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Analysis of the Temporal Evolution of Climate Variables Such as Air Temperature and Precipitation at a Local Level: Impacts on the Definition of Strategies for Adaptation to Climate Change

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Abstract: Climate change is a global phenomenon that can affect neighbouring territories and the communities residing there in different ways. This fact, which is associated with the specificities of each of the territories, leads to the need to implement adaptive measures to address the new reality imposed by climate change and to create more resilient territories and communities capable of facing this new paradigm. The more these measures are adjusted to the specificities of the territories and their communities, the more efficient they will be. Thus, it is essential to have a thorough understanding of the evolution of the climate on the local scale and the real needs of the resident populations. To identify these needs, a survey was conducted, and it was found that the dominant opinion of all respondents, comprising citizens residing in Portugal, was that climate change can affect geographically close territories in different ways. In the present work, the municipality of Guimarães, located in the north of Portugal, was used as a case study, where a comparative analysis was carried out to assess the period between the current climate, characterized by the period of 1971–2021, and the climate of 100 years ago, characterized by the decade of 1896–1905, to determine trends for the variables of air temperature and precipitation. It was found that the temperature in the winter months increased, with less uniformity in the distribution of precipitation throughout the year. These differences in the air temperature and precipitation, as variables, lead to the need to plan adaptive measures that can be implemented so that the territory and its communities become more resilient to climate change.

Keywords: adaptation to climate change; local effects; climate variables; adaptation measures; effects on communities; Guimarães

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1. Introduction

Climate change is a current topic of interest which has been the subject of analysis and study by the most diverse research bodies, not only in academia but also in the rest of civil society [1,2]. This attention is due to the fact that climate change has a significant impact on the daily lives of populations, causing government structures to dedicate an important part of their attention to the analysis of the problem and, above all, to the ways and measures that can be applied to face it [3]. However, the approach to climate change, as it is a highly complex issue involving an indeterminate set of variables, has to be carried out at different levels of interaction, which can be defined as knowledge, mitigation, and adaptation [4].

The level defined as the knowledge of climate change is related to the need to identify the variables involved in the processes, their interconnections and correlations, and, above all, the causes of their origin [5]. Knowledge of the impacts at different levels is also very important, as is the construction of predictive models that can anticipate trends in the evolution of the processes based on the change in a variable or sets of variables [6]. This knowledge, built up by the scientific community, allows us to move to a new stage, which is the mitigation of climate change, where measures are applied with the aim of, on the one hand, halting the process(es) associated with climate change (since, at this stage, it does not seem sensible to consider reversing the process) [7]. On the other hand, attempts are made to minimize the impacts caused by climate change [8]. At this stage, in addition to the scientific community, the participation of political structures is also extremely important, since mitigation measures require a consensus to be reached between the various stakeholders, which, in this context, are on the global scale [9]. In other words, to undertake global measures, a consensus must be reached between different countries or alliances [10]. This includes, for example, agreements to reduce greenhouse gas emissions [11]. However, the application of mitigation measures, decided on the global scale, with the establishment of goals that imply the alteration of procedures at levels that grow successively closer to the citizens, leads to the need to advance to the level of adaptation to climate change [12,13]. Adaptation to climate change can be defined as the ability of communities to continue to evolve in a climate change scenario, with the understanding that this evolution sustainably takes place through increased resilience in the face of ongoing changes, which often acquire the contours of unpredictability and extreme severity [14–18]. In this phase of the implementation of measures that lead to the adaptation to climate change, complementarity between the scientific community or, rather, the knowledge made available by the scientific community and the political structures that have the ability to make decisions about the best measures to be implemented is required, and at this stage, there is an increasing approach to involve the citizen [19–22].

Research on climate change adaptation has increased significantly in recent years, mainly motivated by the growth of knowledge about the causes and effects of climate change, which has enabled discussions about measures that can be taken for mitigation and adaptation [23–25]. In turn, measures leading to the adaptation to climate change require a knowledge of the evolution of the climate on a lower scale, which can be regional or even local, depending on the territories' specificities and the objectives they aim to achieve [26–29]. The main objective of this work is to present a hypothetical case study based on the municipality of Guimarães, located precisely in the center of the Entre Douro e Minho region (Northern Portugal), where, through the comparative analysis of the evolution of two climate variables, the air temperature and precipitation, over a period of time, an attempt was made to understand and identify the main differences between the current climate and the climate of the past. This analysis presents some examples of locally applicable measures that can contribute to efforts to adapt to climate change.

2. Materials and Methods

2.1. Bibliographic Research

To carry out this work, a bibliographic review of research on mitigation measures, such as carbon capture and sequestration processes, was conducted. Then, a critical analysis of the collected bibliography was carried out to create a simplified explanatory model which could be used to gain a perception of the impacts of mitigation measures as a function of the variable of "time". In this way, a model is presented that allows for the perception of the impacts of mitigating measures according to the evolution of the variable of "quantity" as a function of the variable of "time". The bibliography collected was selected according to previously defined criteria, which emphasized the relevance of each of the articles to the topic, particularly by the number of citations and by the indexing level of the journals in which they were published.

2.2. Meteorological Data

For the analysis of the meteorological data from Guimarães, the METEOBLUE platform was used (https://www.meteoblue.com/pt/tempo/semana/guimar%C3%A3es_ portugal_27387-52, accessed on 20 December 2021). This platform was created at the University of Basel (Switzerland) and regularly calculates two daily high-resolution forecasts for Europe, Africa, and South America. The premium version of the History+ section allows one to select the location where the data series were collected and the climate variables to be downloaded. In this case, data were acquired in a low resolution from 1979 onwards, corresponding to the lower limit of the data available for Guimarães. As parameters, the daily maximum and minimum average air temperatures and daily precipitation were selected. With the data collected, the monthly and annual averages of the air temperature and the monthly and annual cumulative values of precipitation were calculated, as shown in Section 3.

2.3. Survey Carried out among the Population

To assess the level of concern regarding the theme "Climate Change" among the residing population in Portugal, a survey was carried out, as presented in Table 1.

Table 1. Survey carried out to assess the level of concern about the impacts of climate change.

No.	Question
1	Have you ever heard of climate change?
2	Do you think you have felt any effects of climate change?
2.1	If you answered "Yes" to the previous question, what direct effect of climate change have you felt?
3	Does the subject of "Climate Change" concern you?
3.1	If you answered "Yes" to the previous question, quantify that concern on a scale of 0 to 10, where 0 is not a concern at all and 10 is very concerned.
4	What do you think is the most worrying consequence of climate change?
5	What do you believe to be the main cause of climate change?
6	What do you consider to be the main measure that should be taken to mitigate climate change?
7	Do you think that climate change can affect nearby localities in different ways? In other words, can the effects be felt differently in different locations, even if they are geographically close?

The survey was carried from 1 August to 30 September 2022 through the social networks Facebook and LinkedIn, targeting an audience residing in Portugal.

