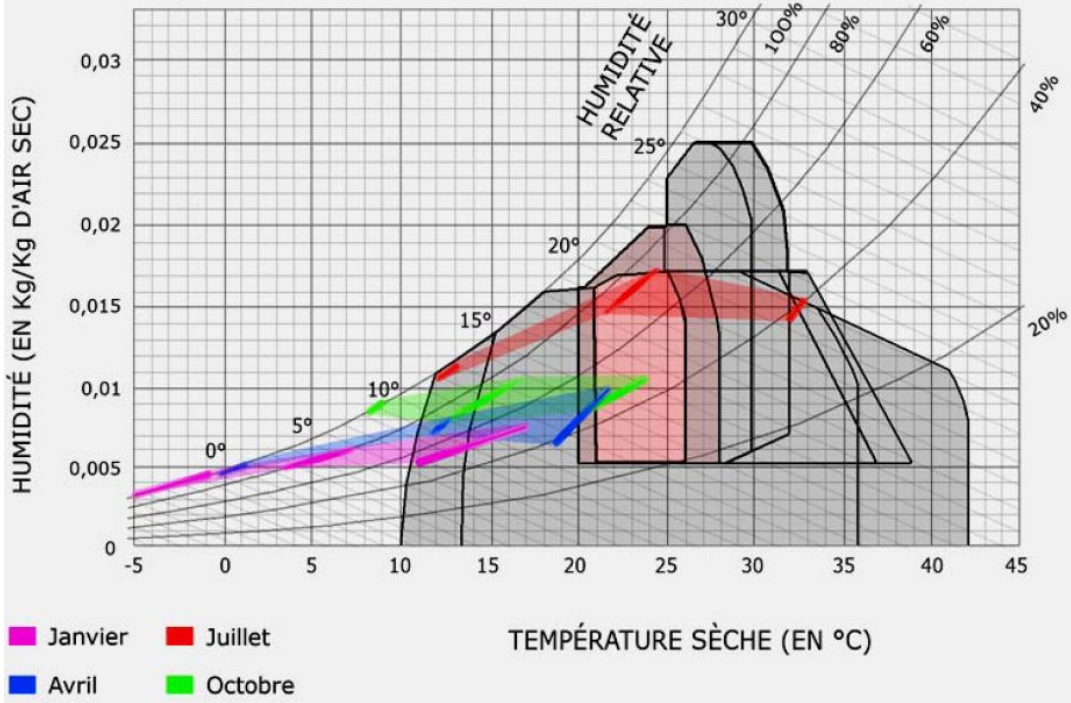
elderly people, events such as heatwaves are decisive factors behind the drama (GREC-PACA, 2017).

Therefore, the specificities to be taken into account in the southern regions are more climatic and less urban morphological. However, exceptions are made for the scale of the building, which usually is adapted to the Mediterranean climate by the inclusion of bioclimatic principles. For instance, as already mentioned, through the creation of inner courtyards which allow natural lighting as well as natural ventilation. In this respect, it is interesting to analyse the sustainable neighbourhood labels that are specific to the Mediterranean climate today in order to eventually understand what are the key elements when redeveloping or creating new neighbourhoods for the Mediterranean climate. For instance, through the analysis of specific labels for Mediterranean neighbourhoods such as the “QDM” (Mediterranean Sustainable Neighbourhoods), created by the enviroBAT association, the emphasis is placed on summer comfort, soft mobility and the health of the inhabitants. In addition, concerning outdoor spaces, particular attention is paid to rainwater management, strengthening biodiversity by favouring local economic species in the water demand. The technical solutions are accompanied by a participatory process, which is considered to be especially important for the success of the redevelopment projects (EnvirobatBDM, 2016). As a matter of facts, these labels have a dual function; they act as accompaniment during the operational phases of the projects and as vectors of awareness-raising and training of the stakeholders involved (politicians, technicians, etc.) (PACA, 2012). However, any technical solution can start from the municipalities or the competent EPCI who can anticipate particular processes. Notably, to facilitate the operational implementation, development of these actions into local urban planning documents such as SCoT and PLU should be considered as the first step (EnvirobatBDM, 2016).

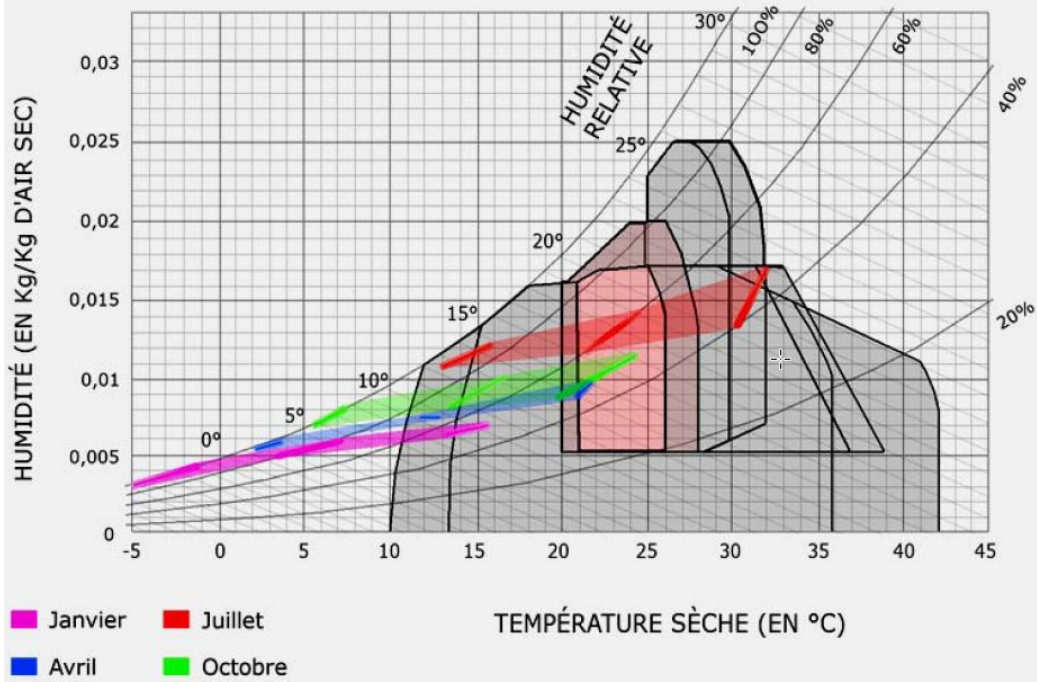
Additional relevant features to be analysed beyond the labels characterising the French Mediterranean basin are hygrothermal data. An interesting collection of hygrothermal data from several cities in France highlights the features that should be taken into account in the design of buildings in Mediterranean cities. As a matter of fact, in July, in Mediterranean cities, it is essential for the internal thermo-hygrometric comfort a combination of thermal inertia by absorption (ability to keep a homogeneous internal temperature) plus night ventilation, rather than for cities in northern France where only poor ventilation is recommended (Fig. 11) (Izard & Kacala, 2006).

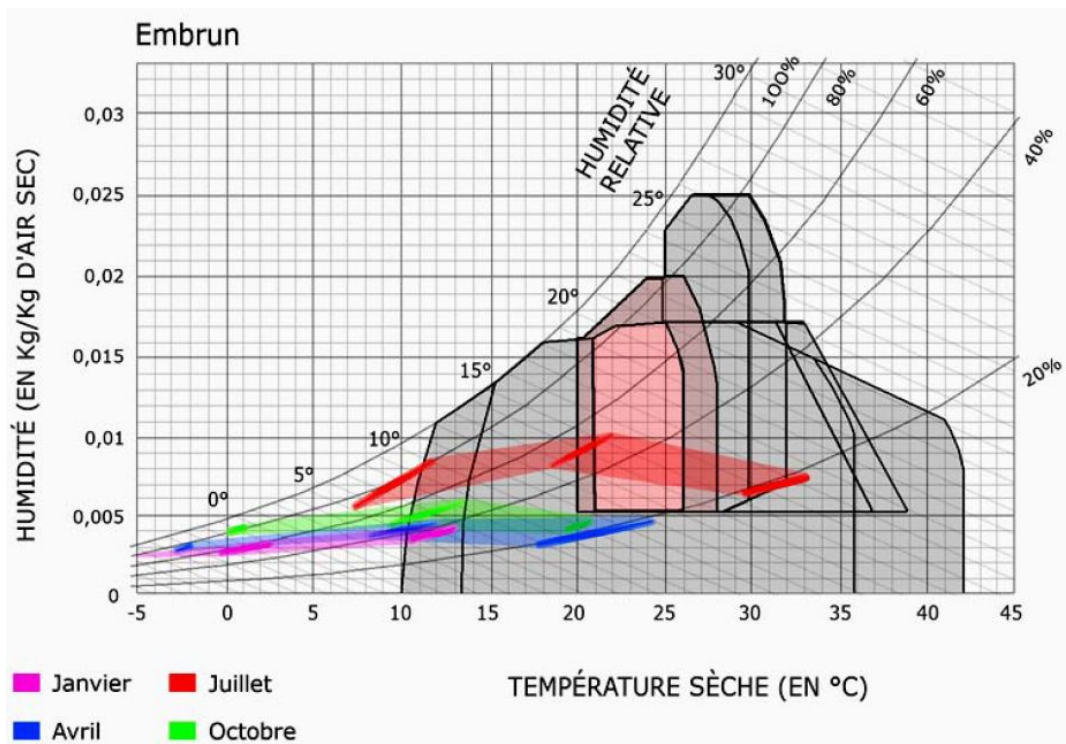
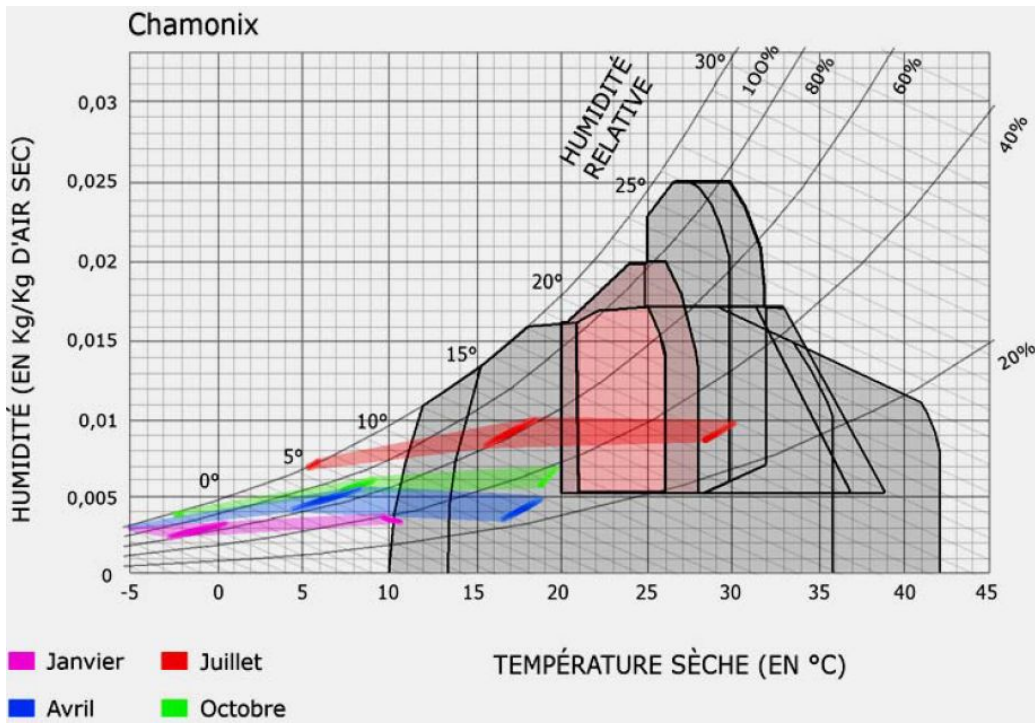


### Carpentras



### Aix-en Provence





**Figure 11.** Example of comparison of relative humidity in July for buildings in southern cities compared to those in the north according to thermal comfort (red and pink zone). Source: Izard & Kacala, 2006.

### *3.1.1. Traditional and morphological specificities*

Sébastien Giorgis, architect, landscape architect and urban planner, identifies a specific relation with water among Mediterranean cities (“Nature For City Life”, 2020). Mediterranean cities, along with other cities in the world, tend to settle close to water sources in order to take advantage of this indispensable resource for the sustenance of human activities (Braudel, 2017). The particularity of the Mediterranean territories resides in the availability of this resource. Winters are characterized by abundant rainfall causing major flooding risks and forcing cities to take preventive measures (creation of dams, walls, etc.). On the other hand, in other periods such as summer, they are characterized by drought and a reduced amount of rainfall at the extremes, thus creating situations of dryness with the risk of fire. This characteristic has therefore prompted Mediterranean cities to install themselves in protected and impermeable areas, and to increase even more this impermeability, thus increasing directly the risk of flooding. For this reason, the cities settled in the Mediterranean basin are characterised by a marked minerality.

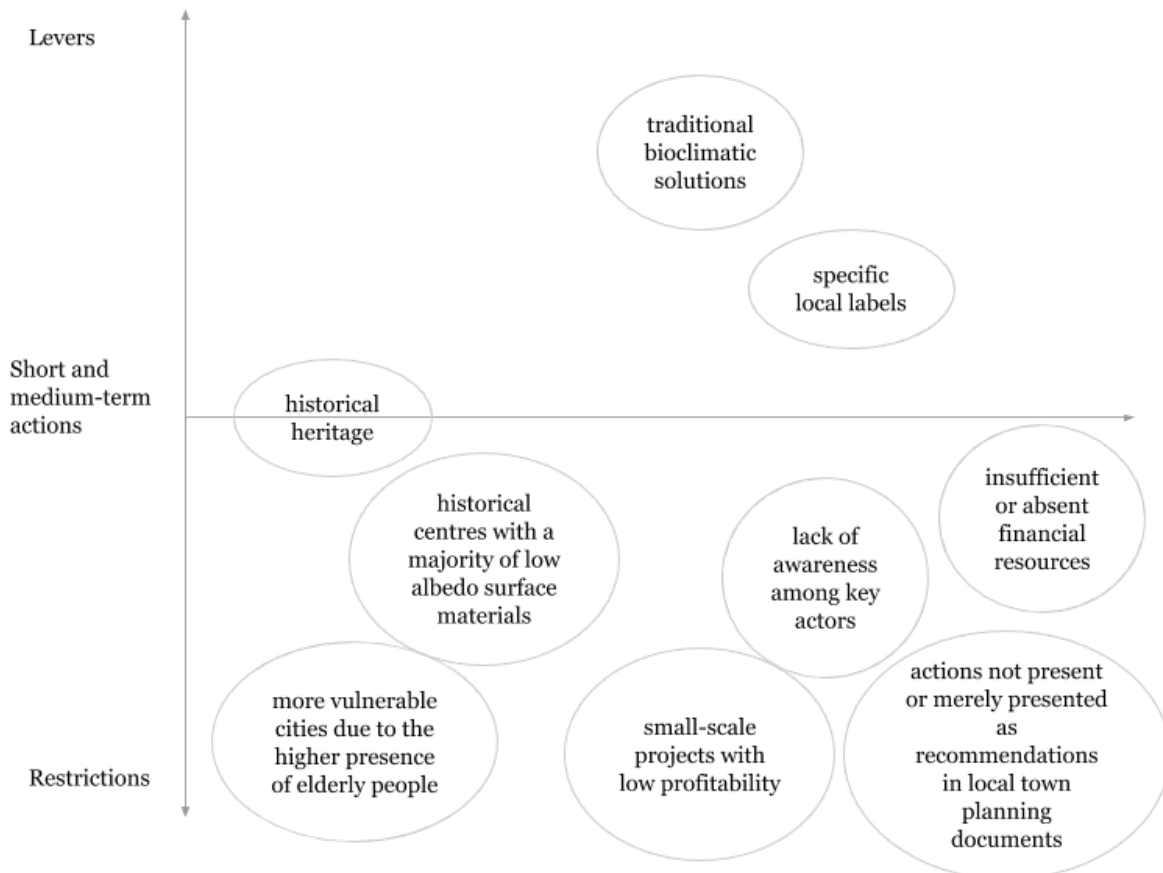
Consequently, not only is it important for Mediterranean cities to be greener to combat the effects created by urban heat islands, but it is even more crucial to do so by permeating the soil, which reduces the risks associated with flooding. Climate change is, therefore, a phenomenon that calls into question very specific choices for the Mediterranean territory (“Planning With Nature In The City”, 2018).

