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GREEN URBAN AREAS WITHIN THE STRATEGIES ABOUT CLIMATE CHANGE: A PRELIMINARY APPROACH FOR LAS PALMAS DE GRAN CANARIA, SPAIN

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Green Urban Areas within Climate Change Strategies: A Preliminary Approach for Las Palmas de Gran Canaria, Spain

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LIST OF ABREVIATIONS

AAP: Adverse Atmospheric Phenomena.
AEMET: Agencia Estatal de Meteorología.
BVOCs: Biogenic Volatile Compounds.
CO_2: Carbon Dioxide.
$CO_{2\text{-eq}}$: CO_2 equivalent.
GHG: Greenhouse Gases.

GIS: Geographic Information System.
GWP: Global Warming Potential.
T_{Max}: Maximum temperature.
T_{Min}: Minimum temperature.
T_{Ave}: Average temperature.

ABSTRACT

Climate change is the most important challenge for our society. It is a major drawback and its impacts are affecting all regions of the planet, especially islands. Accordingly, there are a lot of top-down approaches via global agreements, protocols and strategies. However, the bottom-up approach, where the society is involved, needs more attention, and it is where the urban areas are fundamental. It becomes relevant taking into account that societies are mainly concentrated in urban areas where both mitigation and adaptation should be developed.

The temperature of the cities, as in other parts of the Earth, is increasing due to the Green House Gas emissions (GHG). In addition, urban areas are also affected by other factor that increases the temperature such as the heat islands phenomenon, due to the human activities and urban infrastructures. The GHG emissions in Canary Islands, as total CO_2 emissions, increased until 2005, reaching 24,609.9 Gg $CO_{2\text{-eq}}$. From 2005 to 2014 these total emissions decreased until 16,230.8 Gg $CO_{2\text{-eq}}$. Temperature, measured in the meteorological station located at the Gran Canaria airport, increased since 1951, especially the evolution of minimum temperature where the dependence on time was higher than that for the maximum temperature evolution. Accordingly, in a century the maximum temperature would increase close 1.8ºC, while the minimum temperature would be 3.7ºC higher than the current records.

Among all the possible actions in terms of climate change, green urban areas are effective to ameliorate the impact of the increasing temperature and, at the same time, can be considered as a social tool for a new lifestyle. However, there is not a long-term strategy at the capital of Gran Canaria, which is actually the more inhabited city in the Canary Islands. Then, in the case of Las Palmas de Gran Canaria, the green urban areas could be implemented overall by 51,651.9 m^2 (in different areas), 7,769.3 m (generally in line roads). Eventually, there is a strong social support for the implementation of green areas in Las Palmas de Gran Canaria, as it was proved in a survey.

1. INTRODUCTION

Earth climate is suffering the impact of the human activities, clearly demonstrated by the international community and, as a result, climate is changing the nature and our lifestyles [1, 2]. Consequently, Climate Change and the derived Global Warming is under permanent discussion by the international community in order to improve the impact on human security, the economy and the sustainability, as for example it has been held on the Paris Agreement (COP21, 2015).

It is already known that the reduction of the climate change impacts should be addressed in terms of mitigation and adaptation. In fact, the combination of both will always produce better results [1, 2]. One of the main problems to define strategies for mitigation and adaptation is its proper definition itself. Accordingly, climate change was defined by the United Nations Framework Convention on Climate Change in 1992 as *the alteration of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which adds to natural climate variability observed over comparable periods of time* [3]. Countries are continuously negotiating the political scenarios to decide global actions (top-down approach). An example is the Paris Climate Conference (COP21, 2015), that establishes a global action agreement where participating countries have to mitigate and to limit, among other things, GHG emissions to avoid the increasing of the average temperature in 2ºC above pre-industrial levels [4]. However, the risk of climate-related impacts derives from the interaction of climate hazards with the vulnerability and exposure of both natural and human systems [1, 2]. All our actions will ameliorate the impacts; but adaption is strictly urgent. Changes in the climate system and socio-economic processes, including adaptation and mitigation, have been shown to be drivers of hazards, exposure and vulnerability [1, 2]. Despite these global possible actions, the locality or municipality become more important due to the relevance of adaptation and the implication of the society (bottom-up approach).

Climate change sets out many present and future risk that are fundamental due to the high hazard levels and vulnerability of society and exposed systems [1, 2]. Answering to these risks implies making decisions with constant uncertainty and limits on adaptations [1, 2]. These risks become relevant in urban areas where human overpopulation has been increasing for years. It is in these areas where the impact of Adverse Atmospheric Phenomena (AAP), such as extreme rainfall and dust storm (*calima*) [5, 6], or the impact of the sea level rise and increasing temperatures, requires more attentions and specific solutions.

In addition to the increasing temperature by the climate change, the heat islands phenomenon should also be considered due to its relationship with the human activity and city features [7, 8]. Generally, higher temperatures in cities are achieved from the heat emitted by urban structures where there is an excessive storage of solar radiation. It needs to be considered the lack of green urban areas, of cool sinks, and of air circulation, as well as the reduced capacity of the infrared radiation emitted to escape into the atmosphere [9]. Obviously, higher temperatures in urban areas also increase energy consumption for cooling and raise peak electricity demand [8, 10-14], making difficult any mitigation strategy.

One of the most effective strategies for climate change mitigation, and also important in terms of adaptation, is tree restoration, as photosynthetic carbon sequestration is among the most effective in limiting the increase of carbon dioxide (CO_2) concentrations [15]. Plants and trees also provide environmental and social benefits such as improving public life in cities, contributing to the beauty of the landscape, controlling soil erosion [13], mitigating warming [16, 17], filtering polluting air [18, 19], etc. However, misuse or poor planning of vegetation in cities can be harmful, as many of them emit biogenic volatile compounds (BVOCs) that react with nitrogen and sulphur oxides [20, 21] causing an undesirable effect on air quality and thus harming human health [22-24]. In Spain there is not a specific law on green urban areas: nevertheless, in Las Palmas de Gran Canaria, there is a Municipal Building Ordinance where at least 60% of the surface must be destined to the plantation of vegetable species [25]. However, within the context of climate change and global warming, these species should be properly planned to attend these critical aspects.

This work is a preliminary study to implement the green urban areas and their possible use in the external and internal zones of the city of Las Palmas de Gran Canaria, as a part of the local strategy on climate change mitigation and adaptation in the city. To this end, we studied the regional GHG emissions and the evolution of temperature at different locations of the city. Then, the urban distribution of possible green urban areas was analysed as well as the support of the local population.

2. METHODOLOGY

2.1 CASE STUDY

The current study will be focused on Las Palmas de Gran Canaria (Figure 1), capital of Gran Canaria island (Canary Islands).

The Canary Islands are composed of eight main islands (Gran Canaria, Lanzarote, Fuerteventura, Tenerife, La Gomera, El Hierro, La Palma and La Graciosa). These islands of volcanic origin[1] are located in the eastern Atlantic Ocean, close to southern Morocco

[1] http://elcanario.net/Articulos/macaronesiafgtc.htm

and northern western Sahara (northwest Africa). The archipelago has a total area of 7,447 km^2 and 1,545 km of coastal perimeter [26]. These islands are highly dependent of the tourism, being one of the main tourist destinations in Spain, and representing more than 16.1 million euros per year (35% of the islands' GDP and 40% of employment [27])

The population of the Canary Islands is unevenly distributed: 83% of the 2.1 million inhabitants is concentrated on two islands (Gran Canaria and Tenerife) [26].

Figure 1: Map of the Canary Islands (left) and Gran Canaria (right) [Google Earth]

The capital of Gran Canaria, Las Palmas de Gran Canaria, is the most populated municipality in the archipelago with approximately 851,231 inhabitants[2].

2.2 SOURCE OF DATA

This study used different type of data in order to know the regional scenario in terms of GHG emissions, temperature evolution, urban distribution and, at the end, local support to the green urban areas via social participation. For that, GHG emissions were obtained from the last Official Report of Energy published by the regional government [28]. Temperature was collected from the public database of Agencia Estatal de Meteorología (AEMET[3]). These data corresponded with three stations located in the Airport of Gran Canaria (control station; outside the city), San Cristóbal (coastal station; in the city), Plaza de la Feria (urban station in the city). Urban distribution and potential zones to implement the green urban areas in the city were studied via Geographic Information System (GIS) and ortophotos from regional tools (GRAFCAN[4]).