3. Analysis of the Results Obtained

3.1. Citizens' Perception of the Theme "Climate Change"

In the survey, 730 valid responses were obtained, which were distributed as shown in Figure 1.

When faced with Question 1 (Have you ever heard of climate change?), respondents very convincingly answered affirmatively, with 98.6% indicating "yes" as the chosen answer, while only 1.4% answered negatively. The negative answer can be related to the fact that, for some reason, these social network users feel compelled to answer all the surveys and questionnaires that appear in their social network newsfeeds, without intending, however, to seriously participate in these same surveys. This is one of the causes of the discussions about the validity of surveys carried out through social networks such as Facebook or LinkedIn, since there is no certainty regarding the types of people who can respond to the survey. For example, in the analysis of the results obtained for this specific question, it is difficult to believe that someone who uses social networks such as those mentioned here could have never been confronted with some information about climate change. In this sense, given the disproportion of the results, with 720 affirmative answers against 10 negative answers, the conclusion that can be reached is that an overwhelming majority of the population had already heard about climate change, and that the analysis of the results obtained in this survey reveal the opinion formed on the subject.

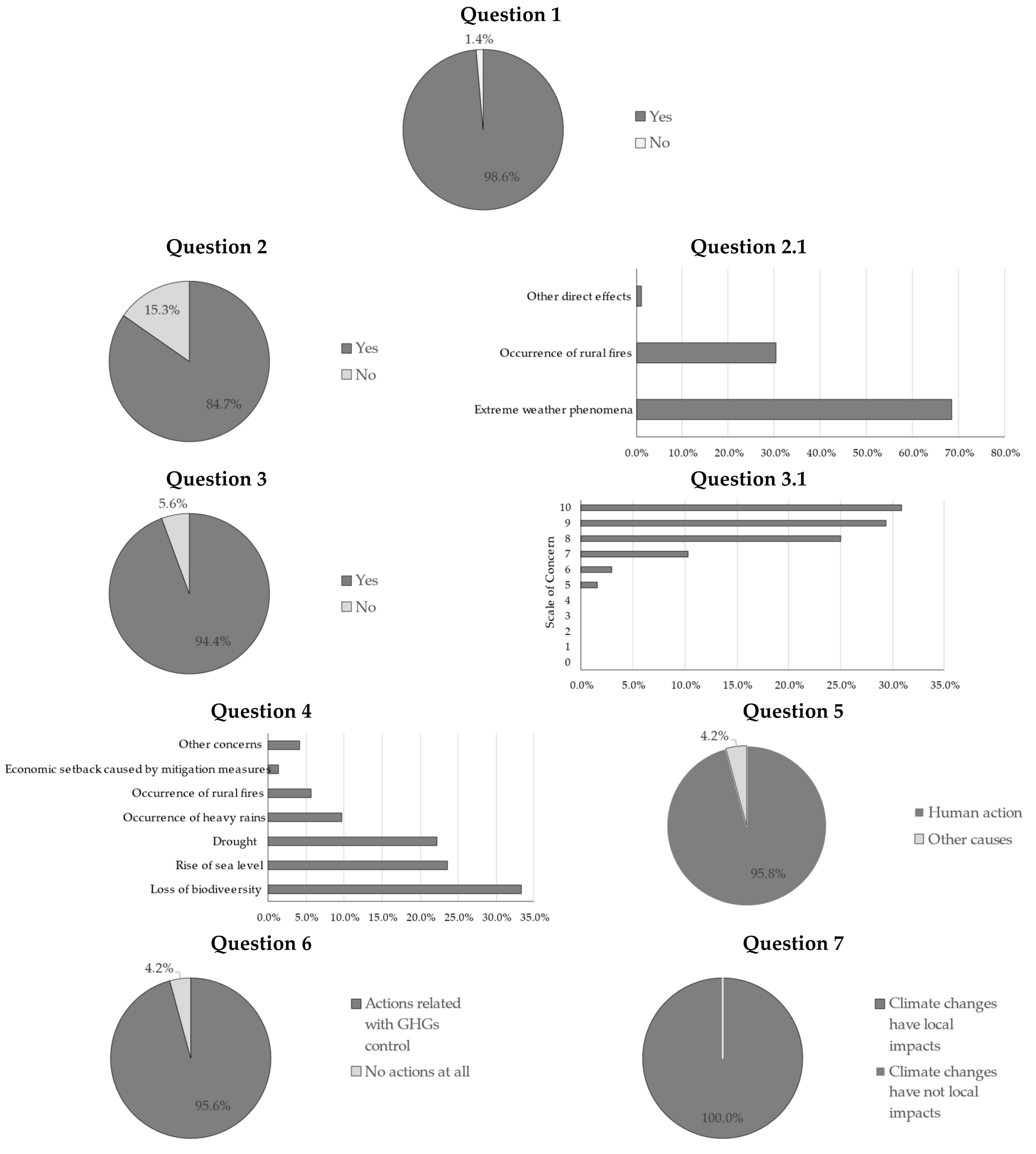

Figure 1. Summary of survey responses.

As the first answer was eliminatory, only respondents who answered affirmatively proceeded to the next question. Thus, to Question 2 (Do you think you have felt any direct effect of climate change?), the respondents mostly answered "yes", with 84.7% agreeing, while 15.3% responded negatively. This question is of decisive importance, as it can be used to infer the degree of knowledge that respondents have on the subject, since a positive answer must indicate that the respondents understand the effects of climate change and their direct impacts on day-to-day life. On the other hand, the negative responses of 110 survey participants may indicate a certain degree of ignorance about the effects of the changes or even a certain devaluation of their effects, to which these respondents did not attribute significant relevance. Respondents who answered affirmatively to the previous question were asked, in Question 2.1, to indicate the effect of climate change that they had already experienced, with their opinions reflecting a certain tendency towards references to extreme weather phenomena, such as drought, waves of heat, violent storms, and the occurrence of rural fires, which, according to the respondents, are reaching increasingly worrying dimensions.

This previous assumption seems to be in conflict with the results for Question 3 (Does the subject of "Climate Change" concerns you?), with 94.4% of the participants answering affirmatively, while 5.6% answered negatively. Thus, there seems to be, in fact, a group of people who do not relate certain types of events and consequences to climate change, while others clearly express the opinion that it is not a topic that concerns them, although they may be aware that they may be affected. When the participants who answered affirmatively to the previous question were asked, in Question 3.1, to assign a degree of concern on a scale from 0 to 10, where 0 corresponds to "not concerned at all" and 10 corresponds to "very concerned", all respondents gave answers ranging from 5 to 10, with the responses distributed from 5 to 10, respectively, being 1.5%, 2.9%, 10.3%, 25.0%, 29.4%, and 30.9%, indicating a growing concern about climate change among an overwhelming majority of the survey participants.