### *2.1.3 Stakeholder involvement*

For the success of projects on an urban scale, especially in terms of strategies to combat climate change, numerous studies underline the importance of the process of raising awareness among citizens, politicians and technicians (PACA, 2012). In the case of the inhabitants, the importance of their participatory process in the planning phase as well as in the future phases is also highlighted. In some cases, through training courses for politicians, it is possible in parallel to draw up guides. The aim is to respond and accompany the municipalities in their planning choices with responses adapted to the territory. Indeed, cities are promoters of actions, in which politicians are one of the key players in the implementation with an impact on the urban climate. Especially, when dealing with issues such as UHIs, a first step taken by mayors is therefore indispensable (PACA, 2012).

### 2.1.4 Conclusion

In conclusion, as a starting point in the fight against climate change, one should tend to create a link with the traditional practices of the cultural context versus the adaptation of generalized strategies from other contexts (Table 4). For this reason, a merely technical reaction to climate change issues is insufficient, while the integration of existing specific responses in the Mediterranean basin, part of the people' culture, is necessary (“Nature For City Life”, 2020).



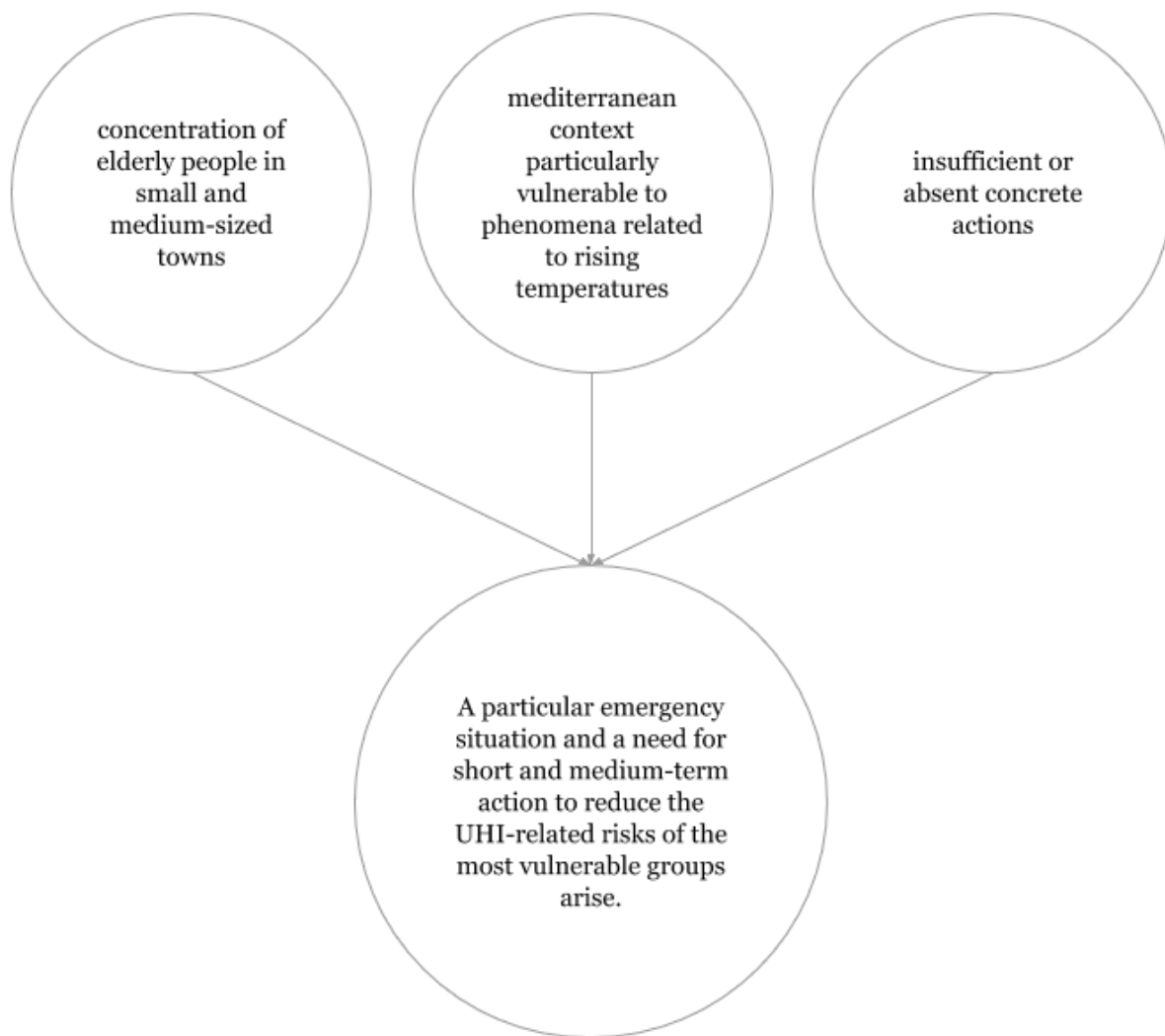
**Table 4.** Additional blocks and opportunities for small and medium-sized Mediterranean French cities (Author).

Furthermore, the inclusion of various actors as mayors, technicians and citizens is a crucial factor in the fight against UHI as well as in the development of city spaces to improve the comfort conditions for the most vulnerable (Fig. 12).



**Figure 12.** The UHI project. Source: Lauriola, 2013.

Urgent response with short-term and medium-term solutions is necessary (Table 5). Both emission mitigation and adaptation to climate change phenomena are necessary. As we have already seen, however, the latter is more difficult to put into practice. Adaptation actions and at the same time actions with perceptible short and medium-term impacts could provide the most vulnerable groups of people real hope of well-being.



**Table 5.** Main causes that impose on the small and medium-sized towns in the south of France, in the Mediterranean basin, the emergency to act for short and medium-term solutions to limit the UHI phenomena (Author).

### **3.2. Trees, urban heat islands and thermal comfort: reduction of health risks in vulnerable populations through resilient cities**

Early studies carried out on urban heat islands have found it difficult to fully understand the phenomenon in meteorological terms (Oke, 1982). Especially the adaptation of cities to this phenomenon is complex and far from being easily solvable (Lambert-Habib et al., 2013). Nowadays there are still considerable difficulties, especially concerning the identification of the phenomenon in its spatial distribution. As a matter of fact, for large as well as small urban settlement the phenomenon is spatially distributed both vertically and horizontally (Fig. 13). Some studies conducted in France focused particularly on the horizontal and vertical extension intensity of UHIs. For what concerns its horizontal characteristic, a distribution that can show irregularities related to the variable of topography and differences in land use must be considered. In the vertical direction,

the night UHI has a generic impact for a few hundred meters above the ground (from 150 to 300 meters).

The UHI consists of the weather change between daytime heating and nighttime cooling in the rural and urban areas which generates the phenomenon. According to Oke (1982), the phenomenon of UHIs is more nocturnal, which concerns not the heating of urban areas during the day but the "non-cooling" of them during the night, especially in the period between one sunset and another.

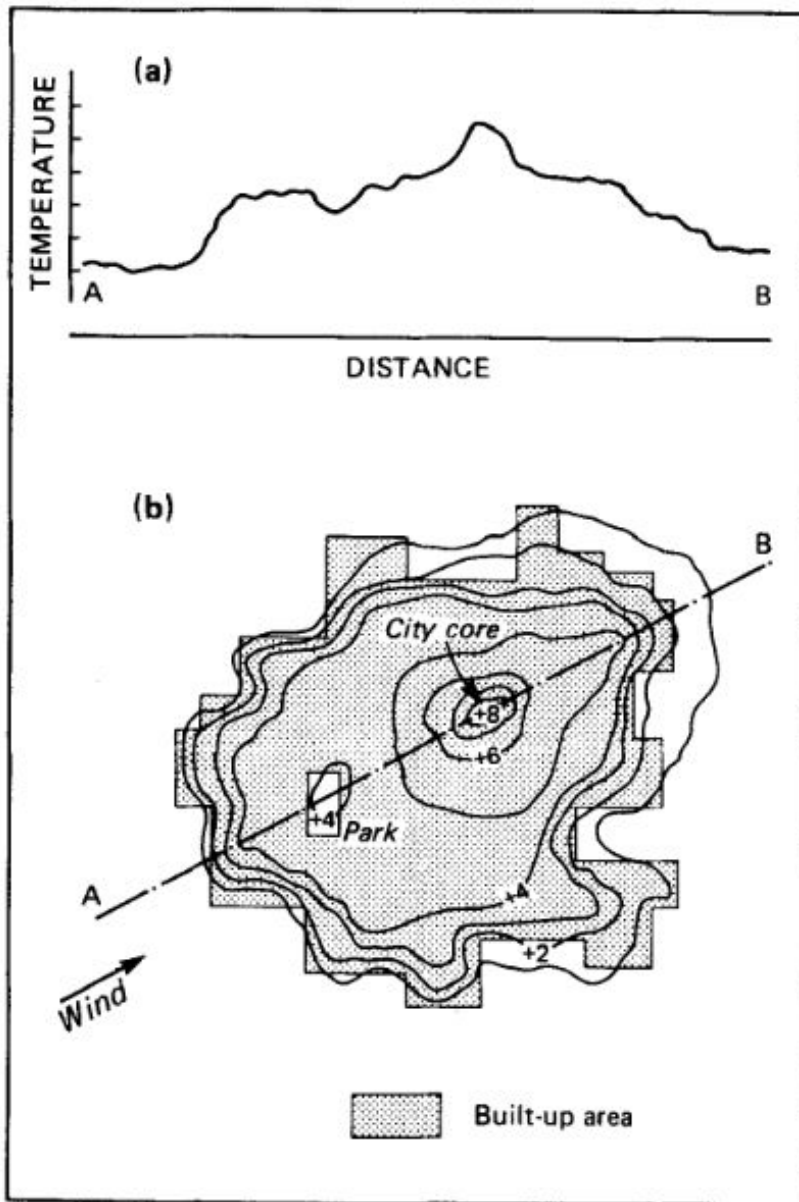
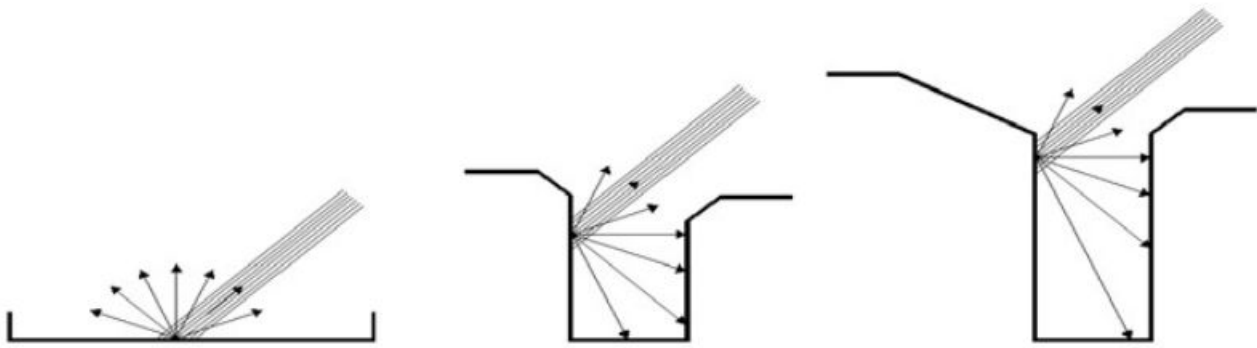


Figure 1. Hypothetical representation of the spatial and temporal features of the canopy layer urban heat island in a mid-latitude city with 'ideal' (calm, clear) weather. Spatial pattern (a) along cross-section AB and (b) in relation to the plan outline of the city. Temporal variation of urban and rural (c) air temperature (d) heating/cooling rates and (e) the resulting heat island intensity. Vertical scale units are approximately  $2^{\circ}\text{C}$  for (a), (c) and (e) and  $2^{\circ}\text{C h}^{-1}$  for (d).

Figure 13. Hypothetical distribution of the urban heat island. Source: Oke, 1982.

Concerning the reasons behind the formation of this urban phenomenon, other characteristics must be taken into account rather than the mere size of the city. In order to be even more precise in the identification and study of the UHI phenomenon, it is appropriate to refer to the enhancement of some features. Firstly, the surfaces of cities (Oke, 1982), especially those materials with a low albedo such as concrete, which have a lower ability to reflect radiation and therefore a more important absorption of heat, reasons for its temperature rise. Secondly, the UHI phenomenon is closely related to the density population within the city (Lauriola, 2013). Thirdly, the geometry built environment can particularly affect this phenomenon, e.g. due to its strict link with the incidence of sun rays on buildings or urban spaces (Fig. 14). Lastly, the local anthropogenic heat (Oke, 1982), as well as the lack of evapotranspiration surfaces such as green areas (Lauriola, 2013), must be considered.



**Figure 14.** Reflections of solar radiation in an urban context, in relation to the variation of the morphology along a vertical section. Source: Pensato, 2009.

These physical and morphological characteristics enable different energy distribution by modifying variables such as air temperature, humidity or wind that affect the climate (C. Route, 2019). Moreover, the comfort level perceived by people can be influenced by these variables, leading to situations of discomfort or well-being. For this reason, it is important to implement strategies that allow greater control of the microclimate with the aim of reducing the intensity and exposure to risky phenomena such as UHIs which can endanger particular groups of vulnerable people. Although an impact on human health as well as increased demand for air conditioning will be inevitable (Lambert-Habib et al., 2013) which, to cool the indoor environment, increases the outside temperature due to heat emissions (Munck et al., 2013).

### *Measure, mitigate and adapt*

Foissard, et al. (2019) states that French municipalities should introduce strategies to reduce the effects of climate change in cities, especially when it comes to UHI. In particular, for



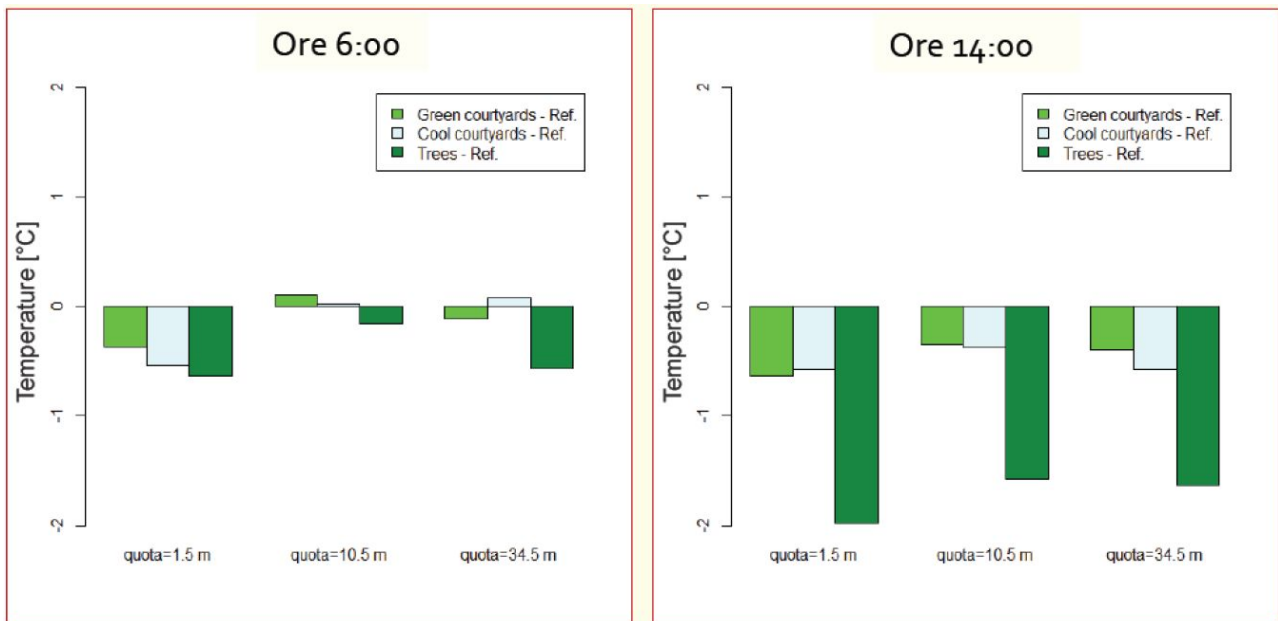
Mediterranean cities the green infrastructure planning strategies “should give priority to wider and more fragmented green patches” (Nastran, et al., 2019, page 40).

Considering the need for geographical context analysis, it is clear that local urban planning documents are key tools for the future and present urban climate. It is even more important to focus on neighbourhood-scale strategies (between 100 metres and 1 kilometre), where not only fewer variables need to be taken into account but also better citizen participation is possible (Foissard, et al., 2019).