A public survey was carried out in order to know the interest and supporting of the local population to increase the green urban areas in Las Palmas de Gran Canaria. In this sense, the survey was divided into three sections. The first part deals with the

[2] http://www.gobiernodecanarias.org/istac/jaxi-istac/tabla.do
[3] https://opendata.aemet.es/centrodedescargas/productosAEMET?
[4] https://visor.grafcan.es/visorweb/

characterization of the participants who made the survey (gender, age, educational level, location and visit to the city). The second section deals with the participant's degree of knowledge in terms of climate change and its effects. And the third section deals with the initiative to increase urban green spaces in the city as a strategy to fight climate change.

3. RESULTS AND DISCUSSION

In order to understand the necessity of green urban areas in Las Palmas de Gran Canaria, we need to know the regional context of the CO_2 emissions, as well as the local scenarios in terms of temperature evolution and the available areas within the city to be potentially used as green urban areas. Eventually, it is presented a tentative proposal, as the current one should also consider the social support via participation.

3.1 GHG EMISSIONS IN CANARY ISLANDS

The GHG emissions are commonly representing as CO_2 or $CO_{2\text{-eq}}$ (CO_2 equivalent) due to its concentration in the atmosphere [29]. $CO_{2\text{-eq}}$ can be defined as *a metric measure used to compare the emissions from various GHG on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential*[5].

Total emissions in Canary Islands, in terms of $CO_{2\text{-eq}}$ (Gg $CO_{2\text{-eq}}$), have been measured since 1995 (Figure 2) and periodically published by the regional government by using the same sectors as the Intergovernmental Panel on Climate Change (IPPC) guidelines and EMEP/CORINAIR[6]. These sectors included deposits of waste in landfill, energy processing, transport, agriculture and the sum of all of these (process). According to Figure 2, the total CO_2 emissions increased until 2005, reaching 24,609.9 Gg $CO_{2\text{-eq}}$. From 2005 to 2014 these total emissions decreased until 16,230.8 Gg $CO_{2\text{-eq}}$. This decrease was 8.4% as compared 2005, but it was still 2.3% higher than in 1995. The total emissions have been increasing from 2014 to 2017, reaching 18,474.8 Gg $CO_{2\text{-eq}}$, which represents 2.2% since 2014 and 4.6% compared to 1995.

[5] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Carbon_dioxide_equivalent
[6] https://www.emep.int/ ; http://www.air.sk/en/corinair.php

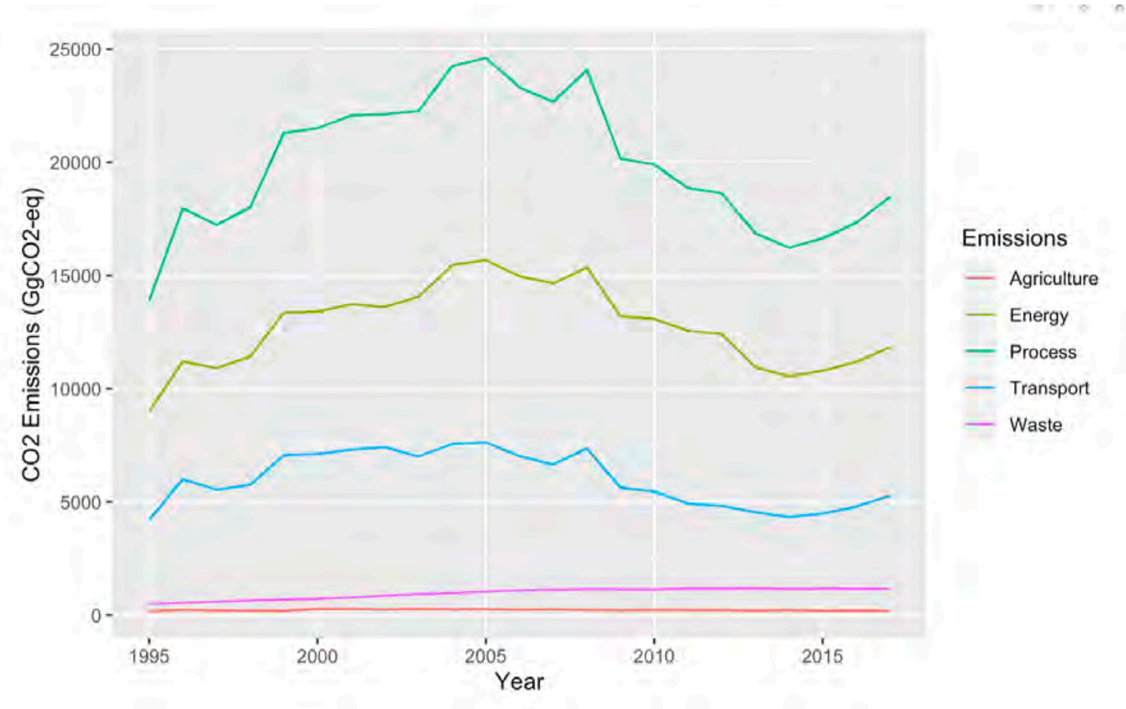

Figure 2: GHG emission (represented as CO_2-eq emissions) in Canary Islands by sectors: waste of landfill, energy processing, transport, agriculture and process from 1995 to 2017. Process is the sum of emission from each sector.

Figure 2 clearly reflects that energy processing is the most significant sector in terms of CO_2 emissions, contributing almost 64% of total average emissions, followed by transport with approximately 29%. If we consider both sectors as a source of energy, they are the responsible of more than 93%. The treatment and disposal of waste in landfill emitted close to 6.3% in 2017. It means that this sector increased its CO_2 emissions in 6.5% as compared to 1995. Agriculture is representing approximately 1.03% of the total average emissions, in relation to the total GHG emissions in the Canary Islands.

Total GHG emissions in Spain (2017) were 340,231 Gg $CO_{2\text{-eq}}$ [30], where the most influential sector was transport (26%), followed by electricity generation (21%), industrial activities (19%) and agriculture (10%) [30]. Then, Canary Islands contribute to the Spanish emissions by 5.43%.

The total GHG emissions in the European Union (EU) have also been reported [31], where there were $4.323 \cdot 10^6$ Gg $CO_{2\text{-eq}}$ in 2017. According to their contribution levels, Germany presented the higher emissions (906,611 Gg $CO_{2\text{-eq}}$), followed by the United Kingdom (470,509 Gg $CO_{2\text{-eq}}$) and France (464,593 Gg $CO_{2\text{-eq}}$). Generally, energy processing was the most influential sector (80.70%) [31]. Spain was ranked in the sixth position by the total GHG emissions in the EU, with a contribution of 7.88%. If we compare the emissions of the Canary Islands to the EU, the archipelago's emissions represent approximately 0.43%. However, the largest GHG emitter on the planet is China with $13 \cdot 10^6$ Gg CO_{2-eq}, (27%), followed by the United States with $6.4 \cdot 10^6$ Gg CO_{2-eq} (13%), and then the EU (7%) [31].

These GHG emissions clearly reflect that the role of the Canary Islands in terms of mitigation can only attend the CO_{2-eq} that is emitted, being the adaptation the big deal in the region.

3.2 TEMPERATURE EVOLUTION

Figures 3-5 showed the temperature evolution in the three studied stations: Airport of Gran Canaria, San Cristóbal and Plaza de La Feria, respectively. The maximum, minimum and average temperature was plotted.

