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The Climate of My Neighborhood: Households' Willingness to Adapt to Urban Climate Change

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Abstract: Regarding the predisposition of individuals to change when confronted with future climate scenarios, it is necessary to understand the perception of the groups under analysis and how to engage with society to collectively act toward climate change mitigation. A question remains to be answered: how to ensure that people engage, participate, and gain awareness of the undergoing problem that urban climate change poses for the future of cities' management? This research intends to contribute to solving this question by raising another question: "How willing are residents of the Alvalade neighborhood (Lisbon) to change their behavior and way of life when faced with climate change scenarios?" We present a methodology using microclimatic modeling with ENVI-met and questionnaires for the resident community. The present and future local climate scenarios (representing a present hot day versus the extreme IPCC RCP 8.5 scenario) were presented to a set of residents. These figures show the projected UTCI (Universal Thermal Climate Index) in a dramatic but accurate aggravated way. The inquiries allowed us to conclude that people are more aware of local climate change and health risks from extremely hot summer weather, but they continue to resist adopting behavior change for adaptation, although most of them declared this could be important to tackle climate change. The second conclusion is that people think that local authorities should be more active than themselves and will have greater responsibility for climate change adaptation and interventions. In times of climate crisis, the participation of the resident community can be an important help in decision making and finding measures to mitigate adverse climate effects in urban environments.

Keywords: urban sustainability; climate change scenarios; willingness to adapt; UTCI

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1. Introduction

Global warming presents a remarkable, if not the most significant, threat in urban areas. These areas are undergoing specific changes that together with global warming and climate change pose a serious threat to the environment. For the last decades, the world has been presented with different scenarios for what is expected to happen in the next years and decades. However, global warming is already happening, which appears to be a climatic emergency that needs to be addressed now. According to the Fifth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), the influence of humans on climate cannot be denied. According to this report, "Each of the last four decades has been successively warmer than any decade that preceded it since 1850" [1] (p. 4), saying that the total increase in human-caused global surface temperature from 1850–1900 to 2010–2019 is 0.8 °C to 1.3 °C, with the best estimate of 1.07 °C [1]. It is said in the report that hot extremes have become more frequent and more intense across most land regions since the 1950s, while cold extremes (including cold waves) have become less frequent and less severe [1]. Furthermore, the health and safety of the world population are jeopardized. The most recent data [1] highlight that the consequences of climate change could affect millions of people (by the year 2050, due to the higher frequency, intensities, and duration of heat waves).

The RCP (Representative Concentration Pathways) are scenarios of emissions and concentrations of greenhouse gases in a time series. Each RCP provides one of several possible scenarios that lead to specific characteristics of a given radiative forcing and a time evolution of the climatic elements. More recently, the new SSP-based scenarios- "Shared Socioeconomic Pathways" (SSPs), a set of 5 narratives (SSP1–5) that describe how the complex global society might change over the 21st century were added to the climate change assessment rationale [2].

According to the IPCC (2021), global surface temperature will continue to increase in all emissions scenarios considered. During the 21st century, global warming of 1.5 °C and 2 °C will be exceeded unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades. The 6th Assessment Report (AR6) retains several scenarios that cover the range of possible future development of anthropogenic drivers of climate change. From 2015 on, CO_2 concentrations will range from 393 ppm in the friendliest scenario (SSP1–1.9) to the highest value of 1135 ppm in the worst-case scenario (SSP5–8.5) by 2100 [3]. In all five scenarios, changes in global surface temperature were assessed based on multiple lines of evidence, for selected 20-year periods and the five illustrative emissions scenarios considered. This assessment shows that from SSP1–1.9 to SSP5–8.5, the differences in the near term (2021–2040) are up to 1.6 °C, ranging from 1.2 to 1.9 °C.

Cities have different thermal patterns forming a mosaic of warmer and cooler areas with humidity islands that distinguishes each urban climate. These patterns result from radiative and energy modifications, lack of vegetation areas, poor ventilation, impervious surfaces, and anthropogenic heat emissions [4]. Dense urban areas are usually warmer than the surroundings (especially during the night), and for that reason, local authorities are creating strategies to adapt and mitigate the effects of urban climate change. In 2018, the administration of the Lisbon Metropolitan Area (LMA) published a report titled "LMA Adaptation Plan to Climate Change" (PMAAC-AML), where scenarios and climatic projections for the Lisbon Metropolitan Area were presented [5]. This report states the evidence of an increase in Lisbon's air temperature and its consequences for resident life in urban centers. In these, the city of Lisbon is characterized by being one of the areas with the highest percentage of sealed surfaces in the LMA, which causes a slower decrease in temperature during the night. Urban heat islands allow a higher frequency of tropical nights in the urban denser center, with a tendency to worsen in the future. Currently, there is an average annual value of 11 tropical nights in Lisbon, which exceeds the frequency for the remaining areas of LMA [5]. In the future, given the RCP 8.5 scenarios for the end of the century, an increase in temperature is estimated that could go up to another 8 °C, and as a result, it will lead to another 60 tropical nights annually [5]. The results warn of the importance of investigating on a more detailed scale the existence of problems that may affect residents, and the need to understand the resident's perception of how climate change can affect their residence area and how they can contribute to mitigating the negative effects of it. These kinds of reports highlight the need to improve one's knowledge of how city elements such as street orientations, buildings, materials, etc., impact the urban climate at a smaller scale (neighborhoods, urban canyons, and streets).