Generally speaking, the strategies to fight against UHIs must be implemented with respect to three factors: monitoring, mitigation and adaptation. Monitoring to date cannot give an overall assessment of the UHIs. Indeed, many variables such as the spatial thermal field or the temporal (meteorological) variable must be taken into account. For this reason, it is necessary to integrate different investigation methods (thermo hygrometers, satellites, etc.).

For what concern adaptation, can be achieved by applying urban planning models, e.g. on the construction characteristics of buildings (green roofs, vegetal walls, etc.), on the structures of urbanized areas ( high buildings, road canyons) and their relationship with green spaces (Lauriola, 2013). In addition, intervention should be made to the scale of urban spaces on paving materials by choosing those with a higher albedo. Moreover, water and natural air circulation should be included in urban planning techniques to improve the comfort of inhabitants (Climate Atlas of the Region of Stuttgart, 2008). For mitigation, it will be necessary to define prevention and warning strategies, through the reduction of greenhouse gases and the prevention of health effects (Lauriola, 2013).

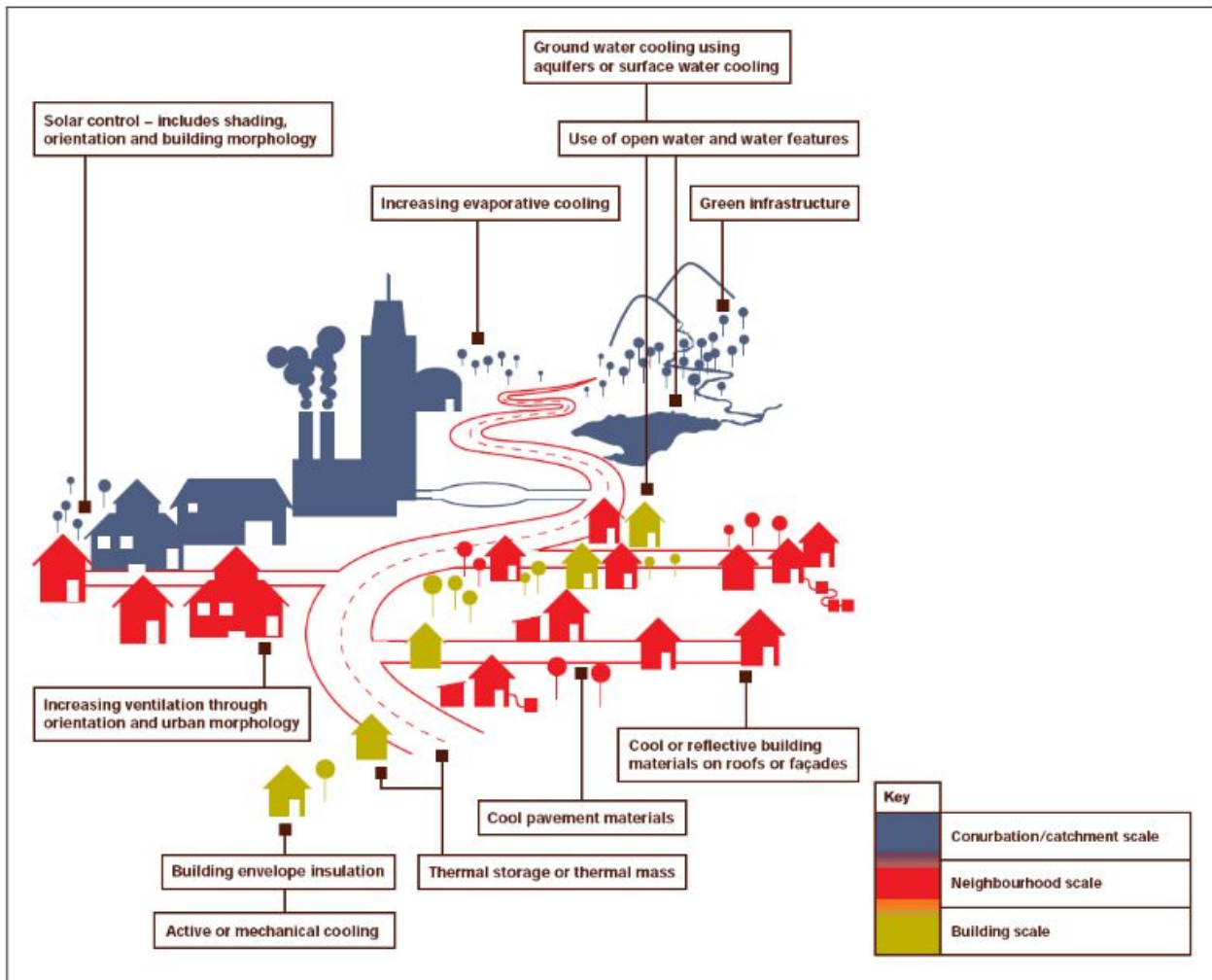
However, some strategies are more effective than others, for this reason, it is worth knowing the actual potential of existing strategies to highlight the most beneficial ones in terms of immediate comfort. For instance, a simulation of a parking area redevelopment intervention for the project "Villaggio artigiano di modena" (Artisan village of Modena) in Italy shows that tree insertion is the best practice for cooling (Fig. 15). As a matter of fact, regarding the environmental thermal comfort, a reduction of the temperatures of the shaded areas created by the trees up to  $-2^{\circ}\text{C}$  has been noticed. On the other hand, a  $0.5^{\circ}\text{C}$  lower temperature was recorded using permeable surfaces. Regarding the insertion of green roofs, the simulation detected the peak of the cooling phenomenon at a height of 10 meters above the ground level where little cooling was detected. Therefore, thanks to its shading power, the tree is confirmed as the most effective measure of immediate effective environmental comfort (UHI, Pilot project “Villaggio Artigiano”).



**Figure 15.** Simulation of the different mitigation measures and their temperature difference in height (1.5, 10.5 and 34.5 meters) during the day, from 6:00 am on the left to 14:00 on the right. Source: UHI, Pilot project “Villaggio Artigiano”.

Furthermore, the impact of some measures compared to others cannot be simply generalized. Indeed, several studies on the effectiveness of green roofs have conflicting results. Nevertheless, there is general agreement on the fact that green roofs have little cooling power at the level of pedestrians (UHI, Pilot project "Villaggio Artigiano"; ADEME, 2018). Indeed, the greater refreshing power of green roofs results from irrigating them. Concerning the effectiveness of trees, there is a common consensus on their significant and positive impact on the cooling of urban areas. Finally, actions like greening large areas have significant impacts in refreshing nearby neighbourhoods densely built. Similarly effective are the practices of homogeneous distribution of small-scale vegetated areas within cities (ADEME, 2018).

As far as summer comfort is concerned, below a scheme by Shaw et al. (2017) (Fig. 16) summarizes the practices to be taken into consideration.



**Figure 16.** Actions and techniques available to increase a city's ability to adapt to high temperatures. Source: Shaw et al. (2017) as cited in Colombert, 2008.

### 3.3. Take action under the pressure of climate change through local urban planning documents

As already highlighted by several studies, the consideration of the local climate (Lambert-Habib et al. 2013, Oke 1982) as well as local housing ( building typology, urban morphology etc.), social and cultural specificities (GREC-PACA, 2017) are essential components to consider to take correct steps. Furthermore, climate and energy issues need to be addressed with different drivers as labels or local planning documents, including a wide network of local actors (GREC-PACA, 2017). Therefore, the coordinated action of various stakeholders and strategies appears to be the most appropriate approach to progress from the theoretical phase towards concrete adaptation and mitigation projects on the city.

Urban planning documents cover several fields of action and allow to raise awareness as well as

undertake concrete actions simultaneously. For this reason, it is essential as a starting step to use the existing urban planning tools to act at the local level.

Summer comfort is an almost urgent issue in the context of Mediterranean cities, given the significant impact on the vulnerability of some population groups. Consequently, in order to focus on short and medium-term solutions, an analysis of the relationship that local urban planning legal instruments have towards summer comfort needs to be carried out. Below (Table 6), pros and cons, as well as the operational implementation and immediacy of the actions are analysed.

<b>Tool</b>	<b>Thematic</b>	<b>Advantages</b>	<b>Disadvantages</b>	<b>Operational Implementation</b>	<b>Immediacy Of Action</b>
<b>SCoT</b>	summer comfort	<ul style="list-style-type: none"> <li>-the prescriptions oblige to take into account the theme at territorial level;</li> <li>-the first step for the creation of thematic maps;</li> <li>-Create awareness and a condition for action.</li> </ul>	<ul style="list-style-type: none"> <li>-insufficiently operational</li> <li>-does not intervene on the scale of the buildings as well as the nature of the vegetated spaces</li> </ul>	<ul style="list-style-type: none"> <li>-to be translated into the PLU and planning operations with the ZAC building and renovation permits.</li> </ul>	<ul style="list-style-type: none"> <li>-given the need to translate the issues introduced into other documents the immediacy of action is considered low</li> </ul>
<b>PLU, PLUs</b>	summer comfort	<ul style="list-style-type: none"> <li>-capacity for environmental and energy performance recommendations</li> <li>--important pedagogical role (including illustrated advice or referring to existing guides)</li> <li>-Useful at the local scale to protect and preserve endangered areas</li> </ul>	<ul style="list-style-type: none"> <li>-not requiring the imposition of environmental and energy performance criteria ( this can be considered as an opportunity as it leaves space for the creativity of bioclimatic projects)</li> <li>-Cannot oblige the use of materials with high albedo</li> </ul>	<ul style="list-style-type: none"> <li>-emphasis on inter-municipal level planning (PLUi) as well as strengthening the local document with higher strategic documents (SCoT, PDU, PLH, PCET, etc.).</li> </ul>	<ul style="list-style-type: none"> <li>-if obligations are strongly imposed and projects launched it may be considered to have a rapid impact</li> </ul>

<b>ZAC</b>	summer comfort	<p>-possibility to innovate or exploit operational mechanisms (BDM, QDM, Éco-quartiers et Éco-cités...);</p> <p>-local intervention;</p> <p>-allows addressing issues related to the environmental comfort of buildings</p> <p>-may include large areas of intervention at the scale of the city.</p>	<p>-on large areas of planning the rules of the OAP (density, type of building) must also be added</p> <p>-only the scale of buildings and urban spaces is considered</p>	-	immediate on the ongoing project
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**Table 6.** Differences in urban planning documents regarding measures to improve summer comfort (Author).

It is noted that both PLU and PLUs allow a greater manoeuvre for summer comfort issues, whether a building or neighbourhood level, where the ZAC lends itself strongly in the latter case. The main disadvantage for the PLU lies in having the possibility to choose not to impose energy and environmental performance criteria. This means that many of the proposed recommendations rather than obligations are not truly taken into account at the project development stage, thus reducing the concrete impact of the PLU. On the other hand, for its capacity to make impositions, the PLU emerges as a key document in the inclusion and consideration of bioclimatic design features to improve the environmental comfort of urban areas. This latter is therefore considered as the main document for the proposal of specific short and medium-term recommendations for summer comfort solutions concerning small and medium-sized Mediterranean cities.

### *Strategies for summer environmental comfort*

In order to address the health risks of vulnerable groups associated with climate change, especially concerning heatwaves in small and medium-sized French Mediterranean towns and cities, it is necessary first and foremost to adapt the legal tools of urban planning. Therefore, the inclusion of natural elements in the design process at the building, neighbourhood, and city scale needs to be taken into account. Thus, features such as vegetation and water should be recommended or even imposed in urban planning local documents for the fight against UHIs. Indeed, the encouragement, obligation, and prohibition are the three main actions that can be implemented in the PLU local

planning document (Table 7).

Regulation	OAPP	PADD
Obligation Incite Encourage	Incite Encourage (set orientations)	Encourage

**Table 7.** What the PLU can do: oblige, recommend (raise awareness), and prohibit (Author).

Some strategies mitigate the impact of rising temperatures in urban areas. Two categories of these techniques can be distinguished, the reduction of the anthropogenic influence of human activities (energy use, public transport etc.) and the cooling of cities based on bioclimatic principles (natural ventilation, green elements, etc.) (Lambert-Habib et al., 2013).

Issues related to ecological continuity can be addressed in documents like OAPs within the Local Urbanism Plan (PLU, PLUs) to preserve the existing vegetation species as well as the biodiversity. Indeed, by identifying the existing green spaces, it is possible to foresee vegetal bands at the foot of the facades in the construction of new buildings to integrate them in the vegetal structure (Bur, 2018). In addition, a CBS (biotope coefficient per surface) can be added to the OAP and forced to comply with it. Moreover, bioclimatic building design principles can be established or recommended (CoVe, 2020) until the prohibition of air-conditioning use (Lambert et al., 2016). As regards water management, OAPs provide opportunities to define actions aimed at enhancing the value of the environment and its ecological continuity (Article L151-7, “Urban Planning Code”, 2020).

For what concerns the PLU, it is defining the general rules of the use of land and allows the achievement of some objectives cited in the “Urban Planning Code”. Thus are defining the protection of natural and landscape centres, the preservation of the quality of water, the fight against climate change including adaptation, and finally the control and dominion of the energy and its production from renewable sources (“Urban Planning Code”, 2020). The aim is to define the field of action of the regulation for each zone of intervention. Thus are touching three main issues/challenges: the land use for constructions; the characteristic of these construction regards to its functions (environmental, architectural, urban, landscape); the dotation of resources. The construction of the regulation by articles is not mandatory, in any case, some contents of old articles are in the new structure in the part “environmental characteristic”. For instance the volumetry of implantation of constructions (R.151-39 & R.161-42, “Urban Planning Code”, 2020),

the urban, architectural, environmental and landscape quality (R.151-41 et R. 151-42, “Urban Planning Code”, 2020) and finally the environmental and landscape treatment of the no built spaces and around the constructions (Article R.151-43, “Urban Planning Code”, 2020).

It is interesting to notice that the new article L152-5 3° of the “Urban Planning Code” allows derogation at the rules of PLU. For instance for the high of constructions, the implantation and the esthetic. Not only, but many articles also allow regulate the energetic performance of buildings through a bioclimatic approach, e.g. the introduction of green roofs (Lambert-Habib et al., 2013; Règlement du PLU (i)).

## **4. CHAPTER 4**

### **4.1. Recommendations for summer comfort strategies transcriptions into PLU urban planning document**

Following is a collection of themes related to summer comfort in small and medium-sized French cities. The themes are adapted to the different documents in the PLU from the report of the presentation until each regulation. In addition, some examples of transcription in the PLUs of French cities are given as examples.

Some recommendations may be valid for any city given the urban heat island phenomenon, which is strictly related to the city. Others recommendations are particularly specific and take into account local culture and practices already started in ancient times. For this reason, some practices can be easily accepted in Mediterranean cities and possibly more easily included in local urban planning documents such as PLU or PLU(s).

The recommendations focus on urbanised areas (historical centres, etc.) and areas to be urbanised (areas close to urban centres). This list of recommendations is useful to understand the issues that cities have to address to reduce the potential risks associated with urban heat islands and heatwaves. Moreover, the recommendations aim at particularly vulnerable contexts such as small and medium-sized towns and cities in the Mediterranean basin. Within this context, the translation of summer environmental comfort issues into urban planning legal tools is necessary to protect vulnerable groups of people. Due to the limitations resulting from the generalisation of the recommendations, it is correct to adapt locally to any further specificity in morphological, climatic, social and cultural terms that may be differently present within the same region.

#### *4.1.1. Presentation report*

##### *Knowledge of the territory*

To identify possible areas of greater vulnerability, both in terms of vulnerable populations and in terms of particularly hot urban spaces subject to urban heat islands, it is essential to acquire a broad and detailed knowledge of the climatic conditions of the city.

The first step is, therefore, to analyse the state of the territory from the territorial scale to the scale of the neighbourhood. In the presentation report, it is possible to insert thematic diagnosis maps that allow designers to have a detailed knowledge of the elements to be taken into consideration from the concept phase. It is important to know the areas most exposed to the sun and the dominant winds to make the most of these elements for indoor comfort in summer and winter. It is



important to be aware of the areas most exposed to sun and strong winds to best exploit these features for summer and winter comfort. Furthermore, it is recommended to carry out an inventory of the vegetal areas present as well as of water sources and generally all those features that can be potentially refreshing (vegetal facades and roofs, fountains, rivers, parks, etc.).

Concerning the scale of the building, it is useful to identify those with high consumption of air conditioning during summer (offices, museums, care homes for the elderly, etc.). In fact, through the cross-reference with other maps, it is possible to identify the most vulnerable areas to phenomena such as UHI. Additionally, the status of existing means of transport, as well as potential areas for conversion to soft mobility, is further data to be taken into account and analysed. The data can be cross-referenced with information representing the areas of most vulnerable people nowadays.