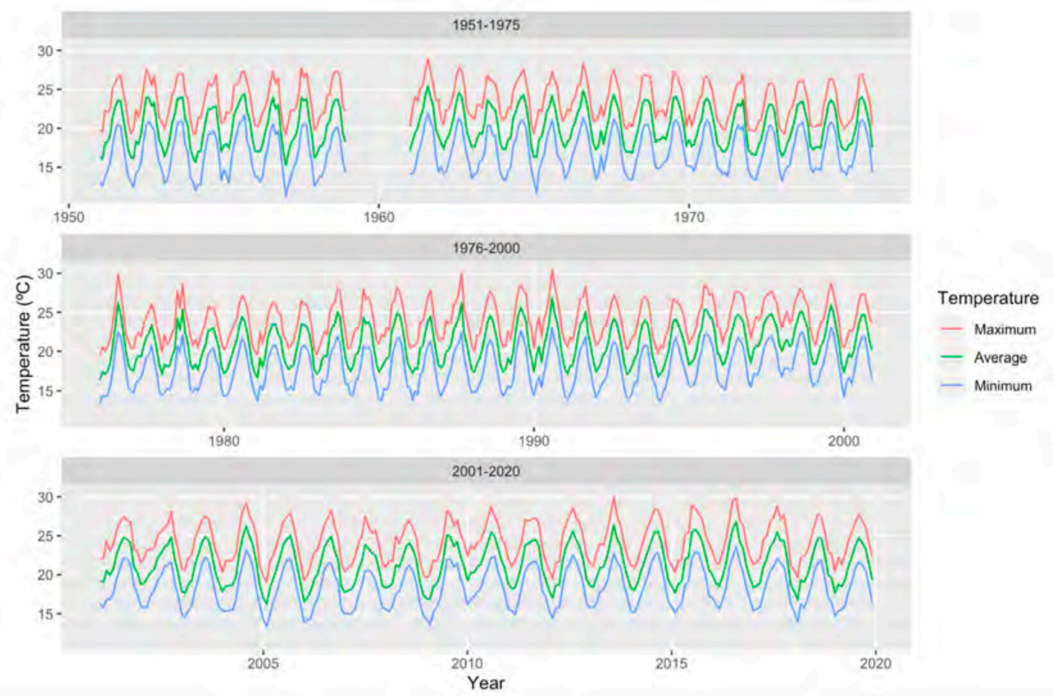

Figure 3:Temperature evolution (ºC) in the meteorological station located at the airport in Gran Canaria from 1951 to 2020. It is divided into three fractions: 1951-1975 (upper panel), 1976- 2000 (middle panel) and 2001-2020 (lower panel). Temperature has been computed and represented as the average per month.

Figure 3 has been divided into three panels only to have better resolution. Figure SM-1 contained the bulk temperature data. These data have been lineally adjusted, by considering the whole data set (Figure SM-2), and the equations demonstrated that the T_{Min} has a higher annually increasing, compared to the average and maximum temperature (Equations 1-3).

$$T_{Max} = 23.61 + 5.249 \cdot 10^{-5} \cdot \text{Time (Month)} \quad (1)$$

T_{Ave}= 20.37 + 7.233• 10^{-5} • Time (Month) (2)

T_{Min}= 17.13 + 9.219• 10^{-5} • Time (Month) (3)

The temperature presented maximum values in 1990, 1987 and 2013 with approximately 30.6ºC and 30.0ºC, respectively (Figure 3). In addition, the station registered minimum values in 1957 and 1965 with 11.3ºC and 11.7ºC, respectively. By the end of the century (2100), the temperature would increase between 17.21 – 23.7ºC (T_{Min} and T_{Max}, respectively). The minimum temperature would increase by 6ºC in 143 years. This temperature increase, taking into account constant growth, can be seen in Figures SM-3 – SM-5 although it may not be correct because global warming processing varies over time.

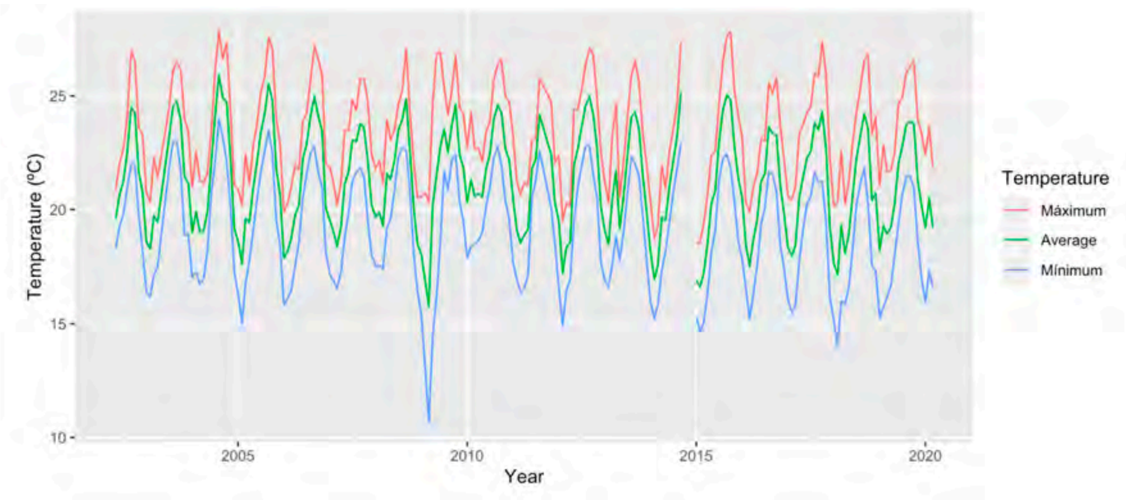

Figure 4: Temperature evolution (ºC) in the meteorological station located in San Cristóbal from 2002 to 2020. Temperature has been computed and represented as the average per month.

At the station of San Cristóbal (Figure 4), temperature presented maximum values in 2004 and 2015 with values of 27.9ºC and 27.8ºC respectively, with a pronounced minimum value in 2009 of 10.7ºC. The bulk temperature data has been plotted in Figure SM-6 in order to compute the linear trend (Equations 4-6).

T_{Max}= 23.82 – 2.649•10^{-5} • Time (Month) (4)

T_{Med}= 22,98 – 1.167•10^{-4} • Time (Month) (5)

T_{Min}= 22.11 – 2.057 •10^{-4} • Time (Month) (6)

Similar to the airport station (Figure 3), the coastal station (Figure 4) presented a higher slope for the minimum temperature (Equation 6) compared to the maximum temperature and average values (Equations 4-5). Here, all equations presented negative slopes likely due to the role of the ocean as temperature regulator. By using these equations, in 2100, temperature could reach 21.91-23.8ºC (T_{Min} and T_{Max}, respectively). To be rigorous and to compare both stations, they have been considered in the same time frame. Then, the slopes at the airport stations would be $1.014 \cdot 10^{-4}$, $1.011 \cdot 10^{-4}$ and $9.982 \cdot 10^{-5}$, for T_{Max}, T_{Ave} and T_{Min}, respectively, which are still much pronounced compared to the coastal data. This prediction can be appreciated in Figures SM-7 - SM-9, although the values may change over time due to temperature changes.

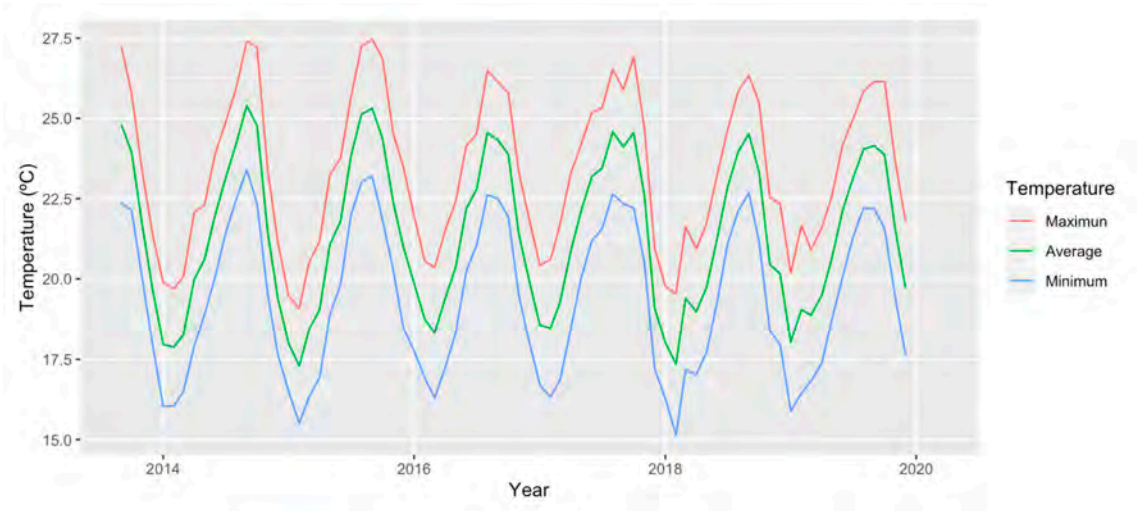

Figure 5: Temperature evolution (ºC) in the meteorological station located in Plaza de la Feria from 2013 to 2020. Temperature has been plotted as the average per month.