Methods are often applied to obtain information about the climate of a specific location through spatial downscaling techniques and mathematical and physical models, achieving results with greater spatial resolution. In addition to the adjustment of the scale that needs to be carried out, the multilevel perspective is also important to critically analyze the constructed scenario, considering the perspective surrounding the portrayed situation [6].

However, from our perspective, one may ask the most important question nowadays: Are people "willing to pay" for climate change adaptations? The importance of the topic is that we believe that individual actions that support local authorities are an essential key point in truly urban climate change adaptation and mitigation measures [7,8].

Regarding the predisposition of individuals to change, when confronted with future climate scenarios, it is necessary to understand the perception of the groups under analysis and how to engage with society to collectively act toward the mitigation of climate change.

Climate change perception is a complex process that is influenced by character, experience, and received information of individuals, and also by the cultural and geographic background [9]. Perception is also a response determined by gender, age, values [10], and education, and can vary over time and within the same country [11].

Collective action is defined as when a group member engages in collective action any time that he is acting as a representative of the group and the action is improving the conditions of the entire group; this is a group behavior motivated by one of its members who wants to improve the position of his or her in-group [9]. From nonviolent actions to participating in acts of civil disobedience to more radical forms such as sabotage and violence, collective action can take many forms [12], and little is currently known about the motives for making a person's decision to actively participate in climate change adaptation and mitigation initiatives.

Public participation in, for example, environmental impact assessments is not only a goal but also a key to effective environmental assessment [13]. The authors also state that most research has dealt with the question of how public participation can be facilitated and say that a closer look at these studies shows that the meaning of public participation, what it involves, and what it requires is not clear. Morrison-Saunders and Early [14] refer to the fact that public participation essentially ensures that all relevant information, such as inputs from those affected, is available so that the decision maker and policymakers can make the most informed decisions. For the authors, public participation is not an end, but it provides an important role for the public in the decision making for their future. There are numerous problems associated with the assumption that the key issue involved is how to pursue effective participation [15].

Thus, the second question we appeal to is the following: how to ensure that people engage, participate, and gain awareness of the undergoing problem that urban climate change poses for the future of humanity?

According to O'Faircheallaigh three fundamental characteristics define what perception is: awareness, concern, and preparation since these factors make a population more resilient [16]. The author also states that a higher level of concern is expected to be associated with a higher level of preparation since individuals evaluate the problem according to their subjective perception. This is because people attribute a certain importance to an event, as they acquire information from various sources involving the individual [16]. Some authors argued that the best way to raise the awareness of a population is to give greater emphasis to local problems that may affect the population and that institutions, with the responsibility of responding to these problems, indicate simple solutions to tackle such problems [17]. Perception is something that comes from the intuitive judgment of individuals, in a context of limited and uncertain information. Other authors add that there needs to be a confrontation between the experience of an event and knowledge so that there is a perceptive context [18,19]. More recently, they argued that awareness of the event assumes a role of high importance for a community to adapt effectively to that event and that this awareness leads to the conscious construction of the responses of individuals and communities [20].

The perception of the negative impacts of climate change has reached a growth in terms of citizens' concerns. According to [19] in the questionnaire carried out from 1986 to 2002, Portugal, compared to the European Union, shows that respondents have been increasing their concern. Another questionnaire was conducted which demonstrated that, within the sample that was collected, respondents considered that climate change is a very serious problem, but, even so, it accompanies a decline that originated from the financial crisis that Portugal was going through in 2009 when the survey was carried out [21].

Thus, it is necessary to promote a culture of citizenship and to involve communities in decision-making processes based on awareness and dissemination of scientific knowledge through meetings, participatory workshops, and other forms of cooperation with local actors. It is also necessary to promote the participation of the population in meetings to discuss their neighborhood's problems and to speed up the actions of implementing policies for the environment and mitigate and adapt to climate change.

In the last years, climate maps and guidelines for urban planning have been developed in Lisbon Municipality [22,23]. However, these studies were conducted on the mesoscale (the whole city) and when a finer scale (microscale—urban canyon) is needed, there is a lack of information and adaptive measures are still missing. Recently, urban climatology researchers have begun to investigate at a microclimatic level and apply these studies to new-generation municipal plans. Some of this work uses micrometeorological models to simulate urban climate at a greater scale and obtain information about the climate of a more specific location through techniques of spatial downscaling and mathematical and physical models allowing better spatial resolution [24]. Currently, software such as ENVI-met is the most used when performing climatic simulations [25,26]. The characteristics of the site under study are also an important factor: Cortes and López-Cabeza identify ENVI-met as the tool to be used since it brings greater advantages in outdoor spaces [27,28].

Attention should be drawn to studies that examine whether people's awareness of health issues can be used as a catalyst for changing their behavior with regard to climate change [29] or studies that claim that public support for climate change adaptation measures is influenced by people's perceptions of risk [30]. How the public views and is conscious of initiatives aimed at combating climate change and global warming were discussed by Rao [31]. The author's research revealed that people believe governmental organizations should implement mitigation measures rather than private citizens. Surveys about climate change awareness in Houston (TX) and Portland (OR) show that private mitigation efforts must be reinforced by mitigation efforts from business, government, and industry [32].