To Question 4 (What do you think is the most worrying consequence of climate change?), the vast majority answered that they had concerns such as the loss of biodiversity (33.3%), the rise in sea levels (23.6%), drought (22.2%), the occurrence of heavy rains (9.7%), or the occurrence of fires (5.6%). A group of 4.2% of the respondents answered that they all the above possibilities concerned them. However, 1.4% of the respondents answered that their main concern was the economic setback caused by the measures necessary to counter climate change. These answers are in line the analysis presented above, which meets the concerns of a still significant group of citizens, who, because they are not denialists, understand that it is more burdensome for society and the well-being of citizens to accept the impacts on the economy caused, for example, by measures implemented for the purpose of decarbonization, than to accept the direct impacts of climate change. This group of participants seems to be directly related to some of the answers obtained in response to Question 5 (What do you believe to be the main cause of climate change?), which yielded answers such as "orbital factors", "solar activity", or even "ocean dynamics and solar cycles". This type of participant, who does not deny the existence of climate change, attributes it to a cause external to human and even "natural" actions, embodying a type of participant who accepts the information available on social networks and from other sources without scientific validity, and who contradicts the opinion of the remaining 95.8% of respondents, who attributed the phenomenon of climate change to human action. Likewise, when asked, in Question 6, "What do you consider to be the main measure that should be taken to mitigate climate change?", participants focused mainly on measures such as efforts to "reduce pollution", "reduce greenhouse gases", "decarbonize the economy", "reduce consumption", "reduce industrial production", "reduce the consumption of fossil fuels", and others of similar a nature and significance. However, following the answers obtained in previous questions, it appears that a group of 4.2% answered that "no action should be taken, as it is not in the hands of Man", with a clear allusion to the fact that this group believes that climate change is a natural phenomenon in which anthropic action plays no role and, therefore, Man cannot play a role in its mitigation.

The last question (Question 7) posed in the survey aimed to assess the opinion of each of the participants on whether climate change can be felt differently in locations that are geographically close to each other. In other words, it asked whether climate change can have different impacts on a small scale, conditioning the daily lives of populations in different ways. To this question, all the participants answered affirmatively, indicating that, according to the general understanding of the population, climate change should also be analyzed on scales in proximity to the population, for example, through analyses on the municipal scale.

3.2. The Evolution of Temperature and Precipitation over the Years in the Municipality of Guimarães

The data collected and processed were organized graphically in order to visualize the distribution of climate parameters over the years (1979–2021). Thus, annual graphs were created and organized by decade to show the monthly average air temperatures and cumulative precipitation, as shown in Figures 2–7.

With regard to this year, as it is the only one available for the 1970s in the 20th century, it is not possible to draw any conclusion regarding continuities or trends. However, from the observation of the graph presented in Figure 2, it is possible to see that there seems to be a reduction in precipitation in the period corresponding to the winter months, with the exception of February 1979, which seems to be the only month of the colder period that presents a discrepancy between the values in relation to the remaining winter months.

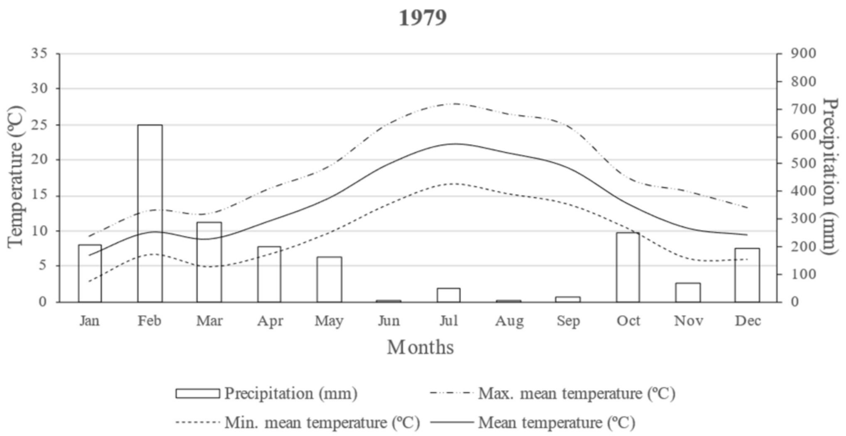

Figure 2. Distribution of climatic parameters for the year 1979.

Figure 3 shows the graphs corresponding to the years of the decade of 1980–1989.

The way in which the air temperature curves fluctuate from one year to the next seems to indicate a kind of turbulence related to the rise and fall of air temperatures over the months. This thermal variation, which should be progressive and less fluctuating, seems to indicate a transition period in which the system is rebalancing. However, when the maximum and minimum values are analyzed, there do not seem to be major differences, with the annual average values being relatively stable. The greatest variability seems to be reflected in a lag between the different months of each year, with the typical air temperature values of a given month progressing to the following month, and so on, giving a less continuous and smoother aspect to the evolution of the air temperature curves and the characteristic of higher thermal variability in all the years of this decade. In regard to precipitation, in the period in question, there is a certain inconsistency, with some months in which there is a very high accumulated level of precipitation, as is the case of December 1989, with precipitation exceeding 500 mm. On the other hand, again in the winter months, there are months with residual precipitation, or practically zero, as is the case of November 1981, January 1983, February 1984, November 1987, December 1988, and January 1989. This variability in the rainfall caused an alternation of periods with very high rainfall followed by other periods of very low rainfall.