At the Plaza de la Feria station (Figure 5), the temperature presented maximum values of 27.5ºC for both 2014 and 2015 respectively, and minimum values of 15.5ºC and 15.14 ºC in 2015 and 2018. All the recorded data have been represented in Figure SM-4 to calculate the linear trend (Equations 7-9).

$$T_{Max} = 22.83 + 0.0113 \cdot \text{Time (Month)} \quad (7)$$
$$T_{Ave} = 20.99 + 0.0072 \cdot \text{Time (Month)} \quad (8)$$
$$T_{Min} = 18.99 + 0.0069 \cdot \text{Time (Month)} \quad (9)$$

It is important to remark that this station is very short and still not enough to have a solid trend in terms of climate change. However, these data would predict a temperature range between 33.7 ºC and 25.6ºC (T_{Max} and T_{Min} respectively) for 2100. In addition, this temperature evolution can be observed in Figures SM-11-SM-13.

Temperature at different stations located in Gran Canaria have been previously studied [32] but considering the average of annual temperature values for each station. On the one hand, it was concluded that the minimum temperatures showed a higher increased than the maximum temperatures in all the studied stations (airport, Puerto de Las Palmas de Gran Canaria and Valleseco). These authors [32] showed negative trends for the maximum temperature. In this current manuscript, we considered the same month at the beginning and at the end of the time series to be statistically coherent. In addition, other investigation [33] studied the average monthly temperatures in Gran Canaria at 26 stations on the island, of which only 11 were chosen and grouped with similar orientation and altitude, between 1946 and 2010. The results were that both maximum and minimum temperatures have a similar increase to the rest of the world, although the maximums with an increase of (0.06˚C ± 0.06˚C/decade), and the minimums of (0.12˚C ± 0.07˚C per decade).

In the same way, there are evidences about how climate change is influencing the increase in temperatures [34], especially in the Canary Islands, concluding that there are greater increases in the minimum values than in the maximum ones. These increases were more accentuated in the 70´s and 80´s with an average global increase of 0.27ºC between 1981 and 2010.

The current results demonstrated the importance of the temperature evolution in Las Palmas de Gran Canaria and its forecast. Then, it also makes evident the needs of local actions to reduce the impact of temperature in our lifestyles.

3.3 URBAN EVALUATION AND TENTATIVE GREEEN URBAN AREA

Among all the possible areas within Las Palmas de Gran Canaria, eight regions have been selected: San Telmo, El Teatro, Hospital Militar, Avenida Marítima, Las Canteras, San Cristóbal, La Minilla and Las Torres (Figure 6). These areas considered three different conditions in the city: coastal scenery, urban scenery and industrial scenery. Therefore, these eight areas have been divided into three zones because of their similar characteristics: the lower zones included San Telmo, El Teatro, Avenida Marítima and San Cristóbal; the upper zones included La Minilla, the Hospital Militar and Las Torres, and the coastal zone is, above all, Las Canteras.

Figure 6: Potential zones to increase the green urban areas in Las Palmas de Gran Canaria. It has been divided in three zones: coastal areas in green (Las Canteras), lower area in blues (Avenida Marítima, San Telmo, El teatro and San Cristóbal) and upper areas in yellow (La Minilla, Las Torres and Hospital Militar)

Lower areas are characterized by the vast influence of traffic and by the dense transit of persons. These areas are the key within the city because they could have a significant impact on the urban green areas due to their potential uses and available surface area. Figure SM-14_SM-17 showed the whole selected areas. At the moment, there are abundant grass in that area, but they are not exploited as true urban green areas and limit the potential of the city as CO_2 sink and temperature regulation, which leads to more pollution.

In detail, the available areas of San Telmo measured a total of 5,005.9 m^2, in El Teatro they measured 4,247.2 m^2 and in San Cristóbal they measured 41,724.9 m^2. Then, in the lower locations, there are at least 50,978 m^2 available for tree or plant restoration. These areas could be used as an advantage for the society's lifestyles, such as source of shadow, or recreational and leisure areas. In addition, the Avenida Marítima has 3,407 m in length crossing the whole city, where no trees are planted.

Upper areas (Figure SM-18 – SM-20) are characterized, above all, by the lack of green areas, the density of urbanizations and the influence of some industries. These zones can be strategical due to its potential in adaptation, in order to compensate the GHG emissions by the industries, to slow down run-off, to secure the land, to facilitate infiltration and to protect the soil [35]. The areas of roads, some slopes and private plots, could be adequate due to the real difficult to arrange them for construction. According to these areas (Figure SM-9 – SM-11), there are 767 m around the Hospital Militar, and other 413.3 m around La Minilla. Las Torres presented the availability of 679.9 m^2. In total, the upper region of the city has an area of 679.9 m^2 and 1180.3 m in the road sites.

The coastal area, Las Canteras (Figure SM-21), is characterized by the influence of the sea, humidity and wind, and the poor adaptation of the plants. This area may be a reference as recreational zone for the high density of people living in the city and to buffer the temperature trend [35]. There are 3,182 m from one end to the other (Figure SM-21) that could be used.

Green urban areas are a great environmental, social and economic benefit. The green urban areas have been studied in America for the reduction of CO_2 concentration, as well as the social, economic and environmental benefits of green urban areas such as pollution control, soil conservation, microclimate modifications (climate, temperature, wind) [36]. That study revealed that the proper election of trees can have good effects in terms of particle adsorption and air-quality. In addition, there are different local considerations that must to be considered to increase the green urban areas [37]. These authors reported a guide on the importance of green urban areas, and they presented how to choose different type of species for different types of soil by recommendations on the care of plant species. Here, it is always recommendable the use of native species among others, but this should be minutely studied by experts in botany.

3.4 PUBLIC PARTICIPATION

Once the necessity for increasing green urban areas has been analysed and discussed, it is also important to know the public perception. This current preliminary study would modify the aspects of the city as a part of a bottom-up approach for climate change. Then, these initiatives should be approved by the society. At the end, climate change adaptation has wide implications of socio-economic sectors. For that, a survey has been carried out in which 197 people participated (Figure SM-22_SM-24). The survey was divided into three blocks: the first was the characterization of the participants (Figure SM-22), where 52.8% of them were females and 47.2% were males. The sample was ranked between 18-30 years old (33%), 30-45 years old (23%) and 45-65 years old (39.6%). It is important to note that 44.7% of the participants had a bachelor's degree or engineering degree and 16.2% a master's degree. Then, the sample of participants had a considerable academic formation. In addition, among all the surveyed people, 52.8% were residents of Las Palmas de Gran Canaria and 47.8%, despite not living in the city, 58.4% go to the city for daily activities. Then, they have a good knowledge of the city and the different benefits that green urban areas could have compared to the actual conditions.

According to the results of the second block (Figure SM-23), 98% of participants confirmed to have knowledge of climate change and 78.7% believe it should be tackled with mitigation and adaptation measures in parallel. In addition, 74.1% believed that the impacts of climate change in Las Palmas de Gran Canaria are important while 25.9% thought they are moderate. Among the impacts, 95.4% of the participants believed that the increase in temperature is a major effect of climate change in the city, but only 46.2% know what the heat island effect is. Even so, 89.8% considered that cities should be rethought against climate change. In addition, 65% of the participants contemplated that Las Palmas de Gran Canaria is not adapted yet.

The third block (Figure SM-24) showed that 91.9% of participants considered that green areas are strategies against climate change, where 57.4% pondered green urban areas as an adaptation and mitigation strategy, 27.4% as mitigation, and 15.2% only as adaptation. It is important to remark that 88.8% of the sample did not think there are enough green spaces in the city, and 51.2% have an urban green space close to their residence in Las Palmas de Gran Canaria, although these spaces are not always a true green area, just small gardens or similar. Regarding the degree of satisfaction that participants have with the existing green urban areas in the city, only 7.1% have a high degree of satisfaction, the rest are medium (41.6%) or low (50%). It can justify that only 69% make use of green areas. In addition, 85.3% of participants thought that urban green areas would help to buffer the impact of climate change, 93.9% considered that would help absorb more CO_2. One of the main excuse to avoid the increasing green urban areas in cities is the lack of water. However, 83.8% of the participants contemplated that regenerated water should be used. Then, 97% believed that green urban areas would improve the quality of citizens live. So, it could be concluded that 97.5% would support the increase of green areas in the Las Palmas de Gran Canaria.