Having the latter in mind, this research intends to answer the main question: How willing are the residents of the neighborhood of Alvalade (a very active local population in Lisbon) to change their behavior and way of life when faced with climate change scenarios?

To answer the starting question, micrometeorological models of the Alvalade neighborhood were constructed according to the scenarios foreseen by the IPCC. Two scenarios were prepared with Envi-met software: current (2017) and future conditions (RCP 8.5—2070–2100).

To understand the predisposition to adopt measures to adapt to urban climate change, the community of the neighborhood of Alvalade was confronted with the meteorological conditions in the future and asked about their willingness to adopt more sustainable lifestyles.

2. Study Area

Lisbon is located in the western part of mainland Portugal (38°42′ N; 9°10′ W) and has hot and dry summers and mild winters according to the Köppen-Geiger climate classification Csa—[33]. The average air temperature is about 17.4 °C, with the minimum values in January (11.5 °C) and the highest average values in August (23.5 °C) (Lisboa Geofísico meteorological station—IPMA climate normals 1981–2010 (www.ipma.pt/en/oclima/normais.clima/1981-2010/, accessed on 21 May 2020).

Lisbon's climate depends essentially on regional geographic factors, such as the proximity to the Atlantic Ocean, the large estuarine area of the Tagus River, and the topography, creating in the city a distinctive thermal amenity marked by a high frequency of winds from the north and northwest all over the year (Figure 1).

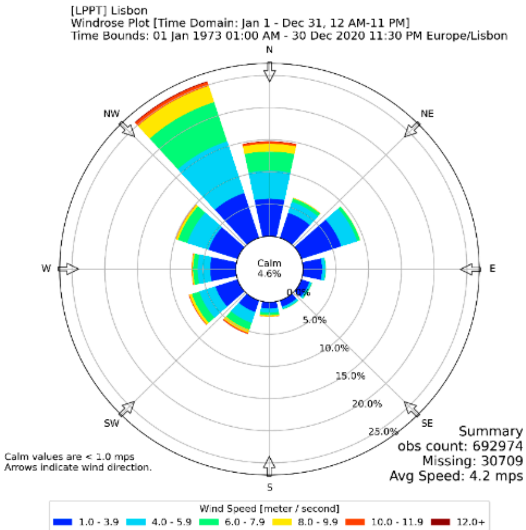

Figure 1. Wind regime at the Lisbon/Airport from 1971–2020. Source: The Iowa Environmental Mesonet (IEM), Iowa University. https://mesonet.agron.iastate.edu (accessed on 21 May 2020).

This north wind pattern is essential to ventilate the city, more compact and denser to the south, where more intense urban heat islands (around 2/3 °C) can arise [34,35]. In summer, when extreme temperatures can overcome the "amenity", south to southwest breezes can be very important to ameliorate thermal stress in the southern part of the city [34].

The city of Lisbon (Figure 2b) has a heterogeneous urban morphology, which resulted from several phases of urban growth over the years, sometimes in an unplanned and unsuitable way without considering the consequences that this may bring to the environmental level [36]. Strong contrasts and different architectural styles in the city are obvious [37]: from the evidence of the Roman and later the Muslim central historical area, chaotic and plenty of shadows that persist until nowadays in the Colina do Castelo, passing through the design of the quadrangular streets after the great 1755 earthquake near the Tagus bank, until the recent early 20th century new avenues style in the northern part of the city, Lisbon is a mosaic of different neighborhoods.

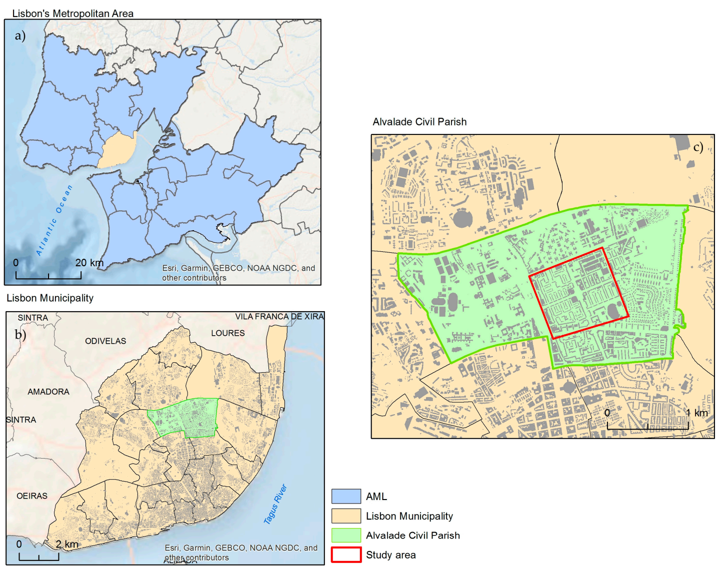

Figure 2. Study area framing map. AML = Lisbon Metropolitan Area (**a**).

For this study, the Alvalade neighborhood (marked on Figure 2c with a red square), located in the northern part of the city, was chosen. Alvalade can be described as an example of an organized urban network with most of the buildings constructed from 1946 until 1970. The neighborhood is quite regular and flat, and its main functions are residential and commercial. Although it has mainly a residential function, four distinct quarters can be separated (Figure 3): sectors B and D are characterized by being mostly residential with small street shopping, with the presence of a shopping center standing out. The spaces available for some types of intervention are public in nature and belong to the Lisbon City Council, or private. In sectors A and C, the available spaces that may undergo some interventions are private, being that only their owners can intervene on it. In the northern part, a commercial area consisting of warehouses and offices and other types of commerce, there is only a small residential parcel. Figure 4 (Alvalade Square) represents the central square, which one can find in the Alvalade neighborhood (marked with an X in Figure 3).