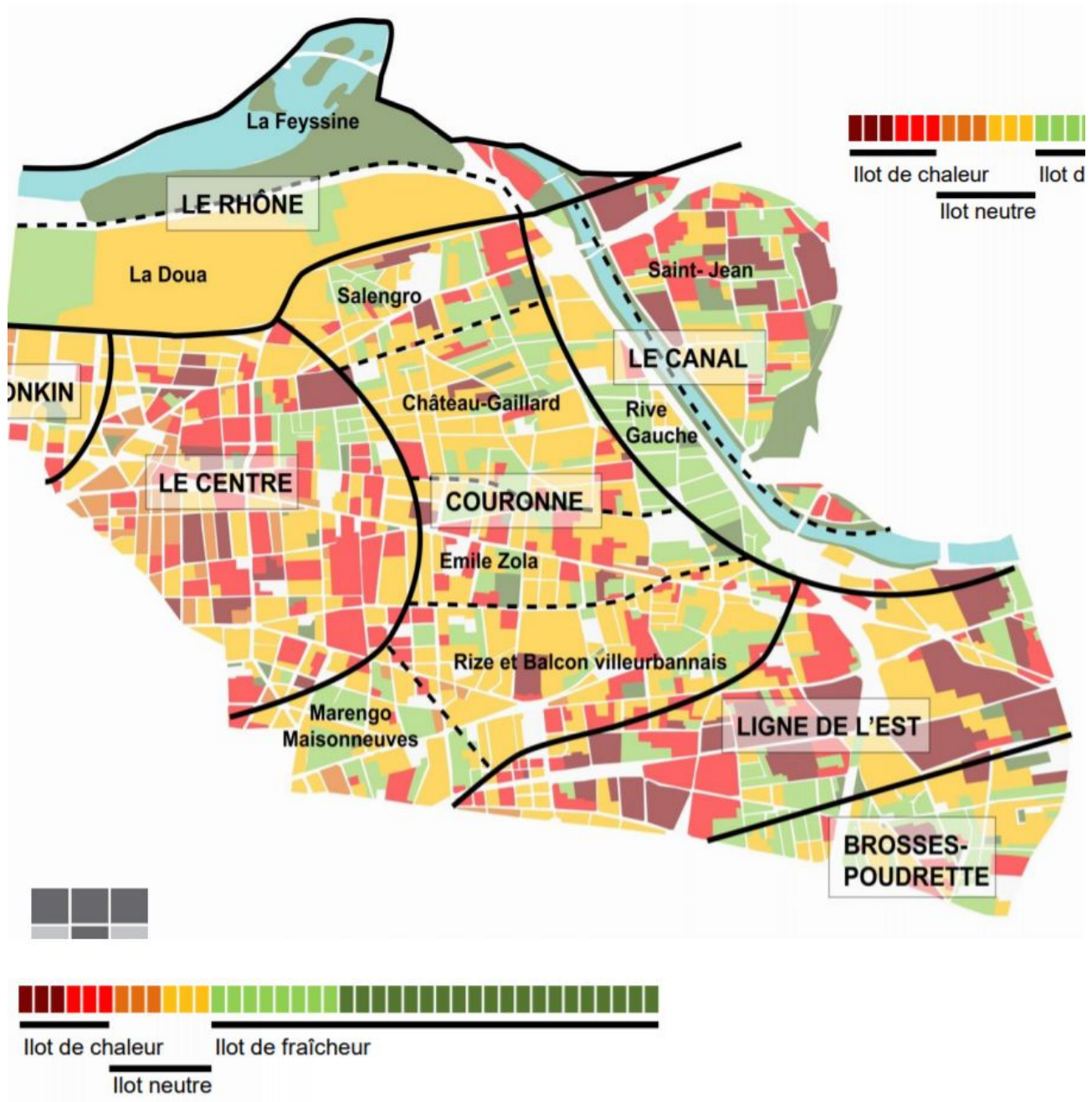
Following are some recommendations for local diagnostics concerning summer comfort and the most vulnerable populations to UHI:

- develop a map summarising the local climate (from the agglomeration scale to the district scale) (CAUE63, & Aduhme, n.d.);
- illustrate the city analysis by thematic maps: realize a diagnosis of the microclimatic conditions of the different urban parcels/streets (monthly wind roses, sunshine, temperatures, rainfall, empirical description of air circles during heat waves) at least the areas of the cities most subject to high temperatures or urban heat islands;
- inventory of existing use status and potential features for cooling the city as follows: vegetation stock, including green roofs and green facades, parks, grasses, trees, as well as natural watercourses, fountains;
- map of the sunniest areas as well as the most exposed ones to dominant winds;
- consider the volume of the building and the areas most exposed to the sun and dominant winds;
- detect high air conditioning consumption buildings and cross-reference the data to other analyses (e.g. thematic maps of less potentially cooling zones) to highlight the most vulnerable urban sites to the phenomenon of UHIs;
- develop a map of potential public spaces within cities for possible short and medium-term projects as well as the most vulnerable spaces to UHIs;
- map of sensitive public buildings (retirement homes, primary schools, etc.) as well as the most vulnerable populations within the city;

The following is an example of an environmental landscape plan for Villeurbanne (Fig. 17). A neighbouring district of Lyon, where a climate diagnosis is carried out, including a map that

identifies urban heat islands and areas with high cooling potential developed by the TRIBU (2016) company.

This empirical model for the identification of urban heat islands is based on data concerning the characteristics of surfaces and their urban shape. The advantages are its rapidity and ease of analysis while the disadvantage is that it does not take into account existing reliefs and winds (ADEME, 2017).

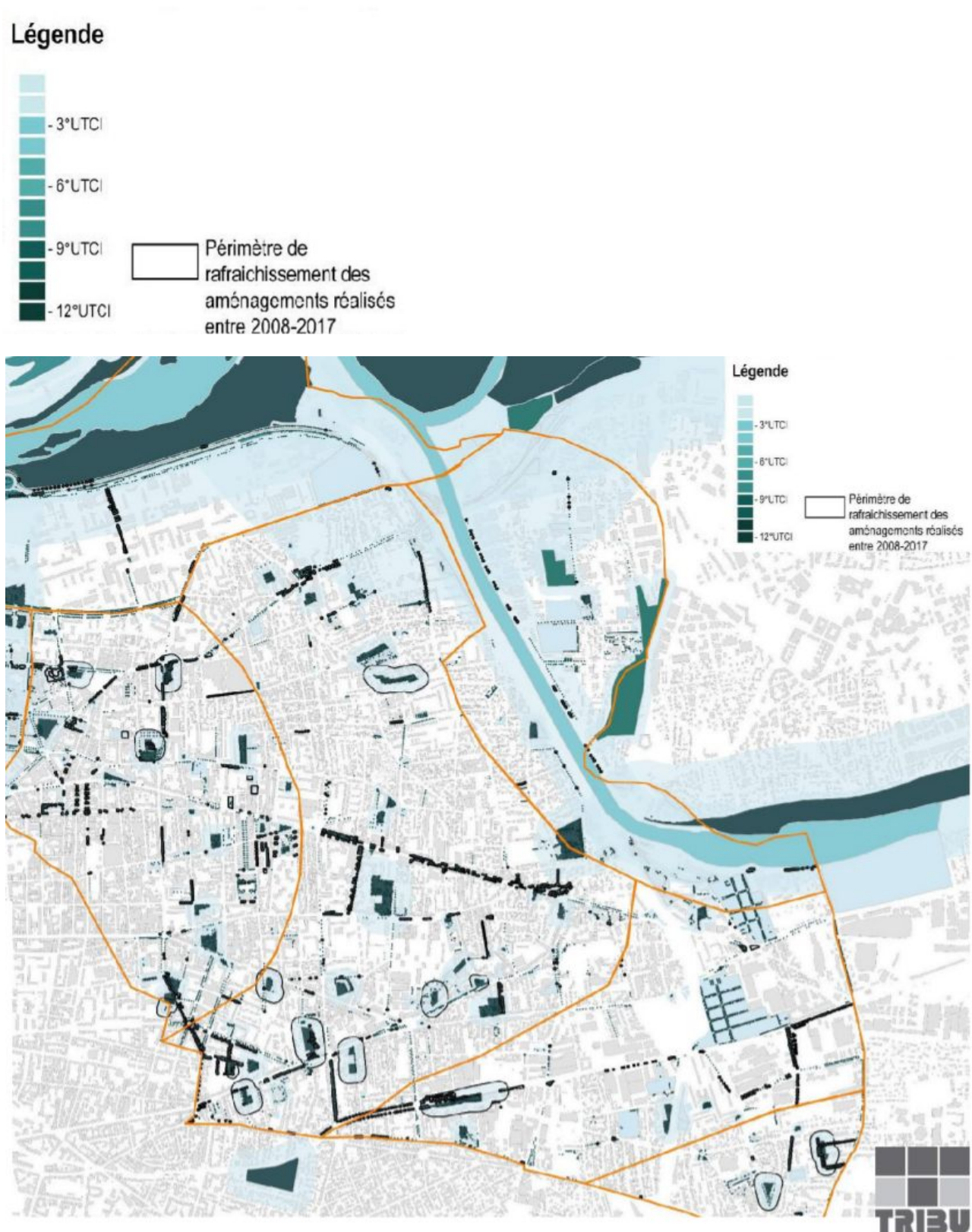


**Figure 17.** Diagnosis of the contribution of Villeurbanne's urban fabrics to urban overheating, From the hottest areas (red areas) to the less hot areas (green areas). Source: TRIBU, 2016.

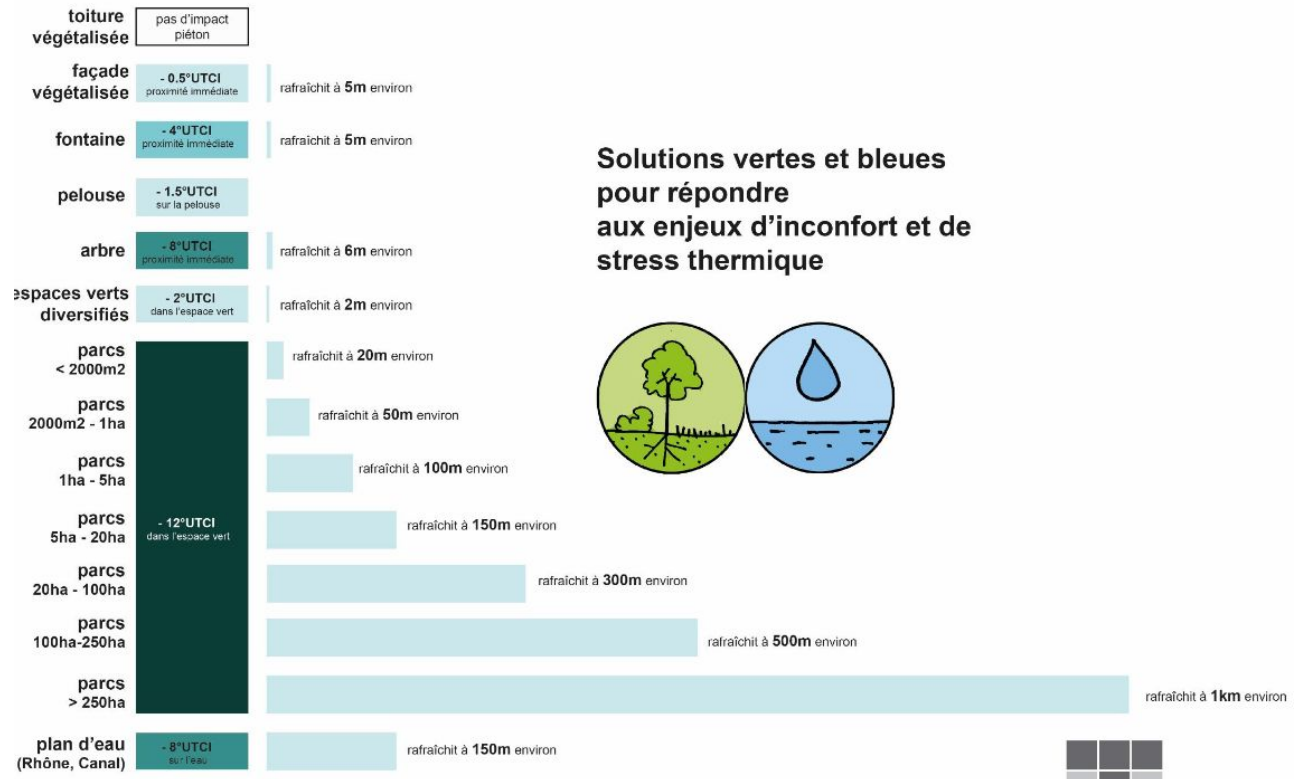
The map of cooling areas (Fig. 18, 19) is based on the consideration of high cooling power areas and

their possible cooling radius by means of an urban cooling indicator. Depending on the particular element considered more or less meters of cooling radius will be available (Fig. 19).

The strength of this system lies in the speed of implementation. On the other hand, however, the generalisation of cooling power on a horizontal level limits its accuracy.

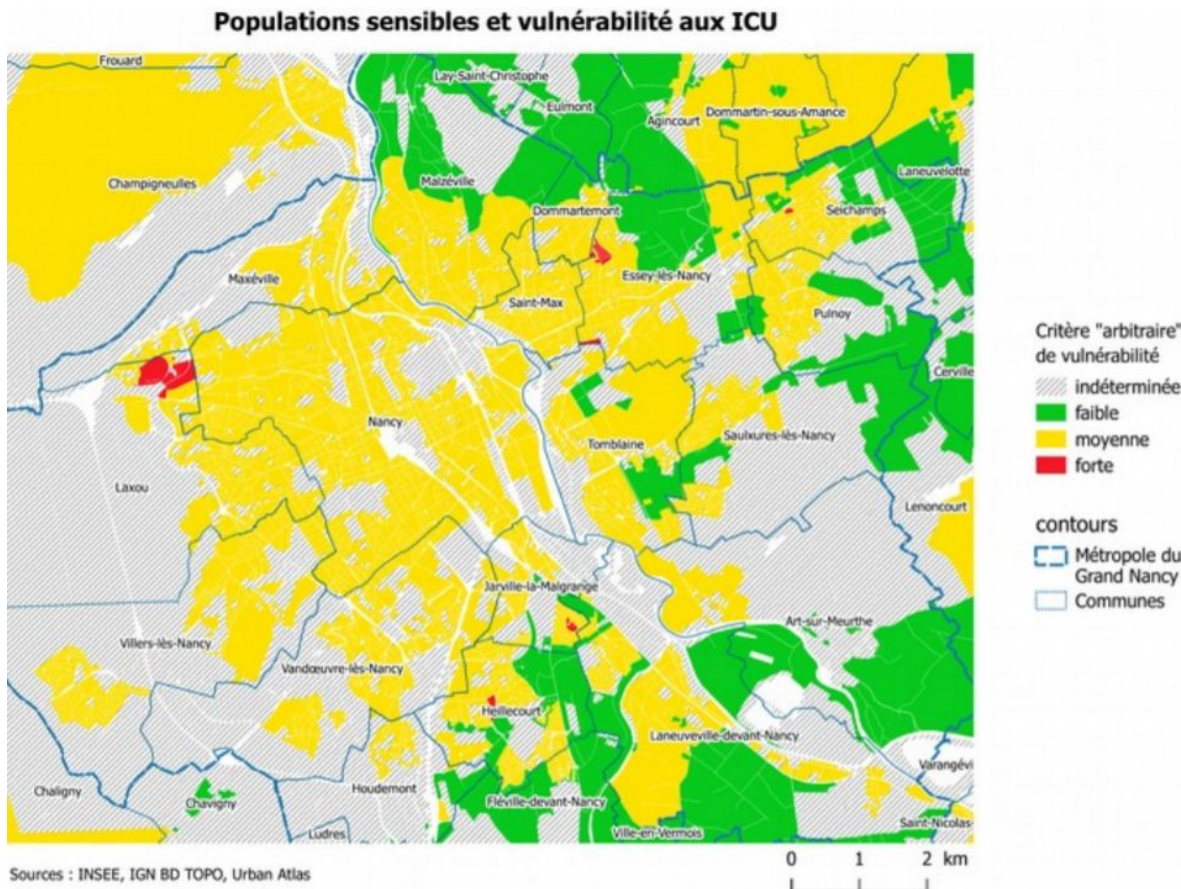
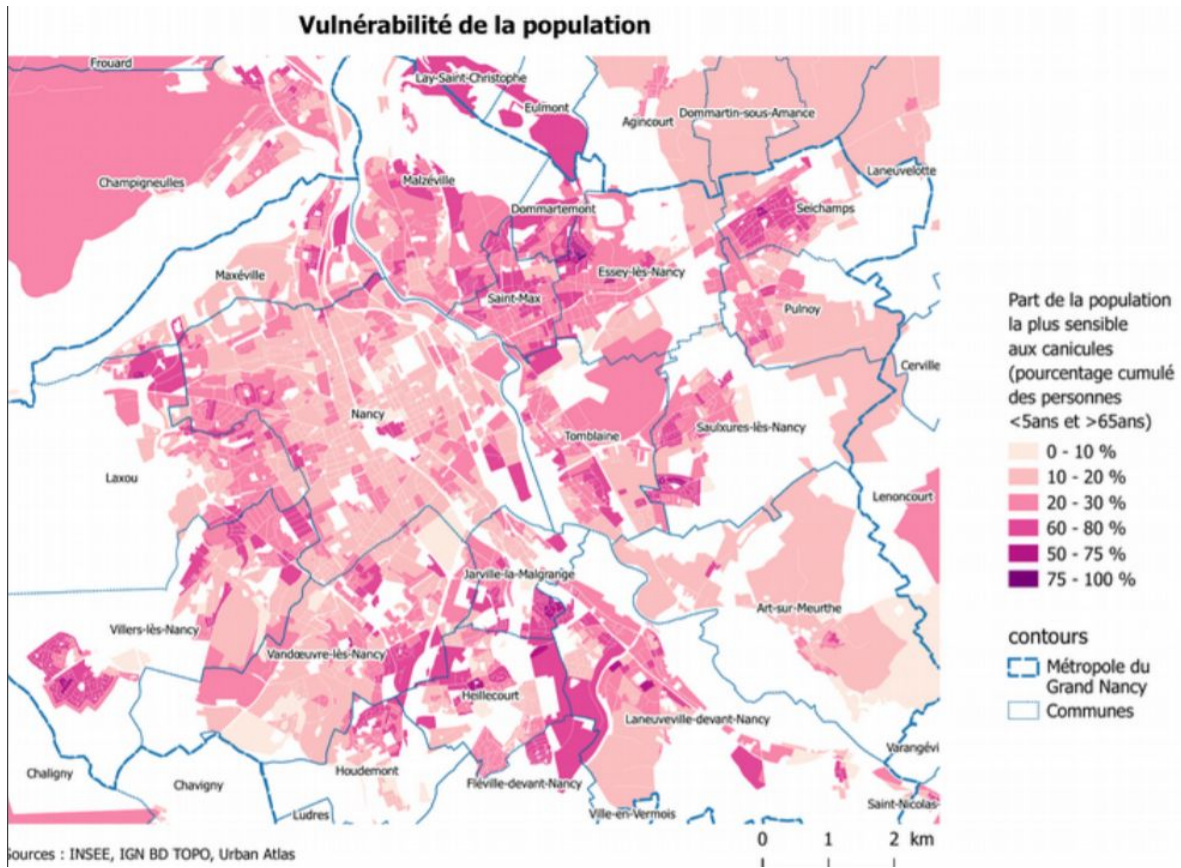