4. FUTURE RESEARCH

Once the necessity of increasing the green urban areas in La Palmas de Gran Canaria, within the context of mitigation and adaptation to the climate change, has been justified and studied, the future research should be addressed to fully identify the available sites in the rest of the city for a future extrapolation to the rest of the island.

On the other hand, an important study has to be developed with a multidisciplinary team about the decision of convenient plants and trees for each green zone. For that, in this current investigation is presented a tentative and preliminary list (Table 1) in accordance with the knowledge of some experts from the Canarian Botanic Garden.

Table 1: Preliminary list of plants to be considered for further studies in order to implement the green urban areas in Las Palmas de Gran Canaria

	Species
Tree	*Delonix regia*
	Tamarix canariensis
	Coccoloba uvifera
	Olea europaea
	Ceratonia siliqua
	Apollonias barbujana
	Dracaena draco
	Pinus canariensis
	Tipuana tipu
	Schinus molle
	Paulownia tomentosa
	Corymbia gummifera
Bush	*Pistacia lentiscus*
	Laurus novocanariensis
	Retama sp
	Bellis perennis
	Periploca laevigata

Another important aspect for future consideration is the increasing of surveyed people. The current situation, under the impact of the COVID-19 with a general lock-down decreed by the government, decreased the possibilities to have a good representative sample of population.

5. CONCLUSION

The Canary Islands, as archipelago and outermost region, is highly affected by the climate change. The greenhouse gas (GHG) emissions of the islands clearly demonstrated the link with the industry and, mostly, with the production of energy. The increase of GHG emissions in the recent years has been about 4.6% since 1995 where the greatest focus of pollution on the islands has been energy processing and transport. These GHG, in terms of global emissions, reflected that Canary Islands have an important role in mitigation but the adaptation is critical as it has a wide range of applications.

As mentioned above, the increase in GHG emissions leads to higher temperatures, especially in urban areas where the effect is greater. Therefore, according to the time series in Gran Canaria, in 100 year, the T_{Max} could increase 1.8ºC while the T_{Min} would be 3.3ºC higher. Hence the importance of green urban areas in the city to buffer these temperatures and thus tackle climate change. In this sense, green urban areas will ameliorate the temperature and the heat island effects. Las Palmas de Gran Canaria could use at least a total of 51,651.9 m^2 and 7,769.3 m for green urban areas in different scenarios within the city (lower, upper and coastal areas). To carry out important change in the city, the population has been consulted and 97.5% of the participants gave a positive answer about the increasing green urban areas. Eventually, if we are not able to achieve good results against climate change is because of our incapacity to develop local solutions.

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SUPPORTING MATERIAL

1. TEMPERATURE EVOLUTION

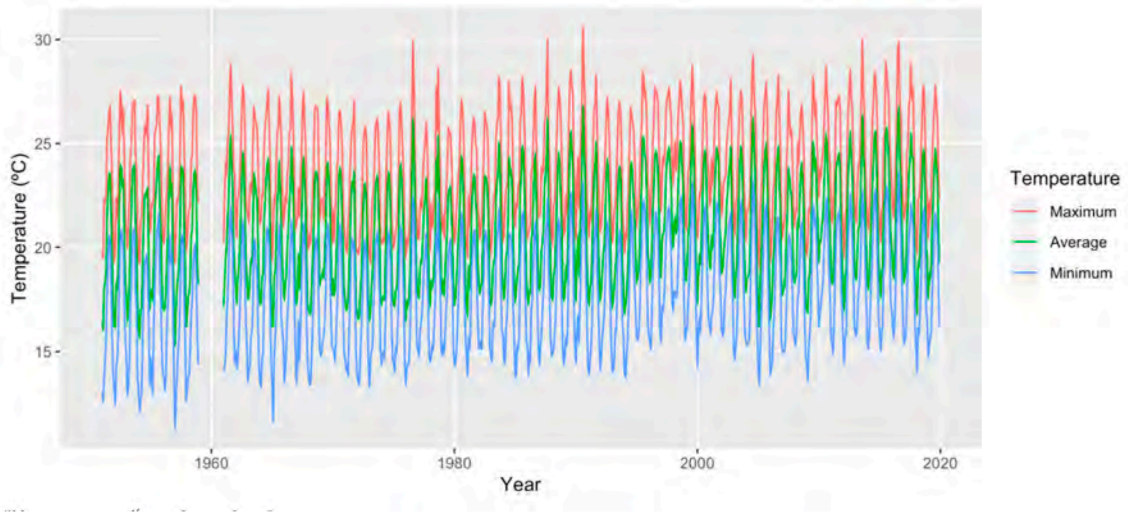

Figure SM-1: Temperature evolution (ºC) in the meteorological station of airport since 1951 and 2020. Temperature has been plotted as the average per month.

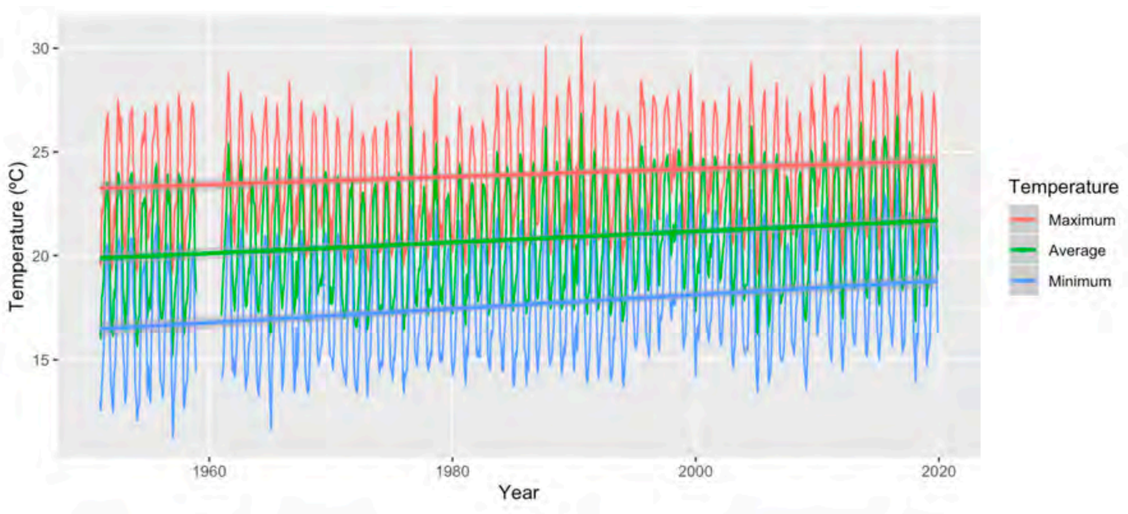

Figure SM-2: Temperature evolution (ºC) in the meteorological station of airport since 1951 and 2020 with regression lines. Temperature has been plotted as the average per month