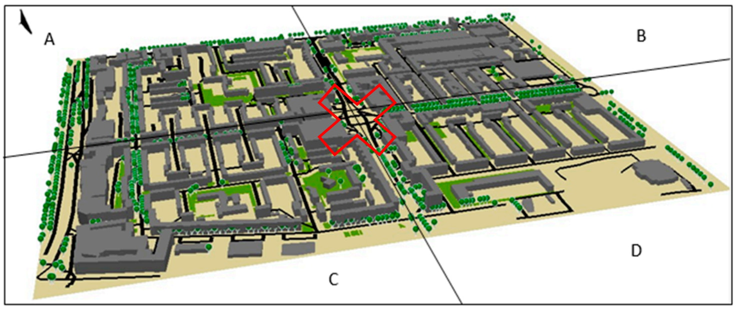

Figure 3. Alvalade neighborhood. X represents the central square one can find in Alvalade neighborhood. (**A**–**D**) refer to the sectors mentioned in the text.

Figure 4. Alvalade Square (X in Figure 3). Credits: Junta de Freguesia de Alvalade.

Due to the geometry and construction of the neighborhood, the buildings inside it have common spaces. These are usually conserved and small, and there are some transformed into small urban gardens. The vegetation present is small and not very dense, without great care of maintenance.

The most recent projections released by the National Statistics Institute in 2021 register a continuous trend of population aging until at least the second half of the 21st century. An increase in elderly people is projected in Portugal, foreseeing a profound transformation of the national demographic structure, with a projected loss of 10% of the total population [38]. The Alvalade Civil Parish is one of the most populous in the city of Lisbon, according to the last national census (2021), where it registered a resident population of 31.813 individuals. The 2021 census data shows an increase in the number of residents to 33.313 individuals, with a percentage of variation of 4.7% [38]. In Table 1, we present the number of individuals per age group in 2011 and 2021, where one can see that the majority of the residents are aged between 25 and 64 years old.

Table 1. Number of individuals per age group in the Alvalade Civil Parish, in 2011 and 2021.

Age Group	2011	2021
0–14	3.823	4.639
15–24	2.938	3.335
25–64	15.905	17.100
65+	9.150	8.239

Source: [38].

3. Materials and Methods

In this study, different types of data were used for the various stages of research. The first step was to collect all the information needed: buildings (including volumetric information), green spaces, trees, and road networks for the study area. This information was collected from several geographic databases of the Lisbon City Hall, namely the Lisboa Aberta (https://lisboaaberta.cm-lisboa.pt/index.php/pt/, accessed on 18 September 2020).

The information on the resident population of the Alvalade neighborhood was obtained from the National Statistical Institute (INE) for 2011 and is divided into statistical subsections [38].

An interview with the head of the division and the chief architect of public space and equipment of the Alvalade Civil Parish Council was also made, with two objectives: the first was to present the survey that would be presented to residents of the Alvalade neighborhood and to understand what the best approach would be for them; the second was to know what kind of interventions between the Alvalade Civil Parish Council and the Lisbon Municipality would have in the future in the study area.

Given the proximity to the study area, the climatic data were retrieved from the meteorological station installed at the Institute of Geography and Spatial Planning (38°44′57.7″ N; 9°09′18.7″ W), which has been in operation since 2017. For the simulation, 3 July 2017 was chosen, because it was considered a dry and hot day by IPMA (Portuguese Institute of the Sea and the Atmosphere), with the maximum air temperature recorded for the month of July of 36.3 °C, low relative humidity (≈30%), and wind speed ≈ 3.3 m/s.

The meteorological data, which served as input for the model for the end of the 21st century (2070–2100), took into consideration the IPCC RCP 8.5 scenario [1]. This represents the most serious and aggravated scenario in the future, which translates into very high greenhouse gas (GHG) emissions and does not consider any mitigation measure. The source of these data was the PMAAC [5], which presented annual and seasonal anomalies for the RCP 8.5 scenario for all areas of the Lisbon Metropolitan Area. The data were compiled from the global and regional Eurocordex climate models project. Present and future scenarios were simulated with the ENVI-met micrometeorological model [39]. The models consider in their simulation different parameters, such as the flow of air around buildings (CFD), through heat exchange processes, aerodynamic turbulence, bioclimatology (Biomet Module), dispersion of particles and pollutants, but also components connected with vegetation. The version that was used allowed the forcing of the meteorological variables (temperature and relative humidity) during the simulation.

The construction of the microclimate models for the Alvalade neighborhood was carried out using the parameters presented in Table 2.

Table 2. Input parameters to build the 3D model of the Alvalade in ENVI-MET neighborhood.

Parameters	
Area (cells)	106 × 79 × 100
Nesting Grids	5
Cell resolution (m)	10 × 10 × 2
Model rotation	337° (−24° rotation)
Localization	Alvalade, Lisbon, Portugal
Latitude	38.72° N
Longitude	9.14° W

In preparing the climate simulation of the 2017 model, it was necessary to define several parameters to start processing. In the climatic simulation representative of the future period (2070–2100), the values with the anomalies were considered according to the RCP 8.5 scenario for the Lisbon Peninsula [40]. The input values are summarized in Table 3. Both simulations started at 06:00 on the chosen day and ended at 06:00 on the following day.