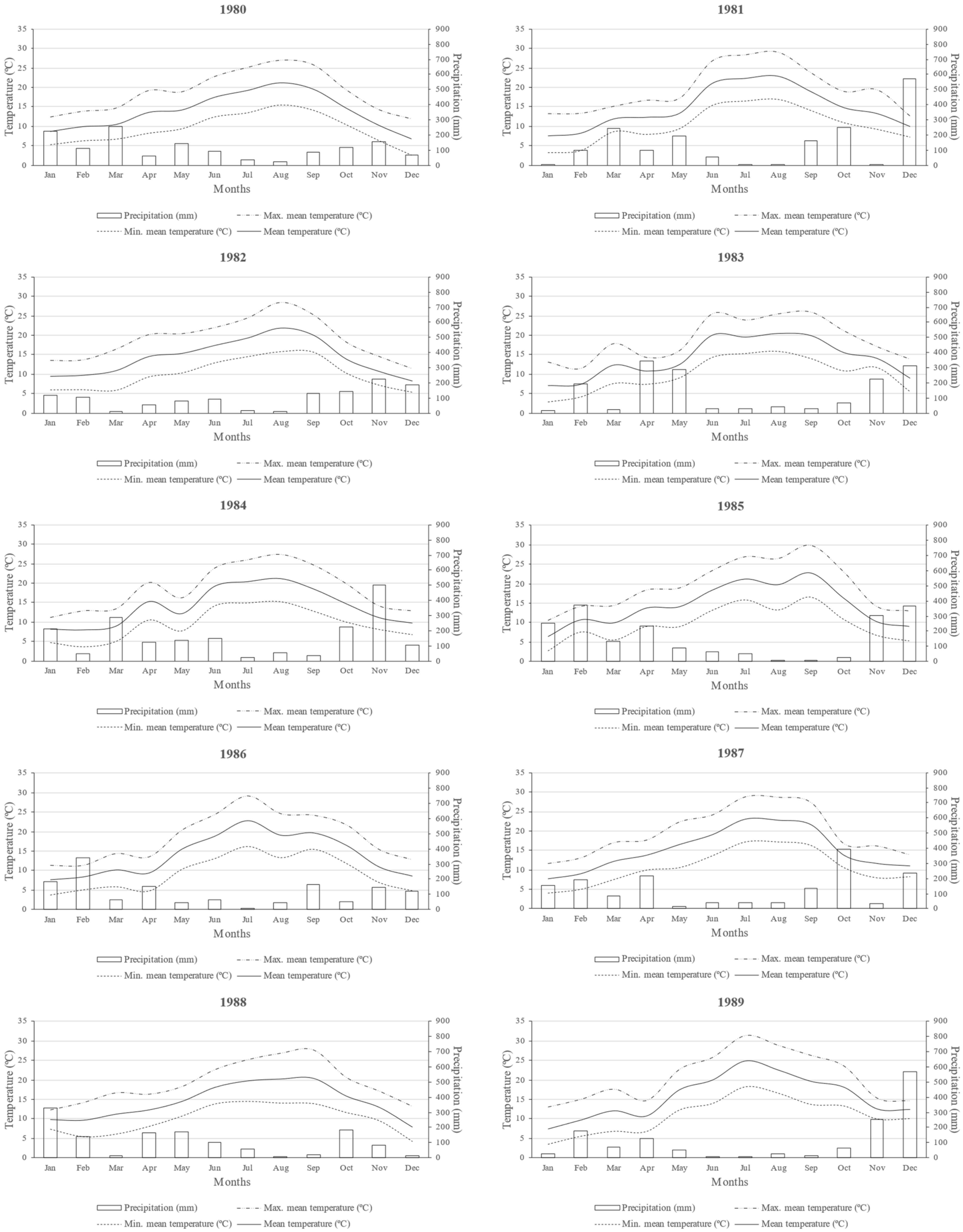

Figure 3. Distribution of climatic parameters for the decade of 1980–1989.

Figure 4 shows the graphs corresponding to the decade of 1990–1999.

From the point of view of the distribution of the air temperatures, there seems to be a certain continuity in relation to the previous decade, with some variability. In this period, there seems to be some differences in the constancy of the air temperature in regard to the same months, mainly from the middle of the decade onwards, when there is a shift towards higher air temperatures, which progressively pass from July and August to September and even to October, as is the case of the years 1996, 1997, and 1999. Regarding precipitation, this decade seems to be marked by a reduction in precipitation, with a few years in which there is a more or less normal distribution. An example of this normality is reflected in the year 1991, in which rainfall was distributed over the twelve months of the year, although it was not very high. Then, the occurrence of months of high rainfall, compared to the previous and subsequent months, is also presented as a fact that deserves attention. For example, October 1990, with more than 400 mm, December 1995, with more than 500 mm, January 1996, with more than 450 mm, November 1997, with more than 450 mm, and October 1999, with approximately 400 mm, seem to be the exceptions in a decade in which precipitation was clearly lower than expected.

Figure 5 shows the graphs corresponding to the decade of 2000–2009.

In this decade, in the first few years, there was a continuation of the extension of the usual air temperatures in July and August and also in September and October. In other words, there already seems to be a trend towards the extension of the summer period—a trend that can be seen throughout the entire decade. With regard to precipitation, there was a marked reduction throughout the decade. However, episodes of extreme and abundant precipitation are relatively frequent, with some months greatly exceeding that which occurred in previous years, as was the case in December 2000, with a monthly cumulative value of about 700 mm, March 2001, with 750 mm, or December 2009, with 500 mm. However, despite these periods of more intense precipitation, it appears that this occurred in a very concentrated manner, and there are also many months in which there is very little precipitation.

Figure 6 shows the graphs corresponding to the decade of 2010–2019.

In this decade, the pattern of the previous decade continues, with air temperatures associated with the summer months extending into September and October. This situation is also associated with a marked decrease in precipitation. The only months of the entire decade that stand out are March 2013, with 500 mm, March 2018, also reaching 500 mm, February 2014, with 400 mm, and January 2016, slightly exceeding 400 mm. The decade ends with two months exceeding 350 mm, in November and December 2019.

Figure 7 shows the graphs corresponding to the years 2020 and 2021.

The first two years of the 2020s are characterized by the continuation of high summer temperatures through September and October. Regarding precipitation, the months that presented the highest value were December 2020 and February 2021, which exceeded 200 mm. In the remaining months, rainfall was clearly weak, with several months with residual, or even non-existent, rainfall.

3.3. Comparison between the Climatic Normal (1971–2000) and the Average of the Period under Analysis (1979–2021)

This section concerns the comparison between the results obtained for the period under analysis, between 1979 and 2021, representing the last 42 years, and the climatic normal, corresponding to the period between 1971–2000. It allows one to verify how the climate has evolved in recent years. Figure 8 shows the overlap of the data collected for the period of 1979–2021 with the climatic normal for the period of 1971–2000.

Figure 4. Distribution of climatic parameters for the decade of 1990–1999.