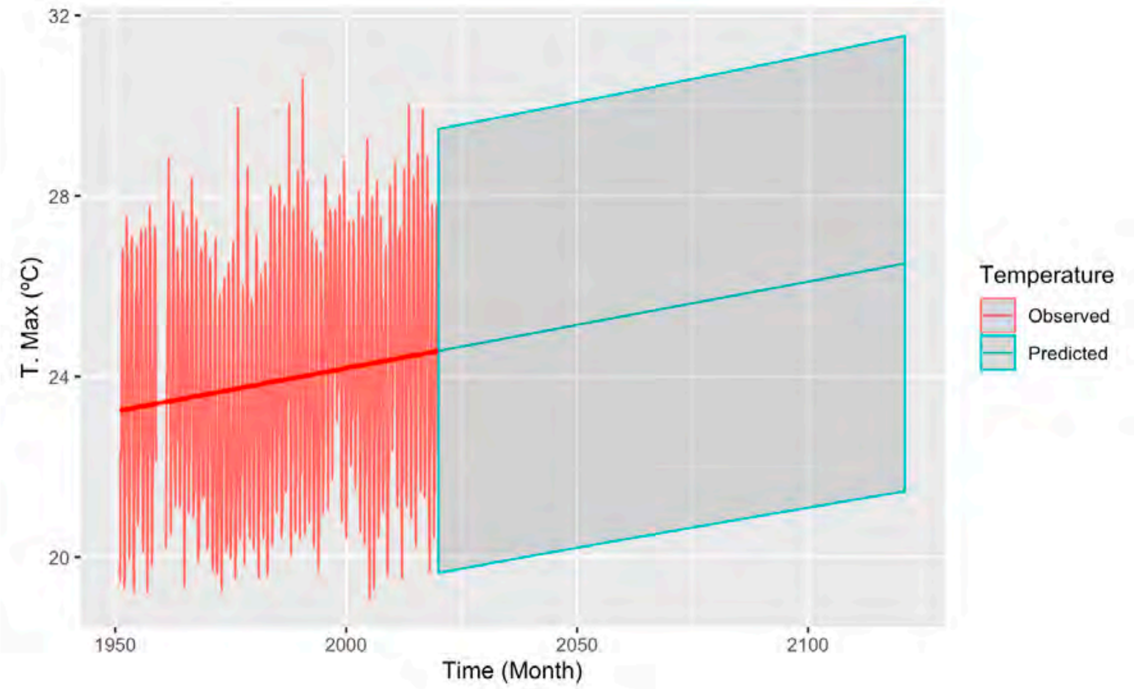

Figure SM-3: Prediction of Maximum Temperature (ºC) in the meteorological station of airport for 2100. Temperature has been plotted as the average per month

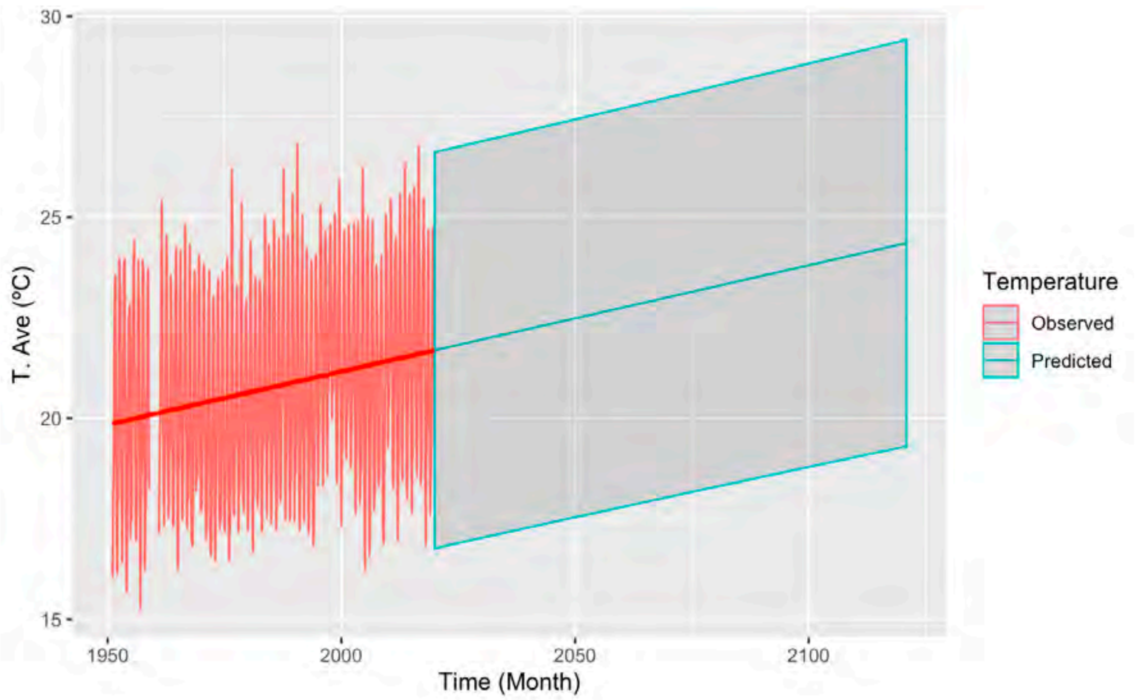

Figure SM-4: Prediction of Average Temperature (ºC) in the meteorological station of airport for 2100. Temperature has been plotted as the average per month

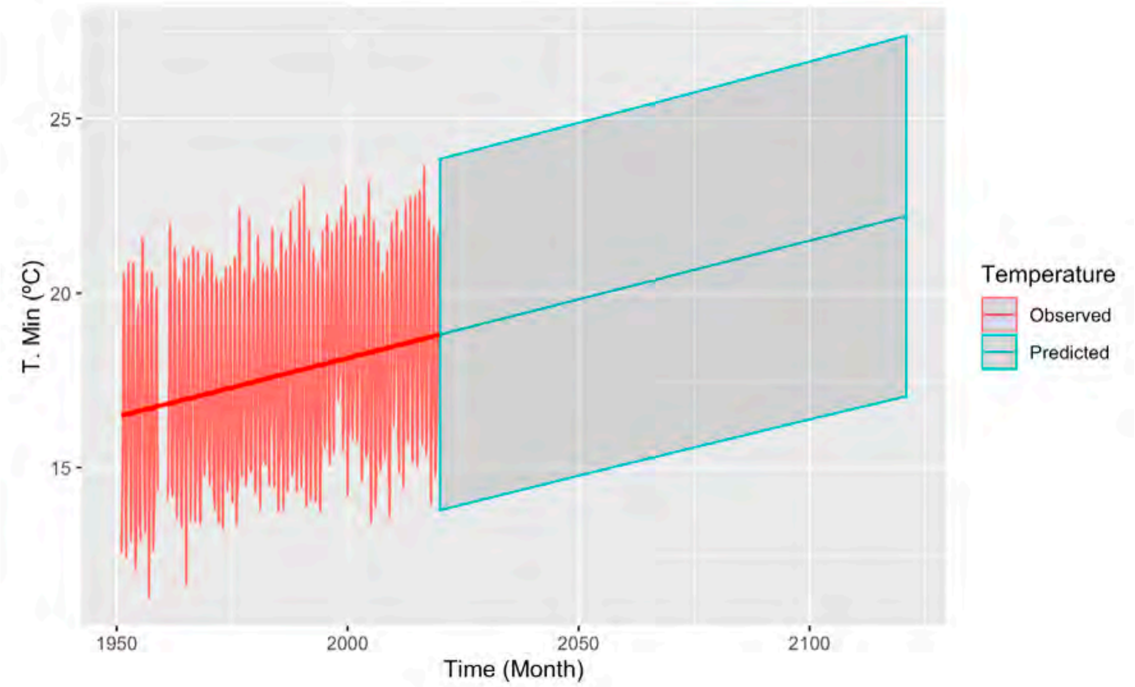

Figure SM-5: Prediction of Minimum Temperature (ºC) in the meteorological station of airport for 2100. Temperature has been plotted as the average per month

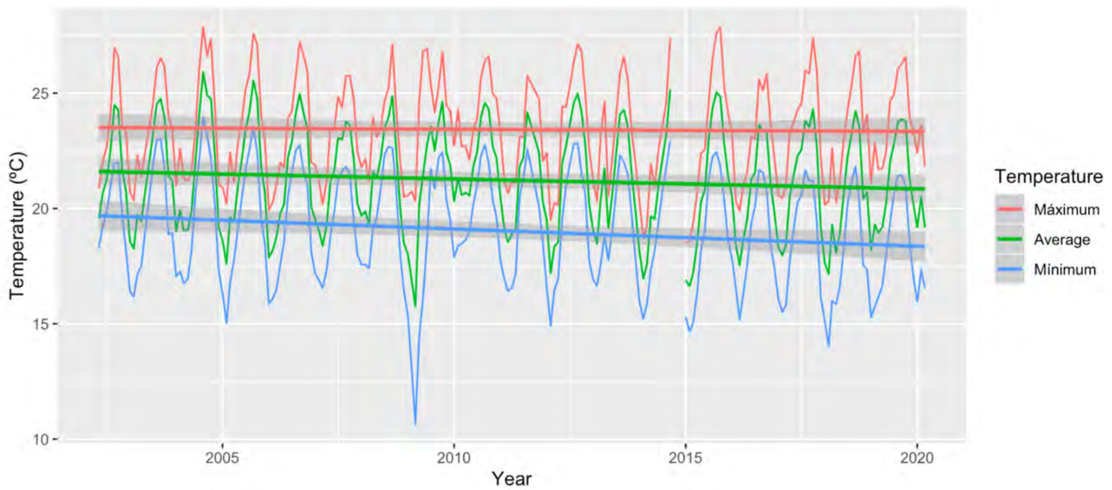

Figure SM-6: Temperature evolution (ºC) in the meteorological station of San Cristóbal since 2002 until 2020 with regression lines. Temperature has been plotted as the average per month.