Table 3. Input parameters to the 3D simulations for the present and future scenarios.

Input Parameters		
Simulation Day	3 July 2017 (present)	IPCC 2070–2100 (future)
Simulation start/stop hour	6–6 h (of the next day)	6–6 h (of the next day)
Number of simulation hours	24 h	24 h
Wind speed (10 m height)	0.7 m/s	0.7 m/s
Wind directions (°)	79°	79°
Aerodynamic roughness (m)	0.01	0.01
Initial temperature (°C)	20.75 °C	24.55 °C
Specific humidity at 2500 m (g/kg)	7.8 g/kg	7.8 g/kg
Relative humidity at 2 m (%)	55.2%	55.2%

For the evaluation of thermophysiological comfort, the UTCI (Universal Thermal Comfort Index) was used. This index was chosen to be presented in the questionnaire to the resident population of the neighborhood of Alvalade because it allows one to assess the physiological responses of the human body to the environment to which it is exposed, and hence is more understandable as the scale is in °C. The UTCI helps to obtain answers about meteorological impacts on humans [41]. This bioclimatic information allows for better planning of cities and urban centers, as it allows the identification of climatic impacts and risks that affect people's health [42].

To understand the population's perception of the sustainability of their neighborhood and all the problems that climate change may add, a questionnaire was developed and presented to the residents. The main objectives of this questionnaire were: (i) to assess the perception of residents of the Alvalade neighborhood about the future climate until the end of the century; (ii) to assess the extent to which citizens are willing to change their current behavior to face the climate crisis that is already being felt. The questionnaire considered the new regulation on the protection of personal data, No. 798/2018, published in the *Diário da República* No. 231/2018, Series II of 30 November 2018. This means that no personal information was collected from people who submitted their responses to the questionnaire.

This questionnaire was carried out and applied in Alvalade, which has a total of 8869 resident individuals. The type of sample that was taken was non-probabilistic, as the objective is not to quantify or create a statistic in the sample collected from the population but to qualitatively represent the opinions of resident individuals.

The questionnaire was mostly with closed answers, with only one open final question aiming to seek an opinion without limiting the individual's response. The questions were different, multiple answers, single multiple answers, scale, or optional. Closed questions are richer regarding the collection of information, but open questions allow a more interesting way to know the reality and the facts surveyed [16]. It was demonstrated by Mattar that a good questionnaire contains questions of various kinds, whether closed or open, so that the respondent can demonstrate his opinion regarding his choices throughout the questionnaire [43].

For the opinion/satisfaction questions, the Likert scale with 7 degrees of satisfaction was used. This scale suggests that interviewees indicate their opinion regarding the question that is being analyzed through numerical values, signs, or words that lead the respondent to answer in the sense of the question. The results of agreement receive higher values, and the results of disagreement receive negative values. An advantage of this scale is its simple construction and the easy decision making by the respondent, allowing an empirical view, as long as it is consistent with the initial question; that is, it allows a bigger range of responses but is accurate enough for the individual's opinion to be assessed. As a limitation, Mattar states that, because it has an ordinal scale, it does not allow one to compare the favorability of responses to each other [43].

The survey was carried out in the summer months of July, August, and September with residents of the Alvalade neighborhood in digital form through google forms. The questionnaire was made available on the Facebook platform, specifically in groups of residents of Bairro de Alvalade. It was published in 4 existing groups ("*Bairro de Alvalade—Divulgação*"; "*Bairro de Alvalade*"; "*Vizinhos de Alvalade*" and "*Grupo do Bairro de Alvalade*").

In total, 121 responses were submitted on the online form, of which 112 responses were validated. This validation was carried out considering only residents of the Alvalade neighborhood, which was the main objective of the study. Subsequently, all collected answers were statistically processed. The results are presented in the next section.

4. Results and Discussion

4.1. Micrometeorological/Climatic 3D Models

In Figures 5 and 6, the results of the micrometeorological modeling for 3 July 2017 and the future scenario for the period 2070–2100 (microclimatic) are presented.

Both maps represent the hour in which maximum air temperature was recorded (15:00 h). In Figure 5, high temperatures can be seen, with a maximum of about 37 °C, especially on the two main avenues. Although there is a presence of trees in these streets, the model shows that their direct influence on air temperature is not enough on summer days like the one chosen and does not translate into lower temperatures. Even in this situation, the lowest temperature recorded was above 27 °C. Analyzing the results of the future scenario, the increase in air temperature is quite evident (Figure 6).

In the study area, they can be found shady areas, such as the Roma Avenue, which crosses the entire area in the North/South direction. This situation, in which the two central avenues in the neighborhood present these differences, can be explained by the fact that the Igreja Avenue, despite having a higher level of biomass, is naturally narrower, thus not allowing the air to circulate more freely, unlike the Roma Avenue, which is wider and more exposed to the north, allowing for the north winds, including the north winds that are so frequent in summer in Lisbon, to cool down those areas.

Figure 5. Present model—Air temperature of a recent hot day in the present situation (3 July 2017).

Figure 6. Future model (2070–2100) air temperature, based on IPCC RCP 8.5 scenario.