**Figure 18.** The cooling potential of the green areas of the public domain of Villeurbanne. Source: TRIBU, 2016.



**Figure 19.** Criteria for evaluating the refreshing potential for the city of Villeurbanne. Source: TRIBU, 2016.

A second interesting example is the maps created by CEREMA for the city of Nancy (Fig. 20), located in the north-east of France. The first map on the left identifies the areas with the highest concentration of people more sensitive to heat waves, including the elderly (over 65 years of age) and children (under 5 years of age). The bottom map situates with arbitrary criteria the most sensitive and vulnerable populations to ICUs.



**Figure 20.** Vulnerability mapping associated with sensitive populations for the city of Nancy. Source: CEREMA (n.d.).

### *Justification and motivation*

It is important to justify the choices made with respect to the issues raised by the analysis of the climate and the vulnerability of the population to heatwaves. These elements also with a mapping of urban heat islands are indispensable for the presentation of the objectives, the motivation of the regulations as well as the identification of potential areas to implement targeted projects.

### *Environmental assessment of PLU impacts*

For the environmental impact assessment of the PLU it is valuable to analyse the impact of some actions. In the short and medium-term, for instance, evaluation of changes in the urban microclimate due to the inclusion of vegetal species appears important. Such changes can include air pollution (due to allergenic species), the presence of humidity in the vicinity of buildings, and possible solar shading. The latter must be realized both for summer and winter comfort so ensure a suitable solution for summer will not compromise winter comfort and vice versa. As regards the assessment of medium and long-term impacts, issues relating to energy, carbon footprint, air pollutants and water consumption should be addressed.

#### *4.1.2. Planning and Sustainable Development Project (PADD)*

In the Sustainable Planning and Development (PADD) project, the microclimate should be taken into account in order to adapt the rehabilitation projects as well as new ones Both must aim to achieve good integration in terms of mobility, with particular emphasis on soft mobility actions, as well as encouraging the use of public transport with a focus on accessibility. A further important element is to try to minimize energy dependence (especially air conditioners usage in summer) through the introduction of bioclimatic principles in the building design phase.

#### *4.1.3. Planning and Programming Orientations (OAP)*

- adapt the projects to the climatic conditions of the sites by integrating summer winds, sun exposure, water points and existing vegetation into the orientation principles;
- adapt paths and car parks to soft means of transport;
- identify and protect the vegetation that can serve as protection in new buildings as well as in redevelopment operations from the summer sun's rays, thus contributing

to inner hygrothermal comfort;

- identify any existing water points that can contribute to the hygrothermal comfort of outdoor spaces;
- manage the effects in terms of the shadows introduced.

Saint-Chamond Local Urban Plan	O.A.P .	Planning principles	Thermal comfort of buildings	<p>A vegetation of the feet of the facade (planted strip of earth) will be carried out. The aim is to avoid the accumulation of heat in the mineral soil and solar reverberation.</p> <p>Facades exposed to the sun will benefit from solar protection ( roof covers, roof edging, brise-soleil, pergolas etc.) to enhance summer comfort.</p> <p>The location of the buildings should encourage the use of renewable energies (solar in particular), the implementation of passive housing, as well as optimal natural lighting.</p>	Source: Saint-Chamond's PLU
Saint-Chamond Local Urban Plan	O.A.P .	Planning principles	Soft mobility (mandatory principles)	The layout of these paths must incorporate thermal comfort by the shading of trees.	Source: Saint-Chamond's PLU
Montvalezan Local Urban Plan - 11 February 2016	O.A.P .		vegetaliziatio n - summer comfort	A vegetation planting of the feet of the facade (planted strip of full ground) will be carried out. The aim is to avoid the accumulation of heat in the mineral soil and solar reverberation. The location of the buildings should encourage the use of renewable energies (solar energy in particular), as well as optimal natural lighting.	Source: Bur, 2018.

**Table 8.** Examples of transcriptions in the OAP (Author).

#### 4.1.4. *The PLU regulation*

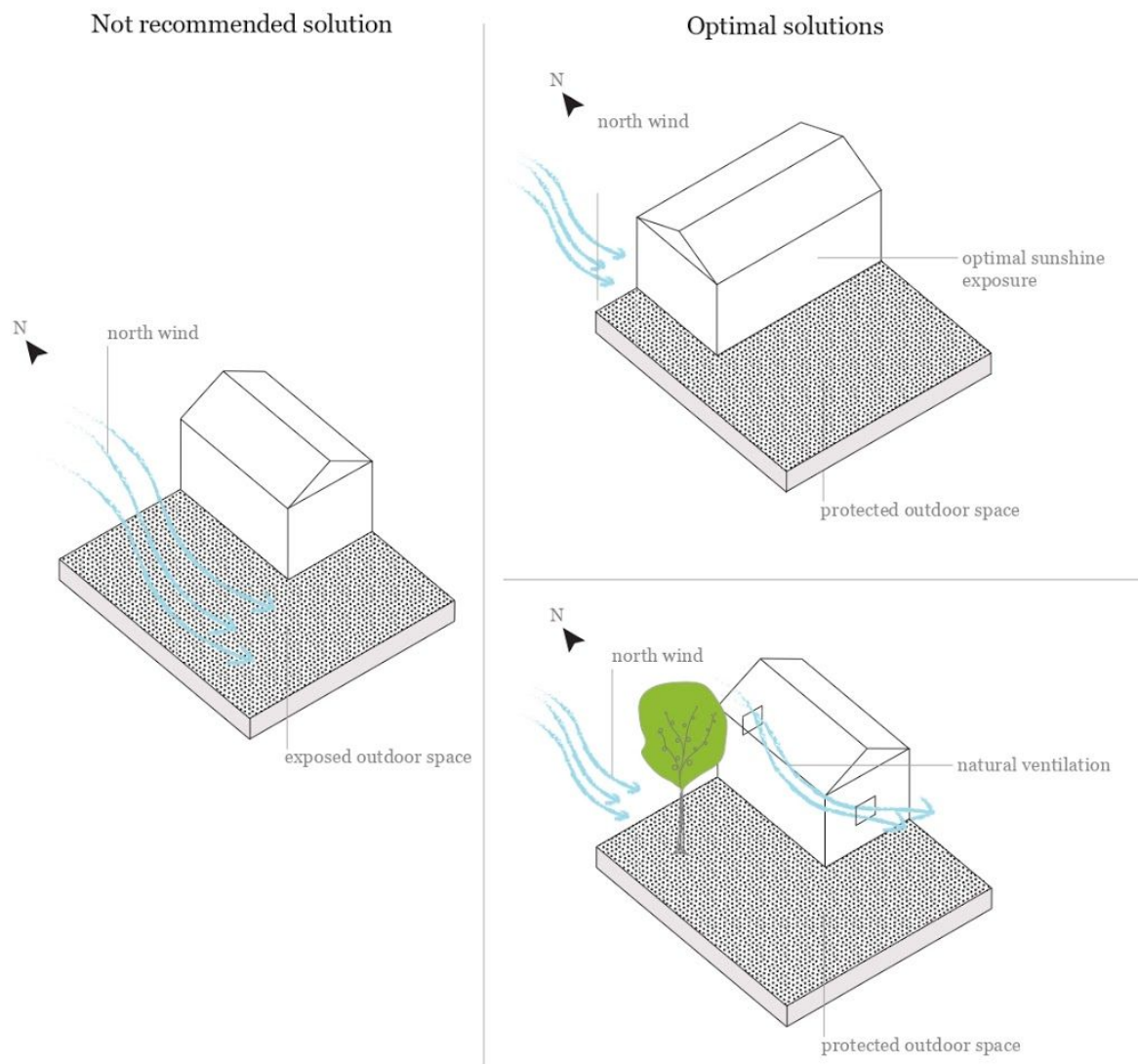
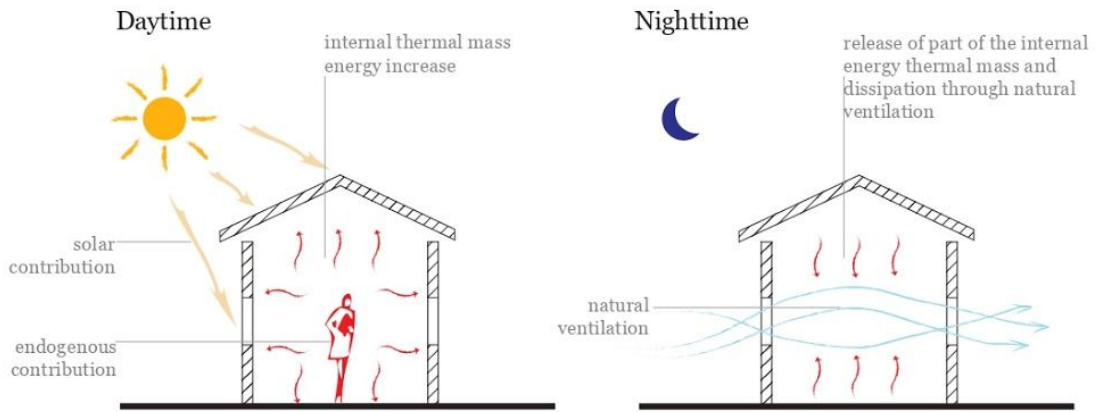
The following section determines the necessary items to take into account in relation to summer comfort. Each topic is highlighted according to the article to which it should be applied. The eventual tables insert as an example and report some transcriptions available in the PLU or PLUs.



## URBAN SPACE

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Adaptation to climatic characteristics of the site (sunshine, wind exposure);</li><li>• Ensuring protection of outdoor spaces from cold winter winds;</li><li>• Ensuring the exploitation of summer breezes to improve the comfort of indoor environments.</li></ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement.</p> <p><u>Immediacy of impact</u> Direct short term impact.</p>
<p><u>Example of objective translation in the PLU document (article 6)</u></p> <p>In the case of new buildings, a design that takes into account the orientation of the main façade towards South must be preferred in order to benefit from optimum sunshine. In cases where a southern orientation of the main façade is not possible due to restrictions of the urban context (alignment along the street or with neighbouring buildings), a bioclimatic distribution of the domestic environment is recommended. Above all, the areas dedicated to night-time activities are recommended to the East.</p> <p>In addition, indoor cross-ventilation using north winds is recommended to improve interior comfort. Particularly important for night areas, through the design of windows in the direction of the north winds. As a matter of fact, thermal dissipation through night ventilation can increase the summer comfort performance of the interior environments.</p>	<p><u>Scale of action</u> Building and neighbourhood scale.</p> <p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; private investors.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents. For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p>	<p><u>Advantages</u> Improvement of the interior thermal comfort of buildings; Protection of exterior spaces from strong prevailing winds; The southern exposure of the facade improves winter sunshine increasing winter comfort; Use of plant barriers with the dual function of protecting from dominant winds, thus increasing the supply of shade and cool summer spaces.</p>
<p><u>Note</u></p> <p>If the orientation of the main façade towards the south is not possible, plant elements such as trees or hedges can be provided to protect the external space from dominant winds.</p>	

URBAN SPACE



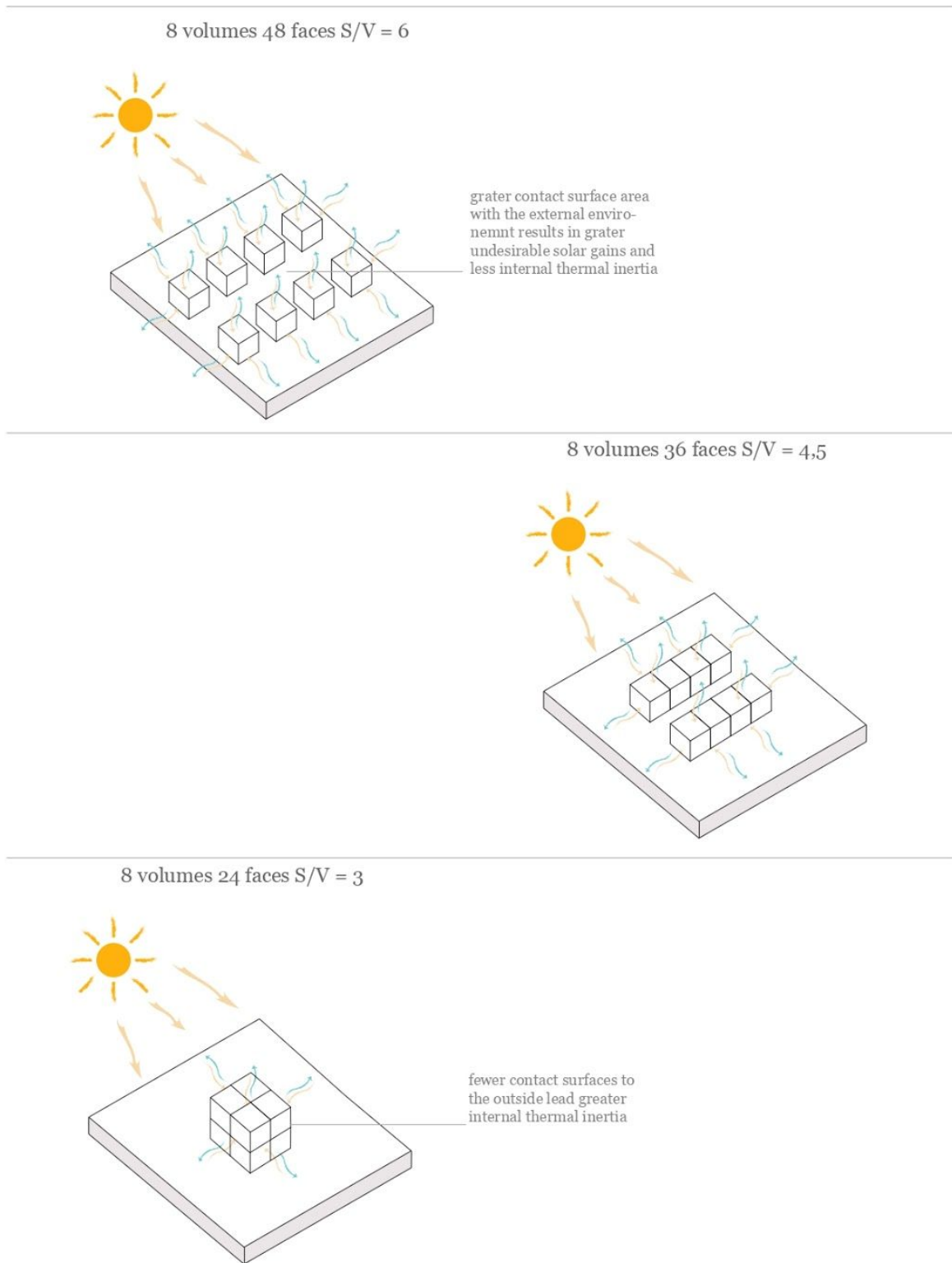
**Figure 21.** Urban space, scheme 1: Protection from dominant winds and exploitation of their potential to reduce indoor temperatures through natural ventilation (Author).