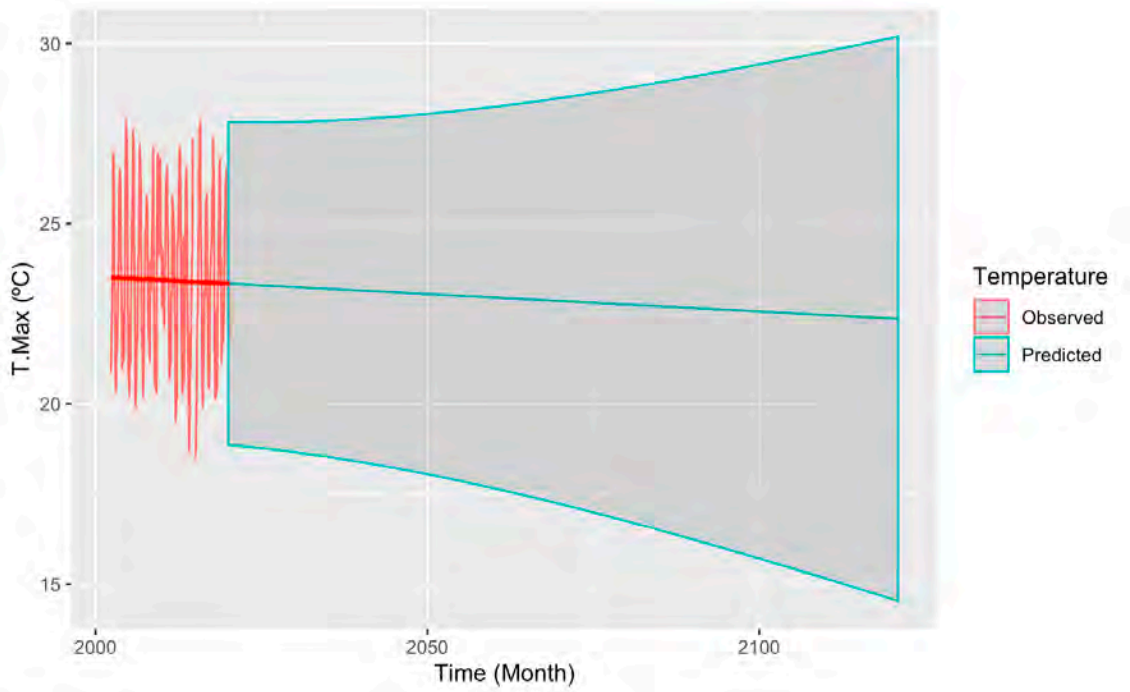

Figure SM-7: Prediction of Maximum Temperatures (ºC) in the meteorological station of San Cristóbal for 2100. Temperature has been plotted as the average per month

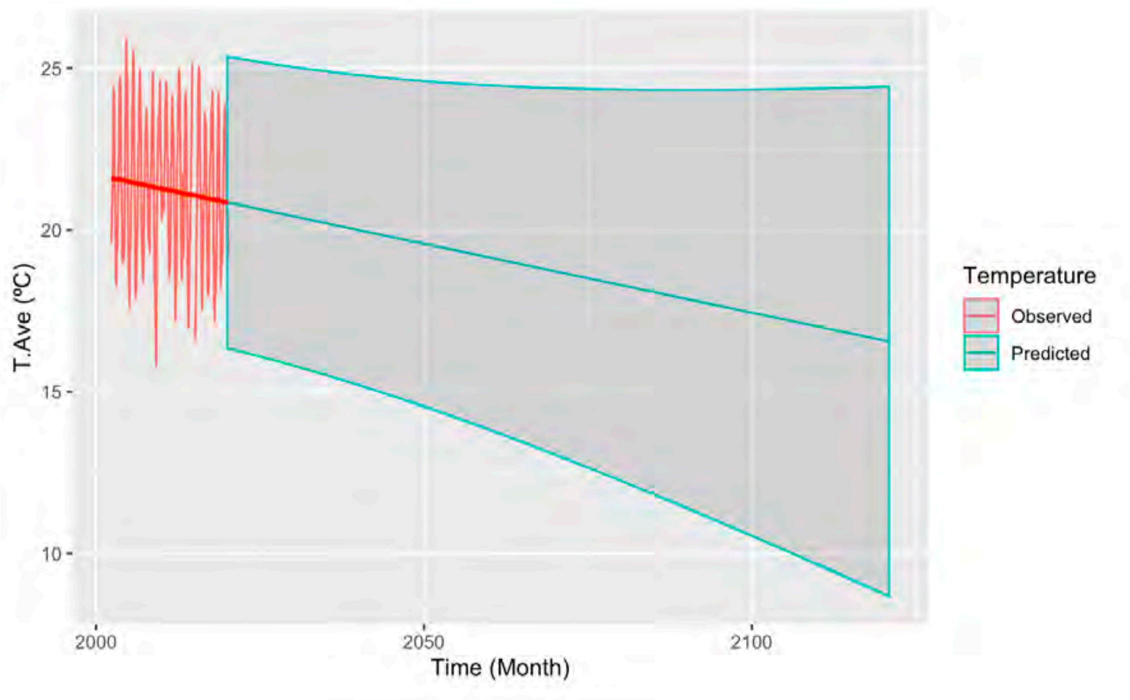

Figure SM-8: Prediction of Average Temperatures (ºC) in the meteorological station of San Cristóbal for 2100. Temperature has been plotted as the average per month.

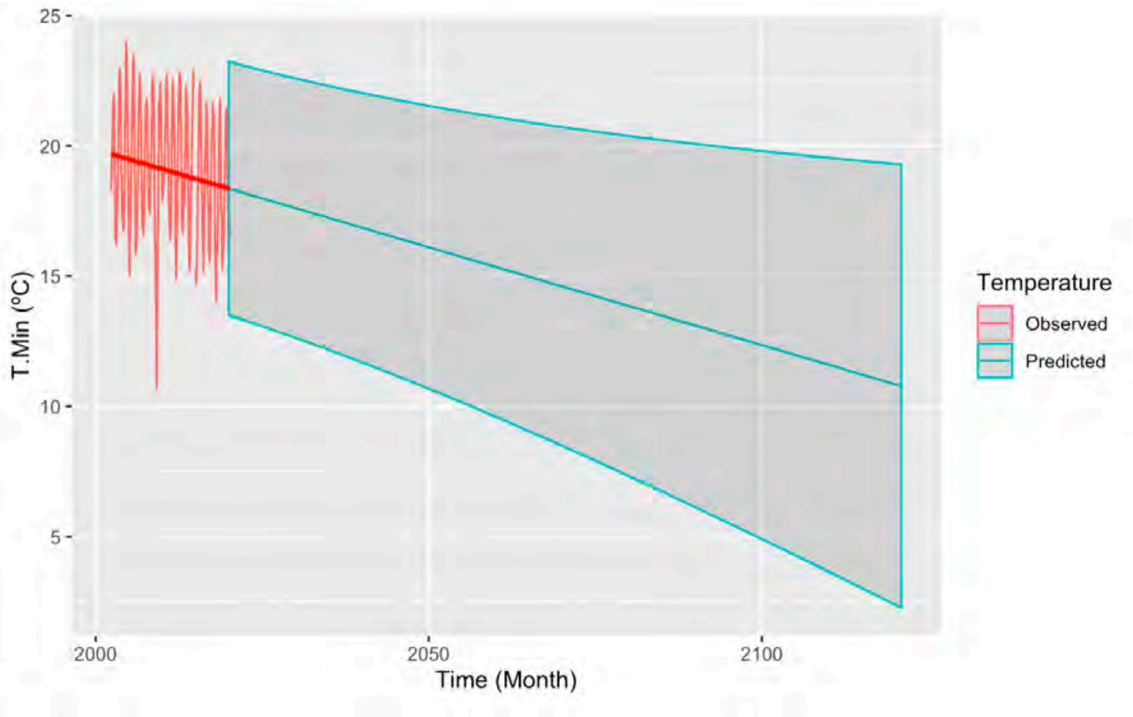

Figure SM-9: Prediction of Minimum Temperatures (ºC) in the meteorological station of San Cristóbal for 2100. Temperature has been plotted as the average per month