In the future scenario, the estimated maximum temperature is 42 °C and the minimum temperature is 20 °C. Although it is not feasible to make a comparison in terms of values, the distribution of air temperature occurs in the same way as in the previous situation; the areas with the highest temperature and the lowest temperature are the same, but considering the difference between them, even though Roma Avenue is "cooler" compared to other roads, such as Igreja Avenue, it registers higher temperatures in the future scenario when compared to the present model. This shows that, in the future, higher temperatures will be recorded throughout the study area and not just in specific locations.

4.2. Thermal Comfort

The modeling done for the present, processed with climate data from 2017, showed high UTCI values, which means a high incidence of outdoor heat stress (moderate to very high risk of stress).

In Roma Avenue, there are lower values due to the effect of the north wind that is normally felt in this area (44.9 °C in the northern part of the avenue and 51.2 °C in the southern part). This can also be explained by the urban morphology which promotes the acceleration of wind speed and by the high building that provides a shadow effect on the street. In contrast, highest values were recorded in Igreja Avenue (51.7 °C in the western part of the street and 51.8 °C in the middle of the eastern part of the avenue). This behavior can be explained by the geometry with a narrower urban mesh and narrower streets, which can lead to overheating of the area. Additionally, the orientation of this street can explain the values obtained since it is perpendicular to the Roma Avenue, with less cooling effect.

For the second part of the century, it is evident that the tendency will be towards an increase in temperature as well as a particularly higher thermal sensation. Like the predominantly north wind, the high stress due to heat can bring health problems, especially for the most fragile age groups (children and elderly).

4.3. Household Willingness to Adapt to Urban Climate Change

The questionnaire elaborating on the resident population of Alvalade, which occurred in the summer period from July to August, was shared on the Facebook platform with four residents' groups in the Alvalade neighborhood.

The questionnaire was divided into four sections. The first was related to the respondent's profile; the second section intended to assess the perception of the concepts of urban sustainability and climate change; the third was to evaluate the predisposition to make changes in the neighborhood; and the fourth was regarding the willingness to adopt measures to be implemented to tackle urban climate change.

Of the total validated responses, around 68.8% were female and 31.2% were male (Figure 7). Of these, around 68.8% were aged between 21 and 50 years and 30.3% were over 50 years of age (Figure 8).

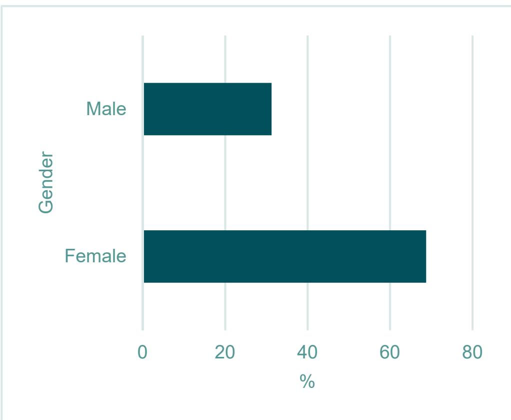

Figure 7. Number of responses by gender.

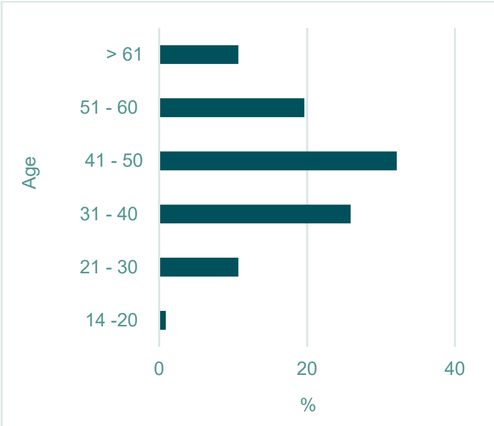

Figure 8. Number of responses by age group.

To assess the respondents' knowledge of concepts related to sustainability and knowledge about climate change, four questions were asked:

1. In what context have you heard of the concept of sustainability?
2. How do you rate your knowledge about urban sustainability?
3. How do you rate your knowledge of climate change?
4. Are you aware of your environmental footprint?

The first question had several multiple-choice options, and the other three had seven answer options, from 1 to 7, with 1 representing a lot of knowledge and 7 a little knowledge.

Regarding the first question, it is noteworthy that 52 of the respondents selected all possible answers: combating climate change, nature conservation, waste reduction, and pollution reduction. It should also be noted that seven of the respondents chose, in addition to the aforementioned options, to add another one. The other options given by the residents were as follows:

- Animal welfare;
- Biodiversity;
- Energy efficiency;
- Mobility;
- Smooth modes;
- Reduction of noise pollution;
- Reduction of consumption, sharing of resources;
- Noise;
- Public health;
- Smart cities;
- Alternative mobility and shared mobility solutions;
- Transport and mobility.

From the answers obtained to the second question, it was possible to perceive that, concerning urban sustainability, the largest number of answers, both among females and males, focused on "intermediate" knowledge levels 3, 4, and 5. The groups that have the highest number of answers in these three levels are between 14 and 60 years old, the age group of 31 to 40 has the highest number of answers at levels 3 and 5, and the age group of 41 to 50 years old at level 4. Furthermore, the highest number of responses among these three levels was given by residents with higher education.