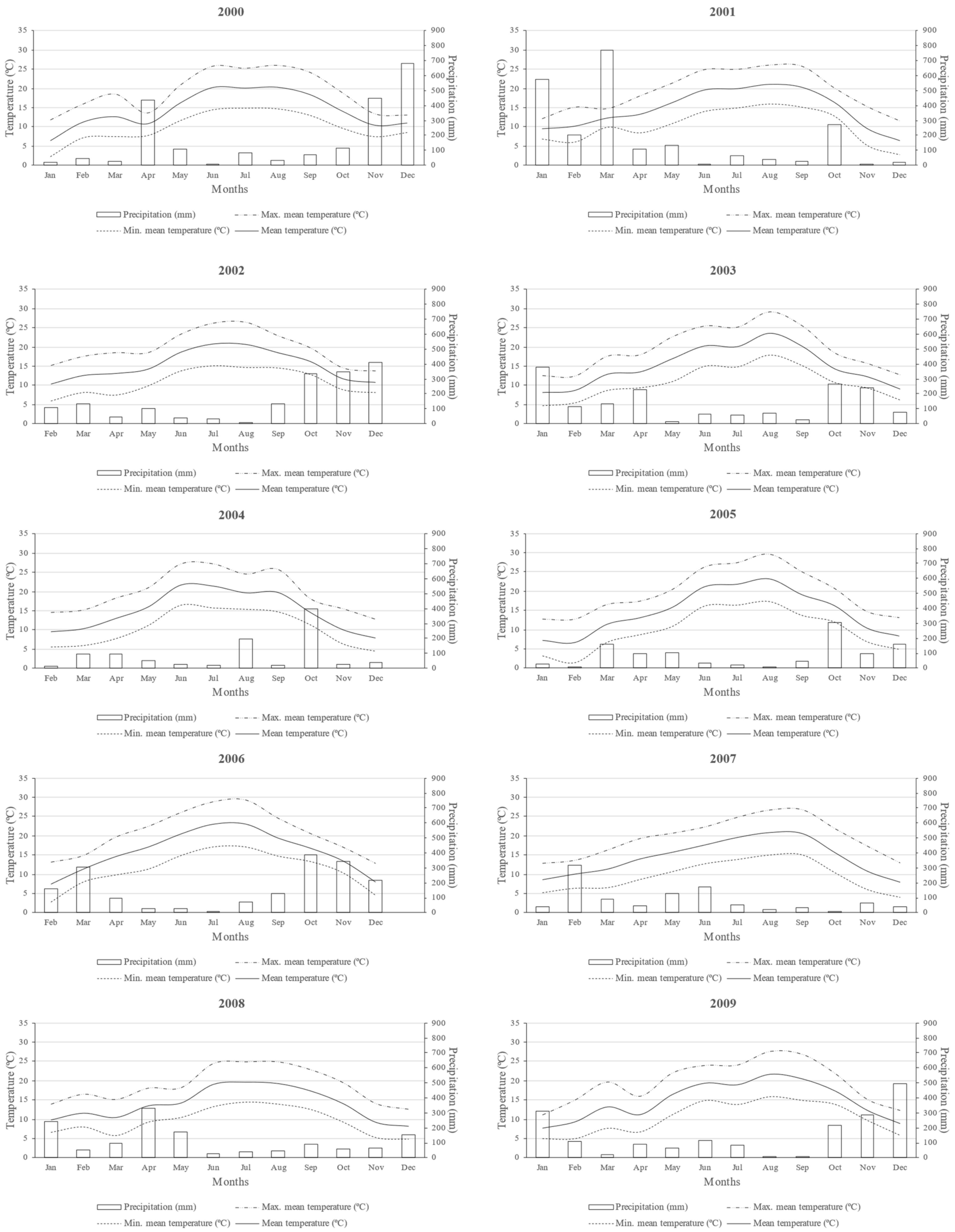

Figure 5. Distribution of climatic parameters for the decade of 2000–2009.

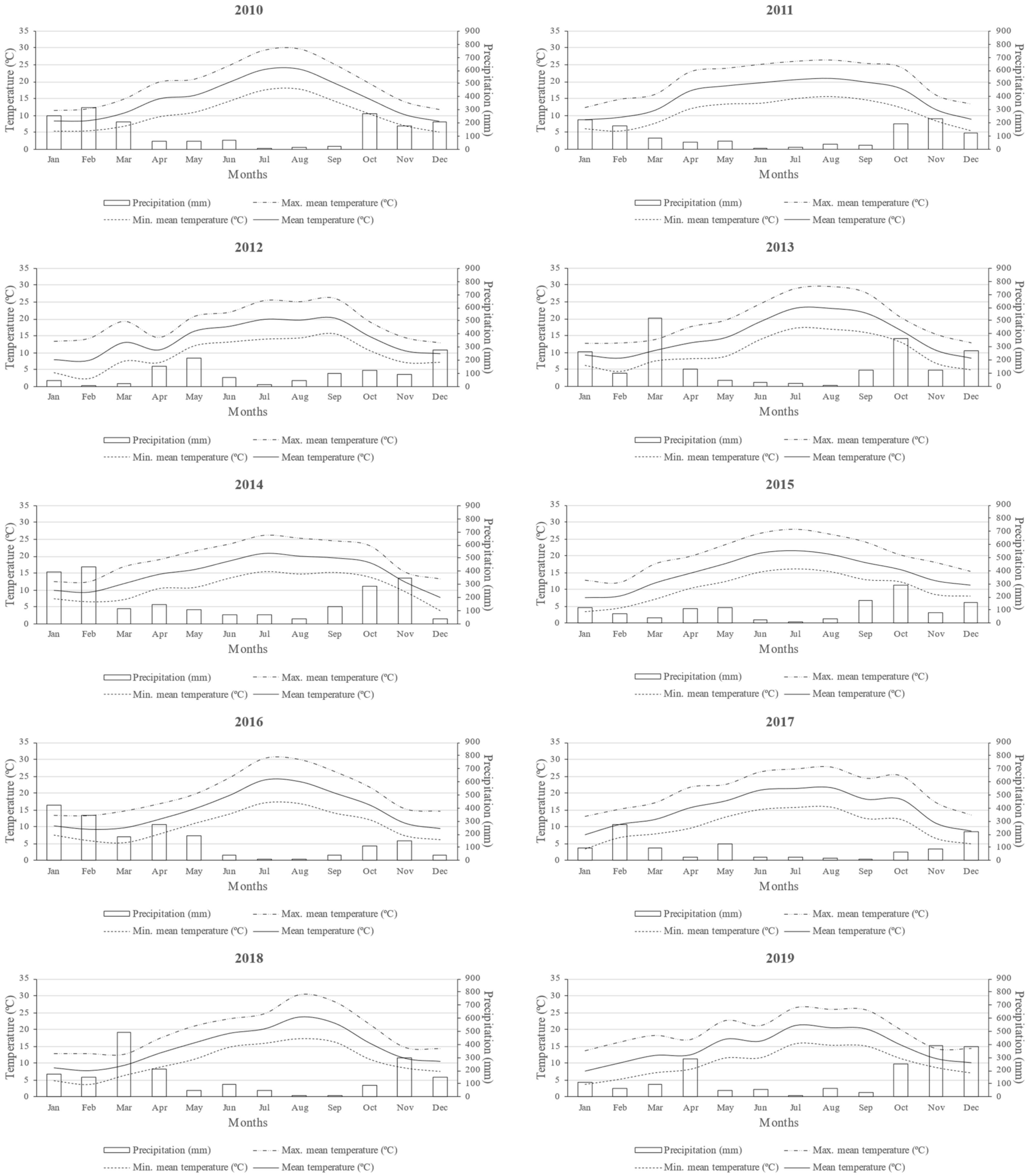

Figure 6. Distribution of climatic parameters for the decade of 2010–2019.

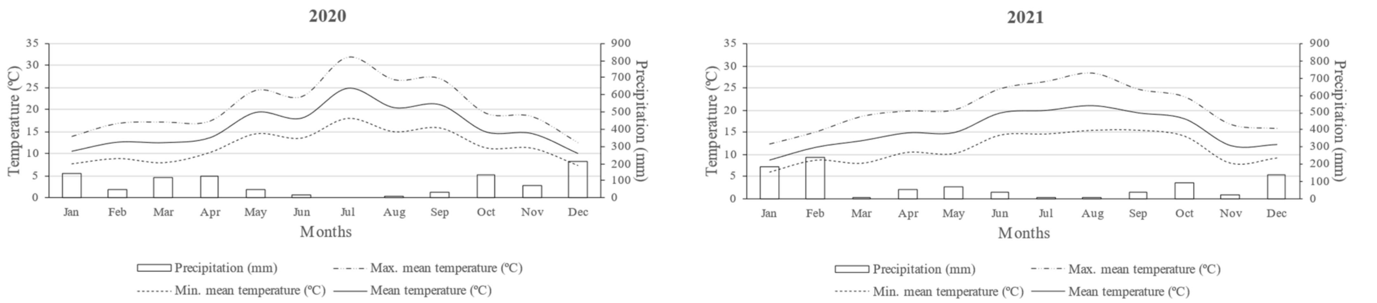

Figure 7. Distribution of climatic parameters for the years 2020–2021.