## URBAN SPACE

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Reduce the need for cooling devices in buildings during the summer months.</li></ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement.</p>
<p><u>Example of objective translation in the PLU document (article 6)</u></p> <p>Promote urban compactness in order to have a smaller external surface area exposed to sunlight, thus avoiding unwanted solar thermal gains during summer. Specifically, this goal can be addressed by controlling the S/V (surface/volume) factor. A low S/V value means a smaller surface area exposed to the sun's rays i.e. a greater thermal inertia of indoor environments. For new construction projects it is useful, in the case of adjacent buildings, to exploit existing perimeter walls in order to increase urban compactness.</p>	<p><u>Immediacy of impact</u> Direct short and medium term impact</p> <p><u>Scale of action</u> Building and neighbourhood scale.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents. For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p>	<p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; private investors.</p>
<p><u>Note</u></p> <p>For projects of new residential neighbourhoods one could consider a minimum of the S/V factor to be respected in order to ensure urban compactness.</p>	<p><u>Advantages</u> Greater thermal inertia of the indoor environments are not only beneficial during cold seasons (fewer heat dispersion towards the exterior) but also during warmer months through a reduction of solar gains on surfaces by radiation. This might affect greater indoor thermal comfort and therefore a decrease of the need for specific cooling systems. Moreover, according to the urban planning agency AURAV, urban compactness would also help to save soil resources.</p>

URBAN SPACE

Urban compactness and surface/volume factor control

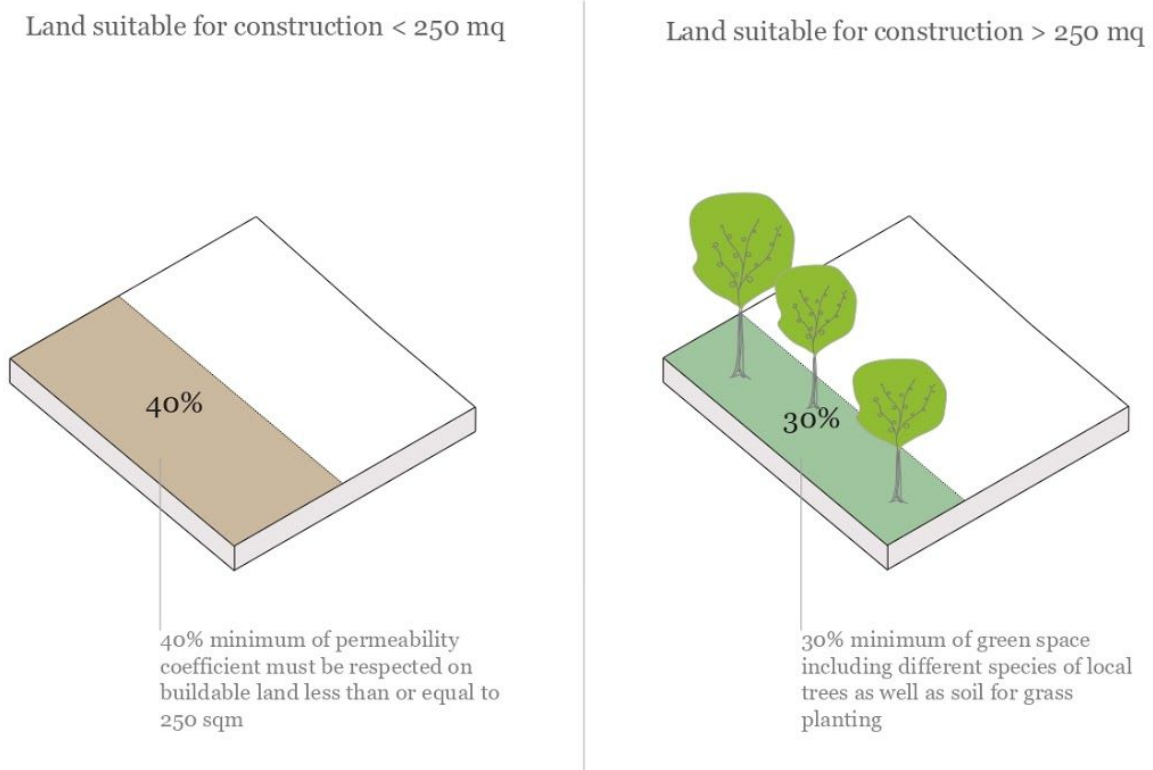


**Figure 22.** Urban space, scheme 2: urban compactness and control of the volume/surface factor (Author).

## URBAN SPACE

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Impose the preservation of land suitable for planting trees.</li></ul>	<p><u>Type of action</u> Adaptation; mitigation. Obligation.</p>
<p><u>Example of objective translation in the PLU document (article 6)</u></p> <p>For buildable land with an area less than or equal to 250sqm it is mandatory that at least 40% of the total surface area is permeable and therefore allows the planting of trees.</p> <p>For buildable land with an area more than 250sqm it is mandatory that at least 30% of the total surface area is designed as green space the inclusion of different local species as well as grassland.</p> <p><u>Example of the municipality of Bernières-sur-Mer</u></p> <p>On buildable land, a permeability coefficient of at least 40% is prescribed, corresponding to a surface area of the land unit that must remain permeable to rainwater through a soil treatment that promotes natural infiltration.</p> <p>For plots of land with a surface area of less than 250sqm, a permeability coefficient of 10% minimum is prescribed.</p> <p>30% of the land unit, for plots larger than 250 m2, must be developed into green spaces composed of :</p> <ul style="list-style-type: none"><li>• Grass or covering plants on the ground;</li><li>• Shrubs of various species and/or hedges of various species.</li></ul> <p>The use of exotic or invasive plants (ex: Japanese knotweed, Buddleia, etc.) is prohibited.</p>	<p><u>Immediacy of impact</u> Short and medium term impact.</p> <p><u>Scale of action</u> Neighbourhood scale.</p> <p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; private investors.</p> <p><u>Advantages</u> Preservation of the soil as well as green existing environment. Reduction of the surfaces composed of impermeable materials with low albedo and increase plant elements in the urban context.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.</p>	

Preservation of land suitable for planting trees

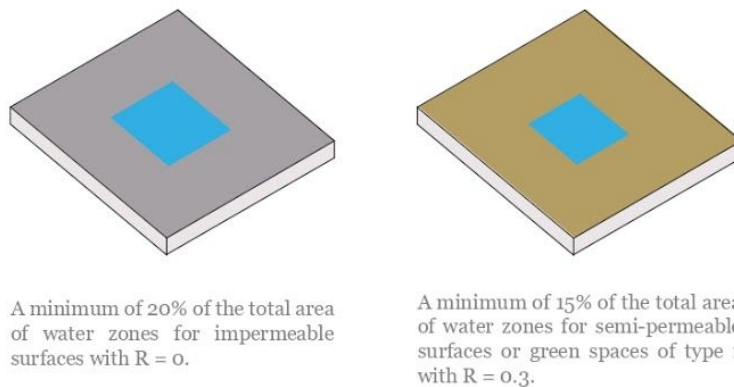


**Figure 23.** Urban space, scheme 3: minimum permeable surface area and green space to be designed for the preservation of land suitable for planting trees (Author).

URBAN SPACE

<p><u>Objectives</u></p> <ul style="list-style-type: none"> <li>• Protect and/or introduce areas of water into the urban fabric.</li> </ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement; obligation.</p>
<p><u>Example of objective translation in the PLU document (article 6)</u></p> <p>For existing fountains or water spaces, it is strongly recommended to restore them and/or put them into operation. In the case of new construction and renovation projects in highly mineralised areas, i.e. areas with a high risk of UHI, it is recommended to provide refreshing urban elements such as water fountains etc. It is possible to oblige, together with the minimum CBS to be respected, a minimum of water surface (fountains, water mirrors, etc.). This minimum percentage can be calculate in proportion to highly mineralised areas with a low ratio to counteract low albedo absorbent surfaces.</p>	<p><u>Immediacy of impact</u> Direct short term impact.</p> <p><u>Scale of action</u> Neighbourhood scale.</p> <p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents. It requires a strong interest from municipalities to put the water elements into operation due to the operation and maintenance costs.</p>	<p><u>Advantages</u> The possibility of having water elements inside the urban building allows to refresh the surrounding areas thanks to the evaporation of water. These areas can provide immediate comfort to people by allowing them to stay in the vicinity, ideally complementing the urban space with shaded areas.</p>
<p><u>Note</u></p> <p>The possibility of rainwater recycling should be encouraged. Moreover, punctual commissioning during the hottest summer hours could be envisaged in order to reduce operating and maintenance costs.</p>	

Minimum surface area of water in UHI high-risk areas



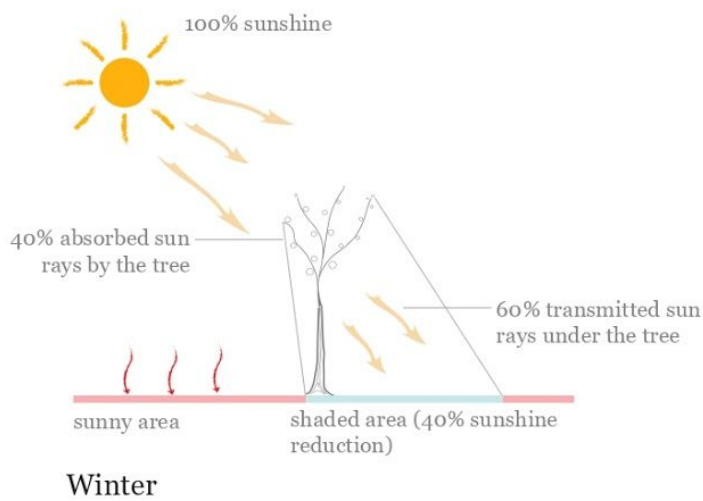
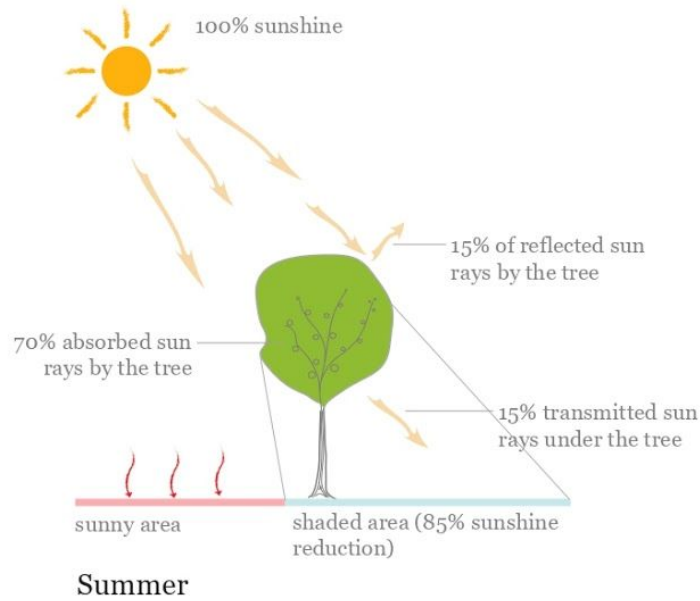
**Figure 24.** Urban space, scheme 4: minimum space reserved for water for urban interventions in areas at greater UHI risk (Author).

## URBAN SPACE

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Ensure winter sunshine as well as protection from summer rays.</li></ul>	<p><u>Type of action</u> Adaptation; mitigation; awareness. Encouragement.</p>
<p><u>Example of objective translation in the PLU document (article 6)</u></p> <p>For buildings, temporary sun protection can be provided. These protectors could be composed of vegetable elements , for example by using deciduous plants. For the insertion of shaded elements it is recommended to carry out a shadow study. A list of local plant species to be preferred should be included.</p>	<p><u>Immediacy of impact</u> Short and medium term impact.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents. For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p>	<p><u>Scale of action</u> Building and neighbourhood scale.</p> <p><u>Key stakeholders</u> Local professionals; citizens and private investors.</p>
<p><u>Note</u></p> <p>A correct management of the maintenance phase of the plant species (irrigation, pruning, etc.), especially during the first years of life, is indispensable in order to ensure proper performance of their function.</p>	<p><u>Advantages</u> Summer thermal comfort, lower indoor temperatures in summer as well as less heat-absorbing surfaces inside buildings.</p>



## Shading effect for deciduous trees



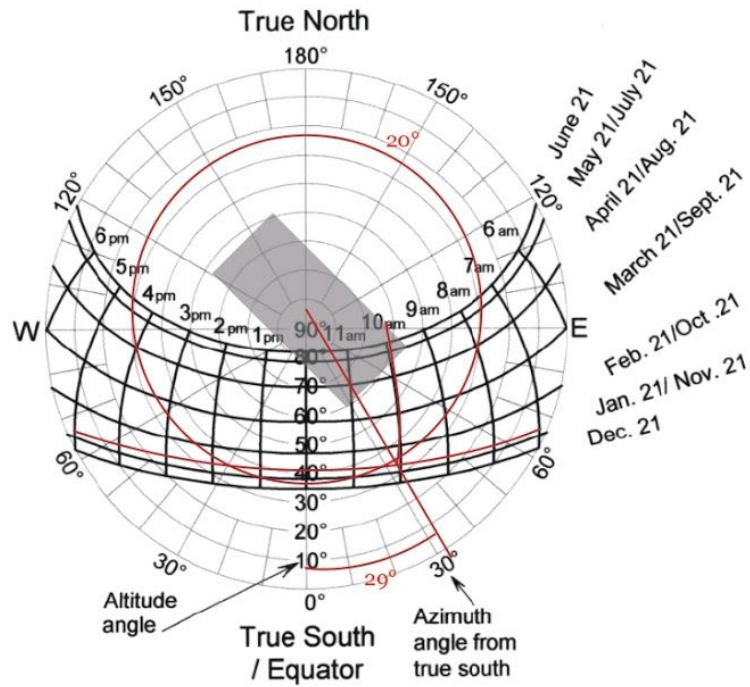
**Figure 25.** Urban space, scheme 5: ensuring winter comfort as well as protection from the summer rays through the use of deciduous trees (Author).