Concerning the respondents' knowledge of climate change (3), the largest number of answers focused on levels 2, 3, and 4 for females and levels 2 and 3 for males. Regarding the age group that has the greatest knowledge on this subject, the largest number of answers was obtained from respondents aged between 41 and 50 years, having selected level 2 of knowledge about climate change, with ages between 31 and 40 and 51 and 60 years of age in females. However, at this level of knowledge, the highest number of responses in men was observed in individuals whose ages ranged from 41 to 50 years.

In the last question (4), about the environmental footprint and the knowledge of each respondent about it, the answers obtained were mainly on levels 2, 3, and 4, with more than 74 responses. Regarding the gender that has greater knowledge about the environmental footprint, the highest number of responses were obtained from females (53 responses at the levels mentioned), in contrast to 21 responses given by males at the same levels of knowledge. When analyzing the responses by age group, it appears that at level 2 and level 4, the highest number of responses were given by individuals between 41 and 50, as well as by individuals between 51 and 60 years. At level 3, the largest number of responses was obtained in the age group from 31 to 40 years old.

Evaluation of the results of the questionnaire made it possible to perceive that there is sensitivity towards the problem of climate change and concepts such as sustainability. It was also noted that, despite the residents of Alvalade being aware of the current situation in their neighborhood and showing a conscious attitude to make it more resilient, they continue to attribute responsibility to other institutions, such as the civil Parish Council and the Lisbon City Council, regarding environmental problems in their area of residence instead of taking individual initiative. This demonstrates that there may be a lack of a culture of active citizenship but also a lack of credibility that institutions attribute to residents concerning decision making. In the interview carried out with two people responsible for the public space of the Civil Parish Council of Alvalade, it was found that when events are held to discuss problems or actions in the area of residence, there is no attendance of residents. This can mean that current directives are not effective, and it is not possible to reach people. It would be interesting to think of alternatives that can reach people more appealingly.

Regarding the predisposition of the respondents to make changes in their neighborhood, around 96.4% (men and women) showed predisposition to do it, answering "yes". Figure 9 shows from that total the percentage of women and man that answered "yes" or "no". The majority of the "yes" responses came from women with higher levels of education, especially those that went to university (Figure 10), and in general, the age group between 51 and 60 years (Figure 11) is less willing to make changes based on the knowledge they presented about climate change.

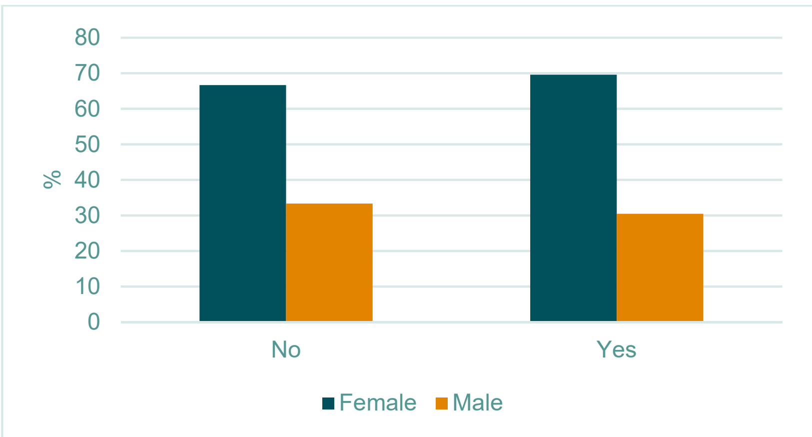

Figure 9. Response to the question "Based on your sensitivity to the presented maps, are you willing to make changes in your neighborhood?", by sex.

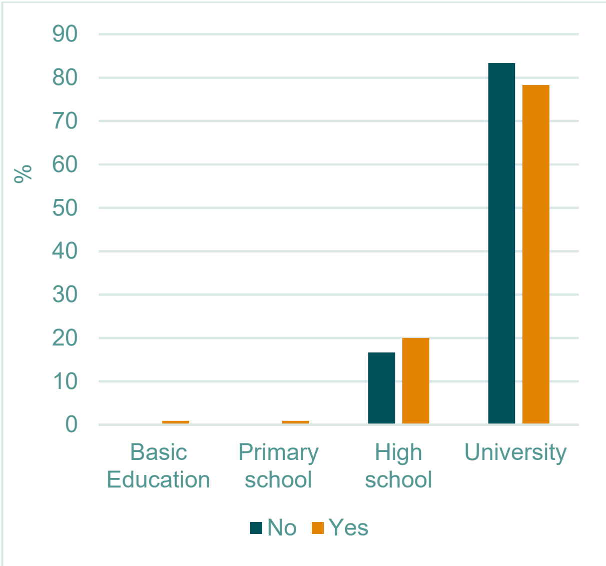

Figure 10. Response to the question 'Given your sensitivity to the maps presented, are you willing to make changes in your neighborhood?', by the level of education.