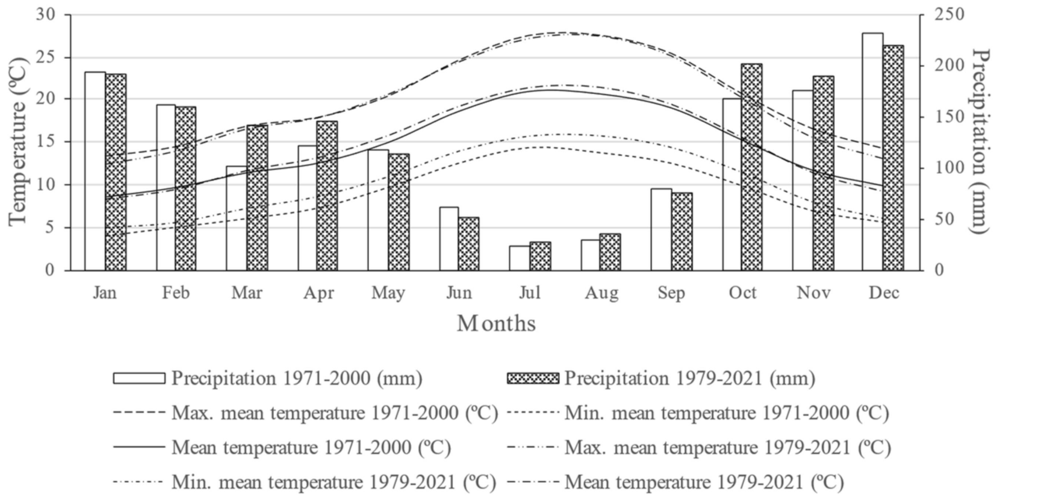

Figure 8. Overlaying the climatic data collected in the period of 1979–2021 with the climatic normal, corresponding to the period 1971–2000.

As can be seen in Figure 8, it is possible to observe a slight increase in the average temperature, mainly in the months tending to be associated with the driest periods, from the end of the first quarter of the year to the beginning of autumn. This increase, although slight in terms of the average temperature, must be mainly related to the increase in the minimum average temperature that occurred throughout all the months of the year. On the other hand, the values of the maximum average temperature remained practically identical to those verified for the period of 1971–2000. Regarding precipitation, the downward trend in precipitation values is confirmed in eight of the twelve months of the year, contributing to the downward trend in annual precipitation.

On the other hand, when the climatic values of the period of 1979–2021 are compared with the values verified for the transition period from the 19th to the 20th century, which were made available by João de Meira in his work entitled *"O concelho de Guimarães (Estudo de Demografia e Nosografia)"* (https://www.csarmento.uminho.pt/site/s/arquivo-digital/item/93894#?c=0&m=0&s=0&cv=0, accessed on 20 November 2021), which the author presented in 1907, there is a slight difference in the average temperatures, as can be seen in Figure 9.

As can be seen, there is a very good overlap in practically every month of the year in terms of the average temperature. However, in relation to the months of August, September, and October, there is an increase in average temperatures in the period of 1979–2021, indicating that the summer period extends into the autumn period. Regarding precipitation, there seems to be a recovery of the annual totals for the period of 1979–2021, which is in line with another work published in 1904 by Paul Choffat, in which the author studies the water supply of the city of Guimarães, which, during this decade, was strongly affected by the lack of precipitation. The author used the same meteorological data as João de Meira, collected by Professor Rev. J. Kempf, demonstrating that, as Paul Choffat himself writes, "the great water scarcity of last summer is not due to the lack of water in the previous years. It was higher, as is generally admitted, but only compared to the little rain that fell in the pluviometric year 1897–98 and at the beginning of the second half of 1898" (https://www.csarmento.uminho.pt/site/s/rgmr/item/54291#?c=0&m=0&s=0&cv=0, accessed on 20 November 2021).

3.4. Climatic Anomalies

The climatic anomalies indicate the variation in the average values of a determined parameter based on the average that characterizes that parameter in a determined period. In this way, the projection of temperature anomalies for each of the years included in the period under analysis (1979–2021) allows us to sensitively observe how the temperature, or precipitation, evolved over this period. Figure 10 shows the distribution of monthly anomalies for each of the years in the period of 1979–2021.

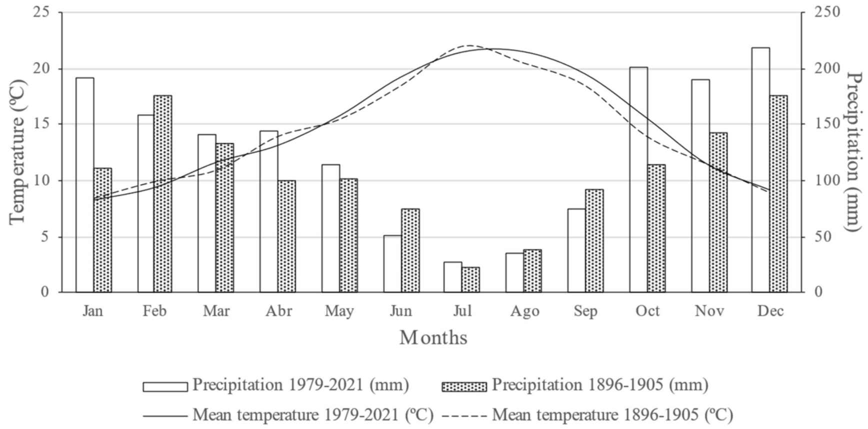

Figure 9. Overlay of climate data for the period of 1979–2021 and climate data for the period of 1896–1905.