## CONSTRUCTION

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Favour an optimal orientation of the construction without jeopardising neighbouring buildings.</li></ul>	<p><u>Type of action</u> Adaptation; awareness. Obligation.</p>
<p><u>Example of objective translation in the PLU document (article 8)</u></p> <p>Perform the solar study and the impact of shadows for new buildings and renewals projects.</p>	<p><u>Immediacy of impact</u> Short term impact.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.</p> <p>An empirical method as illustrated in the example can be easily introduced in order to serve as a pedagogical tool. The empirical model is not sufficient to carry out more complex studies.</p> <p>For more complex projects, specialised professionals will be needed, thus increasing project expenses. In addition, the resources of the municipalities may not be sufficient for optimal project support.</p>	<p><u>Scale of action</u> Building and neighbourhood scale.</p> <p><u>Key stakeholders</u> Local professionals; citizens and private investors.</p>
<p><u>Note</u></p> <p>The shadows produced by the construction of new buildings as well as the renovation of existing buildings must be assessed so as not to compromise the right to light of neighbouring buildings.</p>	<p><u>Advantages</u> The study of shadows allows not only to exploit the sun's rays for winter periods but also to provide shaded urban spaces for warmer areas, especially for areas at high risk of UHI or with particularly high temperatures during daytime.</p>

**CONSTRUCTION**

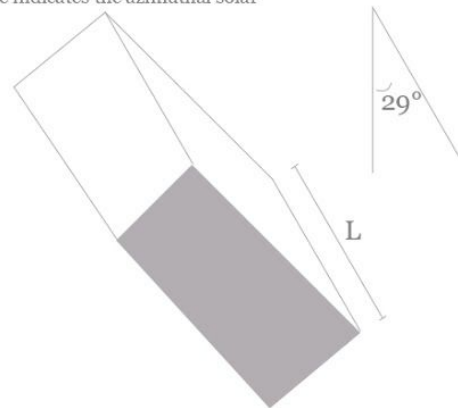
Analysis of the building's shadows



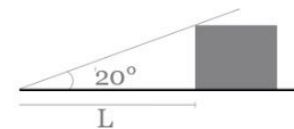
**Sun Path Diagram, 32° N Latitude**

www.HarvestingRainwater.com

- 1 Place the analysed building in the diagram, centered and oriented
- 2 Consider the date line for the period of the year you want to analyse. Example: Winter Solstice
- 3 Choose the time for the sunshine condition you want to determine. Example: 10 o'clock
- 4 Connect the detected point with the center of the diagram: the line indicates the azimuthal solar angle, i.e. the direction of the sun's rays affecting the building.



- 5 Read the solar height on the angles scale and calculate the shadow length based on the building height.



**Figure 26.** Construction, scheme 1: empirical analysis of shadows (Author).

## CONSTRUCTION

### Objectives

- Ensure a minimum of permeable and green space to be included in new constructions and renewal projects through compliance with the surface biotope coefficient.

### Example of objective translation in the PLU document (article 8)

For both new construction and renovation projects a minimum CBS of 0,3 must be respected. In addition, the minimum coefficient to be respected can be diversified if the plot is located within a highly densified neighbourhood facing a high risk of UHI. For example in UHI risk zones a CBS of 0.5 can be imposed for new construction and a CBS of 0.4 for renovation projects.

### Example of the municipality of Roubaix (Local Urban Plan, April 2014)

The CBS describes the proportion between all the nature-friendly surfaces on the plot and the total surface area of the plot (CBS = eco-developable surface area / surface area of the plot). For example, for a 479 m<sup>2</sup> plot with a building with a footprint of 279 m<sup>2</sup> and a free space of 200 m<sup>2</sup>, of which 140 m<sup>2</sup> is asphalt and 60 m<sup>2</sup> is gravel with grass, the CBS will be : 140 m<sup>2</sup> asphalt: 140 x 0.0 = 0 m<sup>2</sup>; 60 m<sup>2</sup> gravel with lawn: 60 m<sup>2</sup> x 0.5 = 30 m<sup>2</sup>; CBS = 30 / 479 = 0.06. In this example, the regulation imposes a CBS of 0.3. The characteristics of the future construction and the development of its surroundings should make it possible to achieve this result, by increasing from 30 to 144 m<sup>2</sup> of eco-friendly surfaces (479 x 0.3 = 144 m<sup>2</sup>).

### Restrictions and levers

The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.

### Note

Particularly important in this case is the return of experience from projects carried out as well as projects composed of bioclimatic characteristic that were blocked due to non-compliance with the coefficient. The return of experiences is indispensable to understand at local level the restrictions of the action as well as the CBS levers.

### Type of action

Adaptation; mitigation; awareness.  
Obligation.

### Immediacy of impact

Direct short and medium term impact.

### Scale of action

Building and neighbourhood scale.

### Key stakeholders

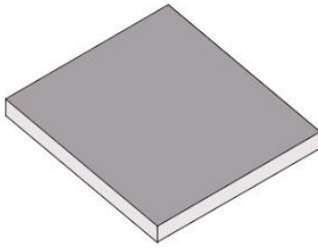
Local and inter-municipal technical operators; local professionals; private investors.

### Advantages

Minimum inclusion of permeable and green spaces for new construction projects as well as renovation projects.

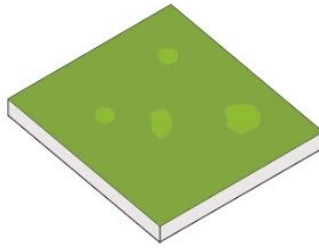
**CONSTRUCTION**

**Impermeable surface**  
 $R = 0$



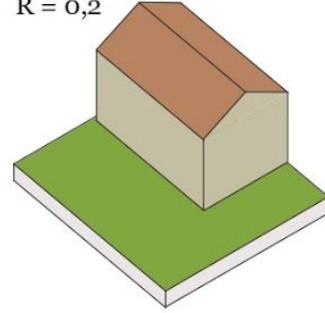
Impermeable covering for water and air, without vegetation (concrete, asphalt, floor with layer of mortar).

**Green space type 1**  
 $R = 0,3$



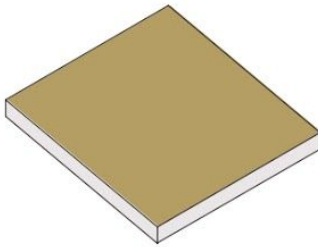
Green space with a layer of vegetable soil of less than 80 cm.

**Classic rooftop**  
 $R = 0,2$



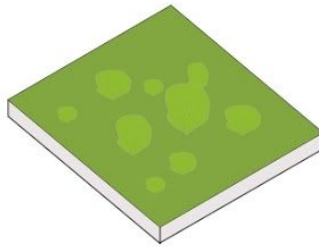
Rainwater infiltration to enrich the groundwater table and infiltration into the planted surface.

**Semi-permeable surface**  
 $R = 0,3$



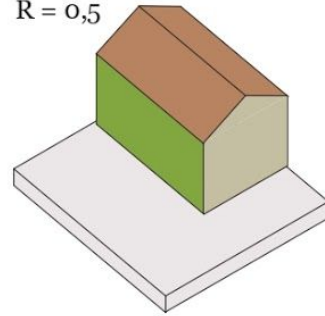
Permeable covering for water and air, without vegetation (clinker, mosaic paving, paving with gravel or sand layer).

**Green space type 2**  
 $R = 0,6$



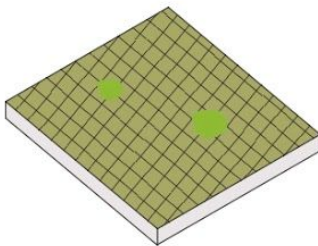
Green space not related to open ground, with a vegetal soil thickness of more than 80 cm.

**Vegetal façade**  
 $R = 0,5$



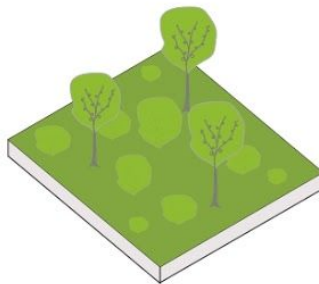
Vegetation of opaque facades or proximity facades from soft mobility flows up to 10 meters in height.

**Semi-open surface**  
 $R = 0,5$



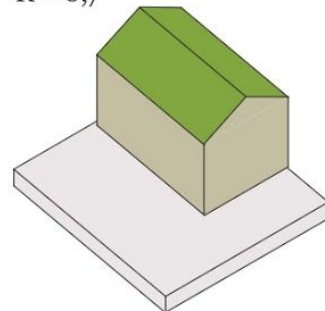
Permeable covering to water and air, rainwater infiltration, with vegetation (wood slab, lawn lattice stones).

**Green space type 3**  
 $R = 1$



Space of continuity with the natural land favourable to the development of flora and fauna with distributed green space.

**Green roof**  
 $R = 0,7$

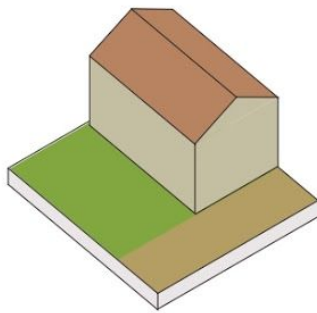


Extensive or intensive green roofing up to 10 metres in height.

**Figure 27.** Construction, scheme 2: ratio according to the different surfaces for the calculation of CBS (Author).

## CONSTRUCTION

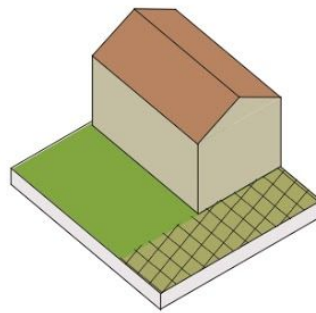
Example of a CBS calculation  
CBSmin.=0,3  
150 mq



Outdoor space  
(10m x 4m) x 1 = 40  
(10 x 5) x 0,3 = 15

CBS  
 $55/150 = 0,366$

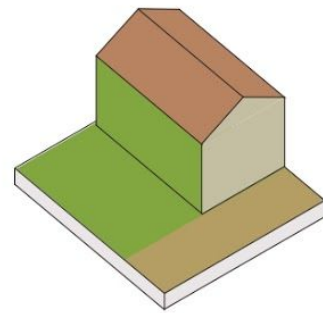
Example of a CBS calculation  
UHI risk area CBSmin.=0,4  
Renovation 150 mq



Outdoor space  
(10m x 4m) x 1 = 40  
(10m x 5m) x 0,5 = 25

CBS  
 $65/150 = 0,433$

Example of a CBS calculation  
UHI risk area CBSmin.=0,5  
New construction 150 mq



Outdoor space  
(10m x 4m) x 1 = 40  
(10 x 5) x 0,3 = 15

Vegetal facade  
(10m x 3m) x 1 = 30

CBS  
 $85/150 = 0,566$

**Figure 28.** Construction, scheme 3: example of calculation for the different minimum CBS depending on the UHI risk level of the area and whether new construction or renovation intervention (Author).

## CONSTRUCTION

### Objectives

- Buildings contributing to the fight against urban heat islands may be exempted from the rules of maximum permitted heights.

### Type of action

Adaptation; mitigation; awareness.  
Incentive.

### Example of objective translation in the PLU document (article 8)

The possibility of creating penthouses or collective vegetable gardens may be envisaged. For new penthouses, a 60% construction bonus of the surface area of the maximum permitted height can be implemented. This implementation is allowed if it is planned to vegetate the rest of the existing roof.

### Immediacy of impact

Short and medium term impact.

### Example of the municipality of Saint-Chamond (Local Urban Plan)

Not into account in the calculation of the maximum permitted height: technical works contributing to the production of renewable energy or the fight against urban heat islands.

### Scale of action

Building scale.

### Restrictions and levers

The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.

### Key stakeholders

Local and inter-municipal technical operators; local professionals; citizens and private investors.

### Note

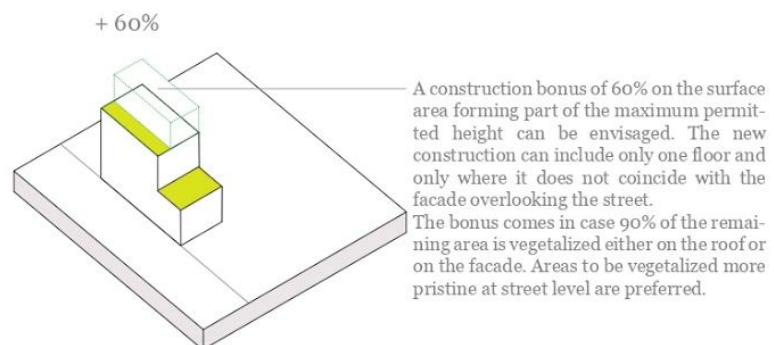
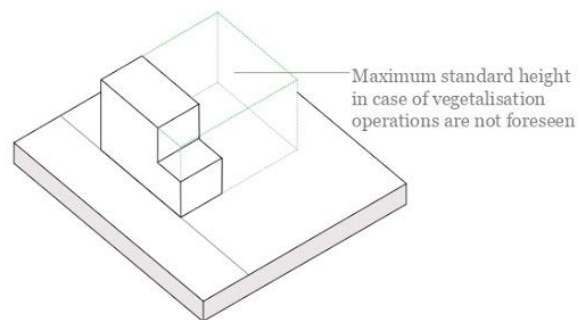
In order to combat UHI and take completely advantage of the cooling effect of vegetation on roofs and façades, it is important not only to use local species but also to study in detail the type of suitable irrigation system. Given the low rainfall during the summer months in the Mediterranean context, it is important to encourage punctual irrigation.

### Advantages

Summer comfort and reduction of green house gas emission by the increasing of the presence of vegetation on roofs and façades.

## CONSTRUCTION

### Height bonus




**Figure 29.** Construction, scheme 5: minimum bonus area in case of green roofs or facades (Author).



EXTERNAL CHARACTERISTICS

<p><u>Objectives</u></p> <ul style="list-style-type: none"> <li>Lower the risk factors of the most vulnerable people as well as the impact of UHI due to low albedo materials.</li> </ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement; Prohibition.</p>
<p><u>Example of objective translation in the PLU document (article 11)</u></p> <p>Advice for the application of facade covering materials, colours, floors for exterior spaces and roofs with a high albedo (a list of materials to be preferred is useful) with attention to contexts with a strong patrimonial issue. Prohibit the use of dark tints with a low albedo in the most vulnerable areas emerging from the diagnosis of UHI and vulnerable population location.</p> <p><u>Example of the municipality of Saint-Chamond (Local Urban Plan)</u></p> <p>As part of the fight against the phenomenon of urban heat islands, the use of floor coverings for outdoor spaces should give priority to light tones characterised by a high albedo.</p>	<p><u>Immediacy of impact</u> Short term impact.</p> <p><u>Scale of action</u> Building and neighbourhood scale.</p> <p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, may not have the internal capacity to manage the action. It might therefore be necessary to foresee the need to use external resources, such as experts, for the development of technical documents such as the material characteristics annexes.</p>	<p><u>Advantages</u> Increase the presence of high albedo surfaces in order to limit the effects of sun rays absorption and reflection.</p>

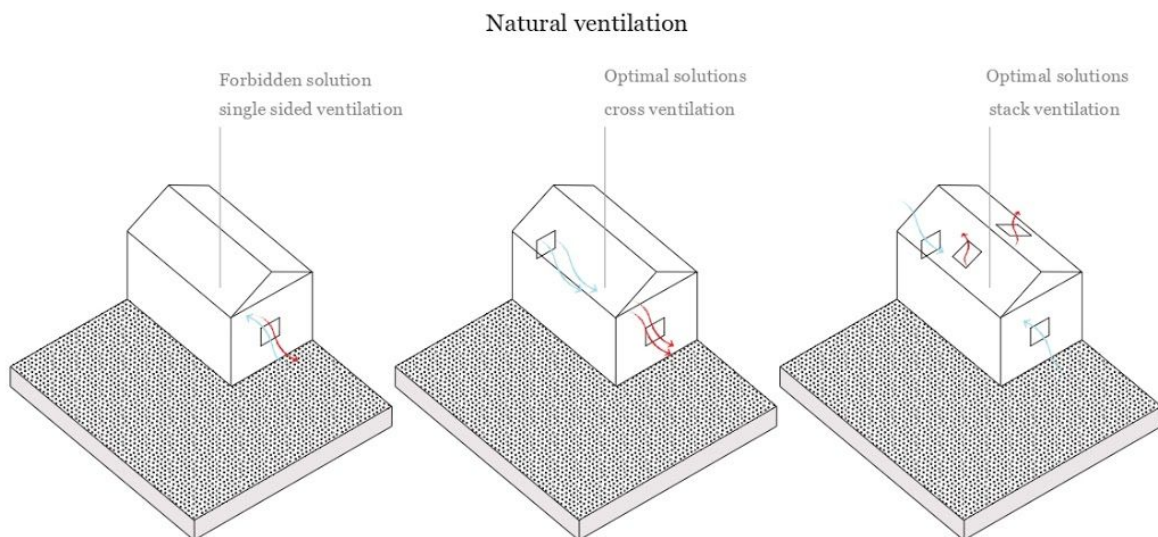
Example of the characteristics to be included in an annex of the materials

Material	Restrictions and strengths	Porosity	Albedo	Maintenance	Illustration
Concrete	<p>Strong points: Resistant to bad weather; different finishes possible; easy maintenance.</p> <p>Restrictions: Not particularly aesthetic performance; limited choice of colors; presence of cracks in case the laying is poorly realized.</p>	10%	0,17-0,27	<p>Surface cleaning with specific sweepers. 1 or 2 times a week on commercial streets. 2 times a month on the outskirts of downtown streets 1 time per month for less frequented streets</p>	

**Figure 30.** External characteristic, scheme 1: example of the characteristics to be included in an annex on prohibited and recommended materials (Author).