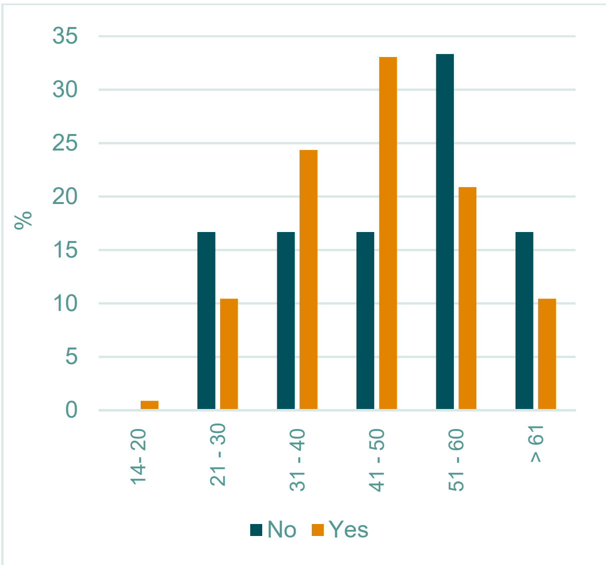

Figure 11. Response to the question 'Given your sensitivity to the presented maps, are you willing to make changes to your neighborhood?', by age group.

Regarding the mitigation measures to be applied in Alvalade, a large number of responses refer to the need for more green spaces and/or vertical gardens, the reorientation of car traffic, secondary pedestrian streets, the creation of water bodies, and the increase of street ventilation for greater air circulation. Regarding measures to promote environmental sustainability in the neighborhood under study, among the various selected by residents, the following stand out: using alternative transport to personal transport; use of "car-sharing" or other forms of shared transport; use of clean energy; creation of urban gardens in the backyards of houses or on the roofs of buildings; switching to electric cars; more electric car charging stations; construction of more ecological islands/eco points for the collection of garbage in a more optimized way; construction of more bike lanes within the neighborhood; creation of discussion groups on the environment and sustainability in Alvalade; and openness to discuss the problems between residents and local authorities. When asked about the impediments to the implementation of the different measures, 63 of the respondents did not comment. However, among the answers obtained, the following were found: “the lack of available area” (for the implementation of green spaces and/or bodies of water); the lack of knowledge of the residents; and the “mentality” related to the “inertia of people”. At the end, “the perception that the impact of the changes will not affect them in their lifetime” emerged as a final remark, suggesting that much more must be done for the public to implement effective measures to tackle local and urban climate changes.

5. Conclusions

The present and future temperature and UTCI (Universal Thermal Climate Index) of summer conditions (hot day) of the Alvalade neighborhood, a Lisbon civil parish, were calculated with microclimatic modeling software (ENVI-met). The future local climate models were presented to the residents of Alvalade through a questionnaire and two figures, representing the extreme IPCC RCP 8.5 scenario versus the present hot day situation. These figures show the projected UTCI in a dramatic but accurate aggravated way. These very high values permit the identification, but not in an explicit way, of an effective health risk. For the current scenario (2017), the average UTCI was 45 °C. Following the IPCC climate projections, for the second half of the century (2070–2100), the average downscale value obtained was 53 °C (an increment of about 8 °C of the thermo-physiological temperature, and therefore a thermal sensation intensification).

When presented with this information, residents had impacting reactions. Responding to the starting question “How willing are residents of the neighborhood of Alvalade to change their behavior and way of life when faced with climate change scenarios?”, as a general remark, the inquiry allowed us to conclude that people are aware of local climate change and health risks from extremely hot summer weather. However, they continue to resist change in their behavior for adaptation, although most of them declared this could be important to tackle climate change.

The majority of responses concentrated on intermediate levels for female and for male respondents when it came to their knowledge of climate change. Regarding the age group with the most information on this topic, the majority of responses came from respondents between the ages of 41 and 50 who chose level 2 of knowledge regarding climate change, with female respondents between the ages of 31 and 40 and 51 and 60. However, at this degree of knowledge, it was found that men between the ages of 41 and 50 had the highest number of responses.

The second conclusion, responding to the questionnaire objectives, is that people think that local authorities should be more active than themselves and will have greater responsibility for climate change adaptation and interventions. From the set of individuals that responded to the questionnaire, one can see that people with higher levels of education and elderly people are the ones that discard this responsibility to higher authorities. Moreover, most of the residents were aware of climate change and had good levels of understanding of climate change mitigation actions. However, the majority were not willing to make changes for their neighborhood because they think local authorities and the government are responsible for that. These results are similar to the ones presented by [30,31] stating that individuals think that the government (and higher institutions) should be responsible for the implementation of mitigation measures against climate change rather than individuals. In line with this point of view, [44] presented as the study’s conclusion that while there may be a high level of general awareness regarding climate change and the mitigation measures against it, it is crucial to encourage media-supported programs to increase the level of knowledge regarding climate change adaptation.

One of the respondents’ main beliefs is that the effects of the changes that could be made will not have an impact on them during their lifespan, which is an additional intriguing finding. This demonstrates that much more work must be done in close proximity to the general population to put effective measures in place to combat local and urban climate change.

In times of climate crisis, the participation of the resident community can be an important help in decision making regarding measures to mitigate adverse climate effects in urban environments. It is essential to remember that public participation is a crucial tool that should be used alongside the institutions that are responsible for climate change adaptation. This type of result represents a fundamental contribution to urban planning because, at such a detailed scale, it is possible to help intervention by the local authorities.

This work is a pilot project, whose main result was to understand its applicability in other neighborhoods. In the future, the authors intend to apply this methodology in different residential areas to increment the sample and monitor its applicability. In summary, we consider that this is an innovative work on the detailed methodology applied, which involves several scientific areas of great importance, to find solutions to tackle urban climate change, where more than ever mitigation measures must be found to create healthier cities.

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