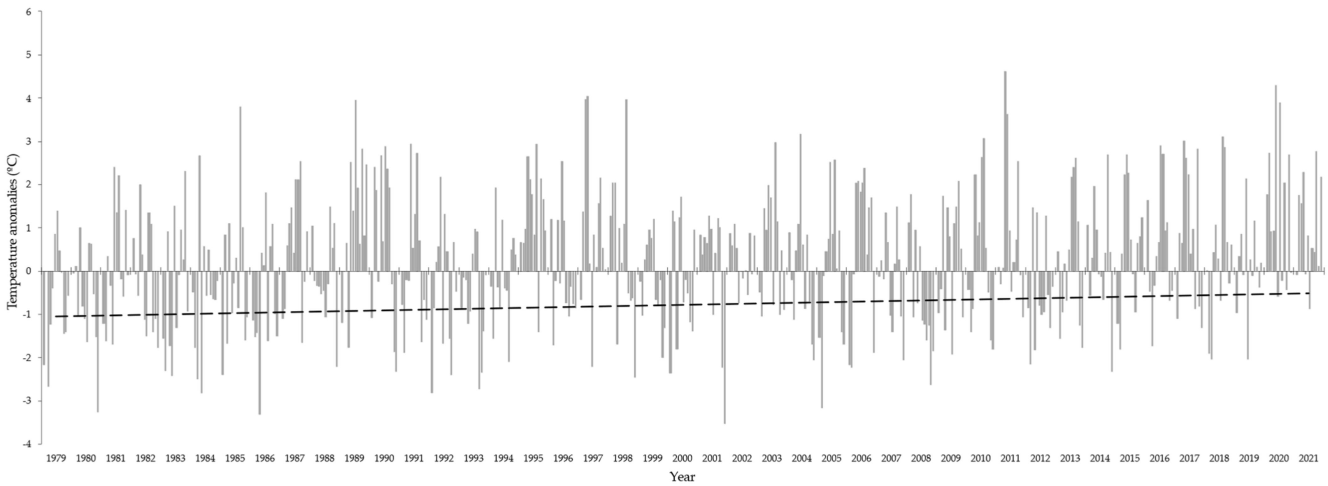

Figure 10. Distribution of monthly air temperature anomalies for each year of the period of 1979–2021.

In Figure 11, it is possible to observe that, despite the temperature anomalies being a reality throughout the period of 1979–2021, there is a change in the values of the anomalies. That is, in the early part of the period, there is a tendency towards the occurrence of negative anomalies that, over time, give rise to an increase in the number of positive anomalies, which dominate the scenario in the final phase of the period. This change in direction is in line with what was seen earlier, with temperatures rising, especially in certain months of the year. On the other hand, regarding precipitation, the scenario seems to be more stable, with a tendency to maintain negative anomalies throughout the period, as can be seen in Figure 11.

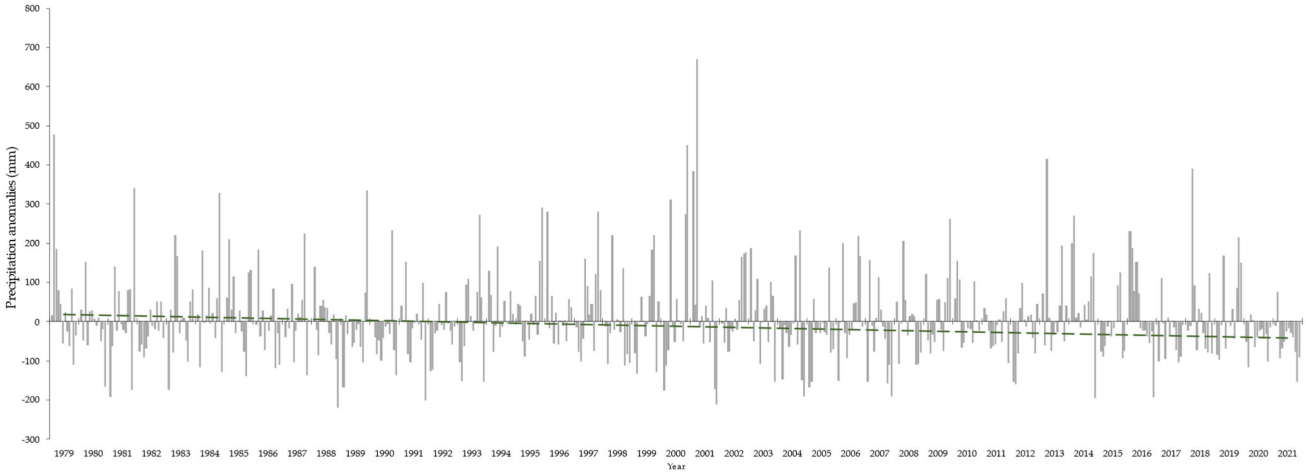

Figure 11. Distribution of rainfall anomalies for each year in the period of 1979–2021.

Thus, as can be seen, the negative anomalies are distributed over the 42 years of the period, increasing in their concentration from about the middle of the period, which corresponds to the year 2000. It is from this time that one can verify the occurrence of some significant positive anomalies, which indicate the occurrence of more extreme meteorological events. In other words, the amount of precipitation observed is not significantly different but is concentrated in certain times. For example, several months of negative anomalies may follow, where precipitation is practically non-existent, and then suddenly a month with an episode of extremely high precipitation occurs, causing a very significant positive anomaly. This scenario was observed throughout the second half of the period under review.

From the perspective of a monthly analysis of the anomalies, Figure 12 presents the average values of the temperature anomalies for each month of the period of 1979–2021.

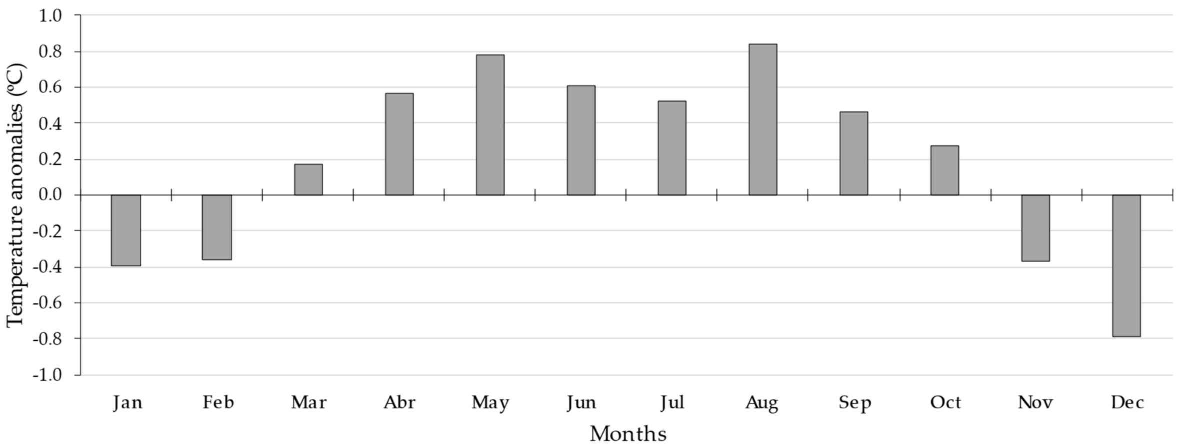

Figure 12. Distribution of monthly mean values for temperature anomalies in the period of 1979–2021.

As can be seen in Figure 12, there is a tendency towards the occurrence of positive temperature anomalies concentrated in the months from March to October, followed by negative anomalies in the months corresponding to the winter period, specifically January, February, November, and December. It is this increase in the positive temperature anomalies in the spring, summer, and autumn months which are significantly higher than the negative temperature anomalies that occur in the winter months, which are the basis for the increase in the annual average temperature that has taken place in recent years.