EXTERNAL CHARACTERISTICS

<p><u>Objectives</u></p> <ul style="list-style-type: none"> <li>Prohibit buildings with one-sided openings in vulnerable areas or for buildings used by vulnerable people (retirement homes, nursery schools, etc.).</li> </ul>	<p><u>Type of action</u> Adaptation; awareness. Prohibition.</p>
<p><u>Example of objective translation in the PLU document (article 11)</u></p> <p>In general, encourage building openings on opposite sides to allow good natural ventilation. At the level of building complexes as well as for neighbourhoods, favour urban forms that allow warm air to escape, especially during heat waves.</p>	<p><u>Immediacy of impact</u> Short term impact.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.</p>	<p><u>Scale of action</u> Building and neighbourhood scale.</p> <p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; private investors.</p>
	<p><u>Advantages</u> Reduces the presence of buildings with poor natural indoor ventilation and therefore reduces the need for air-conditioning during the summer.</p>

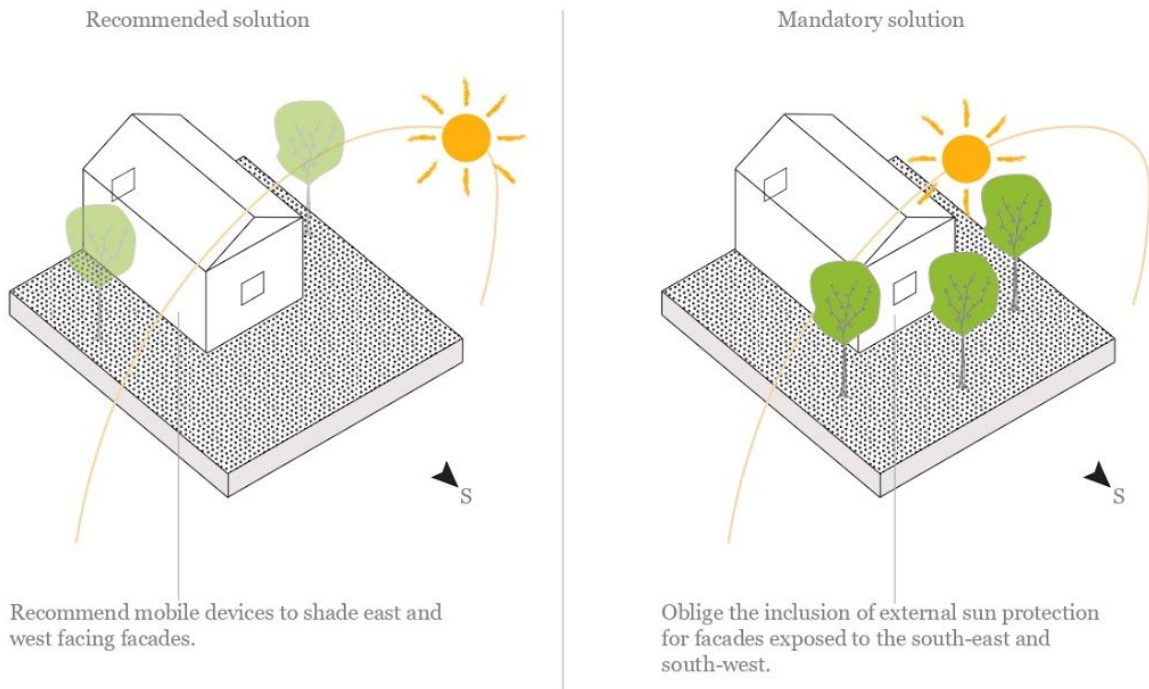


**Figure 31.** External characteristic, scheme 2: examples of natural ventilation to be preferred or avoided depending on the users' health risk and the level of UHI vulnerability in the area (Author).

**EXTERNAL CHARACTERISTICS**

<p><u>Objectives</u></p> <ul style="list-style-type: none"> <li>Limits directly the rays entering the buildings avoiding the overheating of the internal surfaces and therefore the reduction of the average temperature of the internal environment.</li> </ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement; obligation.</p>
<p><u>Example of objective translation in the PLU document (article 11)</u></p> <p>Recommend mobile devices to shade east and west exposed façades. Oblige the inclusion of external sun protection for façades exposed to the south-east and south-west.</p>	<p><u>Immediacy of impact</u> Short and medium term impact.</p> <p><u>Scale of action</u> Building scale.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents. For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p>	<p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p> <p><u>Advantages</u> Summer comfort.</p>

**Sun protection**

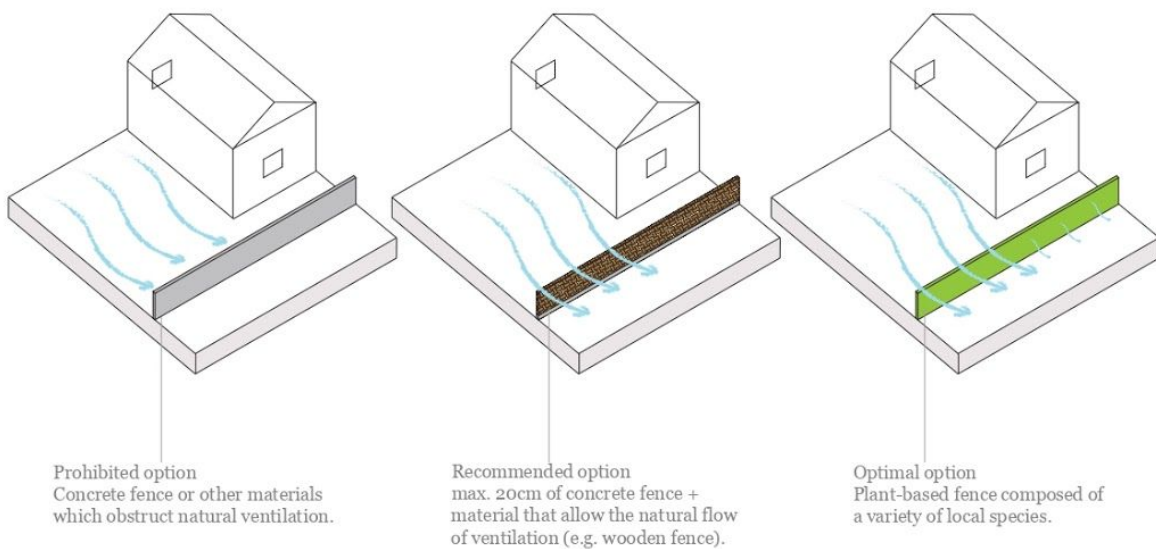


**Figure 32.** External characteristic, scheme 3: recommendation or obligation for the provision of sun protection depending on the orientation of the façade (Author).

**EXTERNAL CHARACTERISTICS**

<p><u>Objectives</u></p> <ul style="list-style-type: none"> <li>• Allow natural ventilation of the exterior spaces.</li> </ul>	<p><u>Type of action</u> Adaptation; awareness. Prohibition.</p>
<p><u>Example of objective translation in the PLU document (article 11)</u></p> <p>Prohibit the use of full fences that obstruct air circulation.</p> <p><u>Example of the municipality of Saint-Chamond (Local Urban Plan)</u></p> <p>The construction of solid or partially solid fence walls is prohibited.</p>	<p><u>Immediacy of impact</u> Short term impact.</p> <p><u>Scale of action</u> Neighbourhood scale.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.</p>	<p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p> <p><u>Advantages</u> Natural ventilation of the outdoor spaces and greater summer comfort.</p>

Fence for air circulation solutions



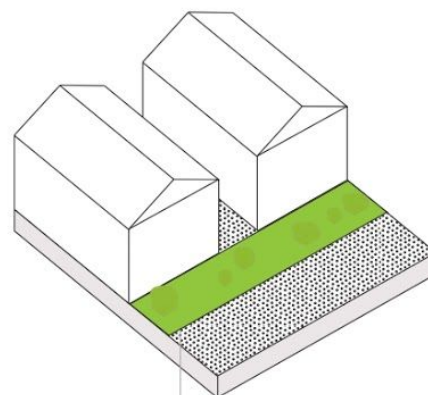
**Figure 33.** External characteristic, scheme 4: recommendation or obligation to use specific fences to exploit natural ventilation (Author).

## PARKING LOTS

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Minimize the mineralized environment with low albedo materials;</li><li>• Promote soft mobility;</li><li>• Reduce vulnerability of UHI risk areas.</li></ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement; obligation.</p>
<p><u>Example of objective translation in the PLU document (article 12)</u></p> <p>If parking spaces are available in the surrounding areas, it is recommended to limit the number of new parking lots in order to promote soft mobility. Adopt shading systems for parking areas identified as UHI risk areas as well as permeable soil, planting of surfaces, and surfaces characterized by a high albedo. A minimum CBS coefficient of 0.3 may also be required for high risk UHI areas.</p> <p><u>Example of the municipality of Saint-Chamond (Local Urban Plan)</u></p> <p>When the garden surface area is reduced (except for building extension projects) due to traffic or parking (pedestrian walkway, surface parking, etc.), the use of permeable pavement should be favoured. Asphalt or asphalt type materials are prohibited.</p>	<p><u>Immediacy of impact</u> Short and medium term impact.</p> <p><u>Scale of action</u> Neighbourhood scale.</p> <p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; private investors.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, may not have the internal capacity to manage the action. It might therefore be necessary to foresee the need to use external resources, such as experts, for the development of technical documents such as the material characteristics annexes.</p>	<p><u>Advantages</u> Greater control of soil permeability as well as spaces with low albedo.</p>

ECOLOGICAL CONTINUITY

<p><u>Objectives</u></p> <ul style="list-style-type: none"> <li>• Impose planting of local species at the foot of façades.</li> </ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement; obligation.</p>
<p><u>Example of objective translation in the PLU document (article 13)</u></p> <p>A realignment of buildings can be considered for the insertion of a plant buffer between the street and the built. The use of local plants should be recommended.</p>	<p><u>Immediacy of impact</u> Short and medium term impact.</p> <p><u>Scale of action</u> Building and neighbourhood scale.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents. For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p>	<p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p>
<p><u>Note</u></p> <p>These actions provide useful awareness tools in case they are undertaken through the implementation of pedagogical actions with citizens.</p>	<p><u>Advantages</u> Increase green and permeable spaces near streets.</p>



For new buildings impose vegetalization at the foot of the facade.

**Figure 34.** Ecological continuity, scheme 1: Imposition of green areas at the foot of the façades for new buildings or street alignments where possible (Author).

## ECOLOGICAL CONTINUITY

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Encourage planting of local species in the most vulnerable UHI districts areas;</li><li>• Require the use of deciduous species and favour species that need little irrigation (punctual irrigation adapted to Mediterranean cities);</li><li>• Encourage the use of local non-allergenic species;</li><li>• Authorise vegetated roofs and green façades.</li></ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement; obligation.</p> <p><u>Immediacy of impact</u> Short and medium term impact.</p> <p><u>Scale of action</u> Building and neighbourhood scale.</p>
<p><u>Example of objective translation in the PLU document (article 13)</u></p> <p>Encourage the use of species included in the annex.</p> <p><u>Example from the AURAV study (2019)</u></p> <p>Promote and encourage the use of vegetation adapted to the climate.</p>	<p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p>
<p><u>Restrictions and levers</u></p> <p>The pilot of the action, i.e. the municipalities, may not have the internal capacity to manage the action. It might therefore be necessary to foresee the need to use external resources, such as experts, for the development of technical documents such as vegetable local species annexes.</p> <p>For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p>	<p><u>Advantages</u> Decrease city temperatures and the costs related to irrigation of gardens and public spaces.</p>
<p><u>Note</u></p> <p>These actions provide useful awareness tools in case they are undertaken through the implementation of pedagogical actions with citizens. The inhabitants are therefore more sensitive to the natural environment present in the city and maintenance works can be carried out by the citizens.</p>	

## DENSITY OF CONSTRUCTION

<p><u>Objectives</u></p> <ul style="list-style-type: none"><li>• Maintain and promote traditional urban forms that promote effective natural ventilation at the building and neighbourhood scale.</li></ul>	<p><u>Type of action</u> Adaptation; awareness. Encouragement.</p>
<p><u>Example of objective translation in the PLU document (article 14)</u></p>	<p><u>Immediacy of impact</u> Short term impact.</p>
<p>In the case of renovation of existing buildings, where possible, it is recommended to keep cooling existing spaces with good natural ventilation systems, such as open stairwells or internal courtyards, characteristic of Mediterranean buildings. Furthermore, for new building blocks project favour the construction of internal courtyards which promote good air circulation. At the neighbourhood scale avoid the design of wide roads and provide tree avenues in order to protect soft mobility flows.</p>	<p><u>Scale of action</u> Building and neighbourhood scale.</p>
<p><u>Restrictions and levers</u></p>	<p><u>Key stakeholders</u> Local and inter-municipal technical operators; local professionals; citizens and private investors.</p>
<p>The pilot of the action, i.e. the municipalities, dispose of the internal capacities for the management of the action through the inclusion of the recommendations in the local PLU urban planning documents.</p> <p>For what concern the recommendation, it might not be sufficiently taken into account by private actors, thus diminishing the impact of the action. For this reason, other awareness-raising actions are recommended to complement the inclusion of the recommendation in the PLU documents.</p> <p>The traditional technical solutions already present in the Mediterranean context could have a greater ease of acceptance and acquisition by the residents and pilot actors of the actions.</p>	<p><u>Advantages</u> Take advantage of traditional technical solutions already present culturally in the Mediterranean context and promote bioclimatic design to improve summer comfort in buildings and neighbourhoods. Reduce the solar gain in urban space and therefore the increase in temperature.</p>



## **5. CHAPTER 5: Conclusions and recommendations**

Climate influenced architecture and urban planning in the past and is having its impact nowadays. Cities in the South of France have therefore been influenced by the fact that they are in the Mediterranean context for different architectural, urban and cultural aspects. Among the specific labels of the Mediterranean today, for example, special emphasis is placed on themes such as urban heat islands, which in turn are closely linked to the health of the most vulnerable groups of people. A popular tendency today among French municipalities, regarding adaptation and mitigation strategies, is the inclusion of nature in the city. Unfortunately, however, a paradox emerges in this regard; the desire to include natural elements in the city does not correspond to the desire to keep protected those spaces already characterized by nature outside the city. It is therefore essential to consider all urban spaces and apply the same importance and urgency in the implementation of sustainable solutions in urban areas as well as peri-urban areas.

Natural elements in cities that have a cooling potential need to be co-designed with most stakeholders. Politicians, citizens, technicians, private investors should be included in the design phase in order to meet as much as possible the needs and expectations of each actor. This participation is especially useful to raise awareness of these actors who can be key players in the front line of successful mitigation and adaptation strategies for climate change issues in cities. Urban planning documents are certainly an important part of this awareness-raising process. In the case of guides and regulations included in local town planning documents, it is recommended to distribute the information to as many public and private actors as possible in order to increase the pedagogical potential of these tools.

In local urban planning documents, forcing is always a difficult choice, since the urban context, seen as an ecosystem, is not easy to predict in its responses. Especially if these strategies include natural elements which require great technical knowledge and control skills. Therefore, it is useful to propose recommendations leaving room for manoeuvre to the architects and urban planners of cities. In case one chooses to propose regulations that oblige, a return of design experiences should be considered. It is crucial to analyse the urban reaction to adapt the different actions in a context still in the experimental phase.

In general, in local planning documents, recommendations are in most cases more desirable than obligations. There is a risk of ending up with repetitive elements that deprive the possibility for contextualized urban and architectural design. Ergo, in order to meet some criteria, it is important to give a choice, e.g. by preferring regulations that prohibit rather than oblige.

In addition, the use of bonuses can be a means to encourage local stakeholders to integrate some elements although great attention must be given to the proposed type of bonus. For instance, if green roofs are introduced giving a higher percentage of building permit height may have no impact on UHIs as the density of the building itself would increase. Furthermore, by increasing the distance from the street level of green roofs the perception of comfort would decrease due to its effect of proximity to the street level of pedestrians. It is therefore essential to calibrate the bonus according to the brought effects by the introduction of some strategies while also looking at the risks, e.g. through the study of an assessment impact.

Consequently, as observed in the context of the small and medium-sized towns in southern France, both due to the large number of elderly people who choose little towns to retire and the climatic conditions that are particularly risky for their human health, it is essential to act urgently. The introduction of summer comfort features in town planning documents, as well as awareness-raising practices, should therefore be applied with particular attention to short and medium-term effects to limit possible health damage. These actions are useful, as they increase the resilience of cities to possible phenomena that may endanger a wider range of people, who may be temporarily in a vulnerable situation under different circumstances.

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