Regarding precipitation, Figure 13 shows precipitation anomalies in the period of 1979–2021.

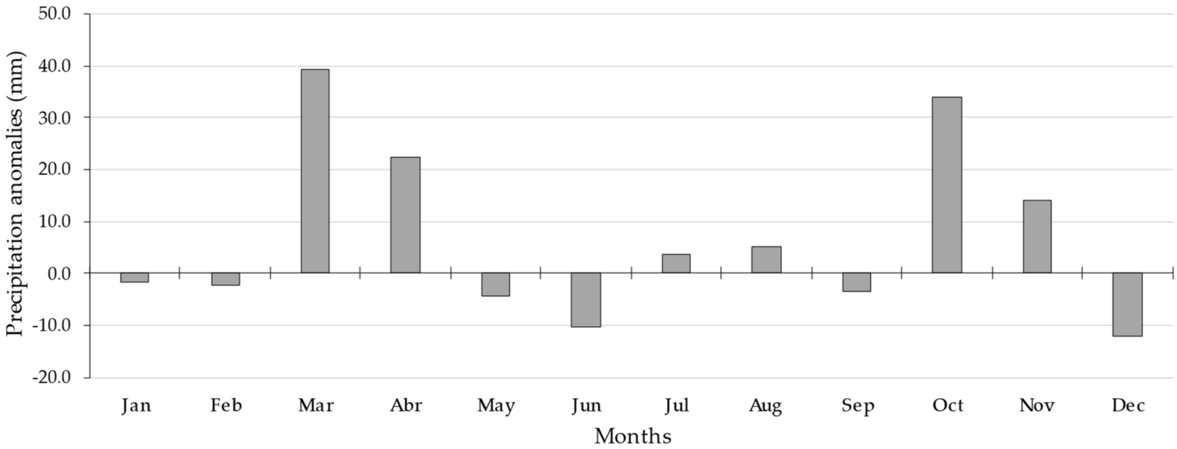

Figure 13. Distribution of monthly mean values for rainfall anomalies in the period of 1979–2021.

As can be seen in Figure 13, precipitation anomalies tend to be negative during the winter and spring months, with positive anomalies during the late winter, early spring months, and during autumn. However, this apparent positive distribution of precipitation, as seen before, seems to be intensely concentrated in certain periods, which, as it is associated with the increase in temperature, may contribute to the occurrence of drought episodes.

4. Discussion

As presented by Reyes-García et al., local indicators of climate change have been proposed as a place-based tool for ground truth climate models which can be used to narrow their geographic sensitivity [30]. The same authors recognized that to assess the potential role of local knowledge to better understand the climate and its impacts, it is necessary to critically review the existing local knowledge of climate change and the potential complementarity links with scientific knowledge. The same authors concluded that the observation and analysis of local data on the evolution of the climate enable the attainment of rich and detailed knowledge in relation to the impacts of climate changes on systems, allowing for a greater contribution to the understanding of the impacts of climate change on the local scale. Naess also shared this opinion, stating that local knowledge may contribute to communities' adaptation to climate change in a number of ways, and demonstrating that this analysis, however, still presents some concerns with respect to its relevance to future adaptation amidst other challenges [31]. From this perspective, the implementation of local-level climate change adaptation plans require an increasing international responsibility of local government entities to prepare and adapt to global climate change through climate adaptation planning, as described by Baker et al. al. [32]. For these authors, although the results indicate that local government agents are aware of expected climate change impacts, their ability to use available information to create specific action plans for a given territory is limited. This, as mentioned by Roja Blanco, further justifies the argument that local governance should integrate climate changes and climate hazards as a means of adapting to their new climate situation [33].

As seen in the results of the survey presented in Section 3.1, citizens are aware that the impacts of climate change can affect populations located geographically close to each other in different ways. They can, in different ways, more consciously understand and accept measures at a local level that, most likely, will have little or no impact on a global scale but may contribute to the implementation of an adaptive strategy in the face of climate change. As shown by the results for the climate in the municipality of Guimarães over approximately the past 100 years, there have been changes in the variables of air temperature and precipitation. An increase in air temperature in the traditionally coldest months can be observed, along with the reduction in precipitation in the autumn and winter months, which later led to the occurrence of periods of drought. However, as verified above, the occurrence of anomalies both in temperature and in precipitation shows that climatic phenomena have increased in recent years. Given these changes, adopting adaptative measures to address climate change at a local level can address the fears of the populations, namely those fears identified as being the direct effects of climate change that can impact day-to-day life. Adaptative measures can be applied, for example, given the recurrence of periods of drought, through the implementation of measures that make the populations aware of the importance of rationing water during periods when there is a lower precipitation rate. On the other hand, infrastructures must be created that enable the storage of water when there are periods of precipitation so that it can be used later in the periods when precipitation becomes scarce again. Given the displacement and extension of the summer period into the autumn months, the adoption of preventive measures regarding the management of agricultural and forest activities, such as the burning of leftovers and fires to reduce and eliminate weeds, must be implemented, given the new climate reality.

The knowledge of the local reality allows decision makers to adopt the most proactive measures adjusted to each territory and to the specific needs of the populations, knowing in advance the fundamental need to ensure consonance between the applicability of these measures and the clarification of the objectives to be achieved to the populations. The implementation of measures aiming to help populations to adapt to climate change assumes that these measures result from the knowledge of the local conditions' reality, specificity, and evolution, and that their main objective is to solve specific problems in the territories where they are implemented. These measures can also be applied in accordance with the immediate satisfaction of the needs of the populations for whom they are intended. In other words, adaptation to climate change starts with the situation, growing in scale by the multiplication of similar cases until reaching a growing territorial area, thus contributing to the mitigation of the problem on a global scale.

5. Conclusions

Climate change is a current, highly complex problem that affects the planet globally. However, despite the globality of the effects, they are not felt homogeneously throughout the territories and may interfere differently with communities that, despite being geographically close, can feel the effects of climate change in an entirely different way. This finding requires us to consider that the measures to be implemented to adapt to climate change are designed considering the specificities of the territory, as well as a deep knowledge of the current state of the local climate and its evolution over time, making it possible to compare the current state of the climate change scenario with a prior period of supposed climatic normality. In the present study, the municipality of Guimarães, located in the region of Entre Douro e Minho in the north of Portugal, was used as an example. From the survey carried out among the population, it was found that all respondents are of the opinion that climate change can affect geographically close communities in different ways. From the analysis of the climatic variables, it was found that the local climate changed, with the increase in air temperature in the colder months and significant changes in the precipitation cycle. These situations are responsible for the occurrence of negative impacts, namely, the recurrence of periods of drought, followed by periods of intense precipitation that can cause floods, along with an increase in the recurrence of rural fires. These situations justify the definition of measures of a local scope, planned explicitly for the territory in question and adjusted to the real needs of the populations.

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