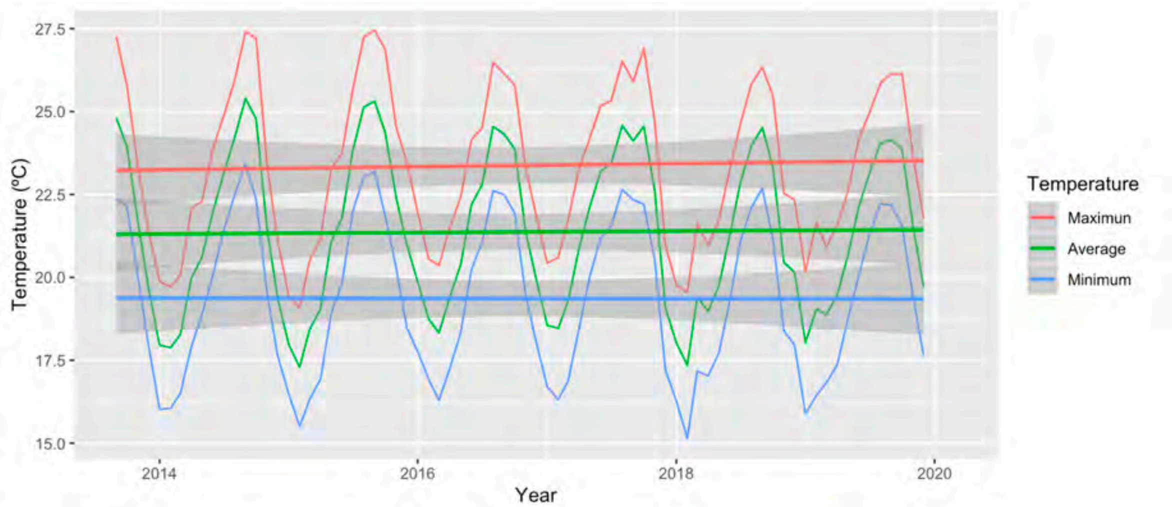

Figure SM-10: Temperature evolution (ºC) in the meteorological station of Plaza de la Feria since 2013 until 2020 with regression lines. Temperature has been plotted as the average per month.

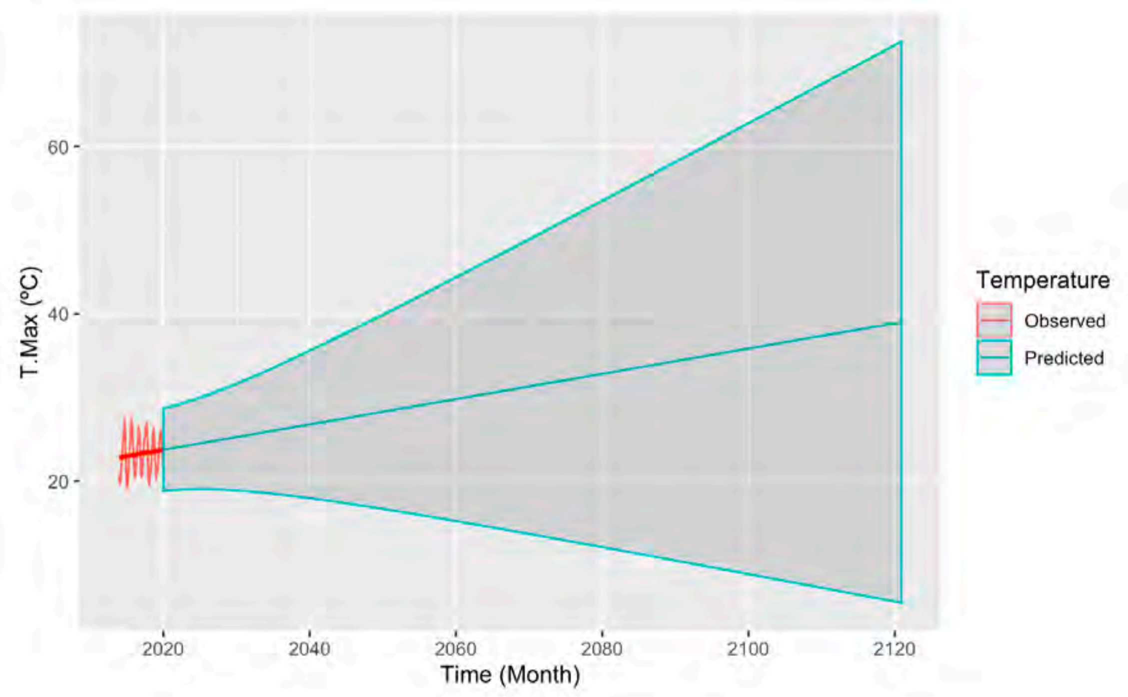

Figure SM-11: Prediction of Maximum Temperatures (ºC) in the meteorological station of Plaza de la Feria for 2100. Temperature has been plotted as the average per month

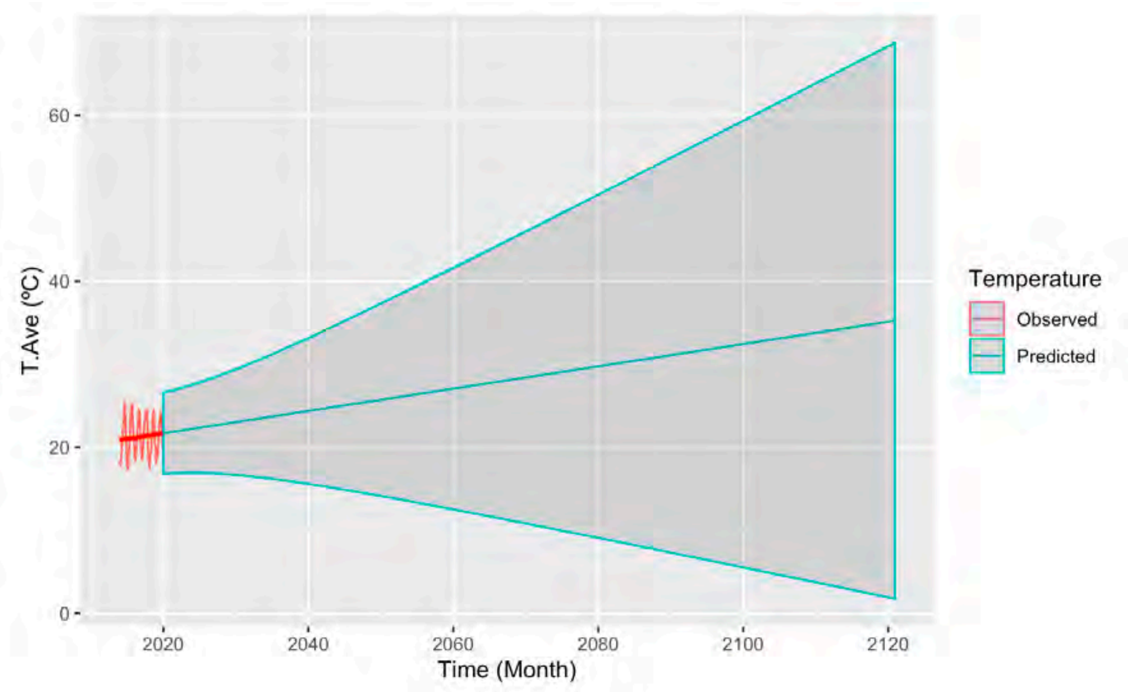

Figure SM-12: Prediction of Average Temperatures (ºC) in the meteorological station of Plaza de la Feria for 2100. Temperature has been plotted as the average per month

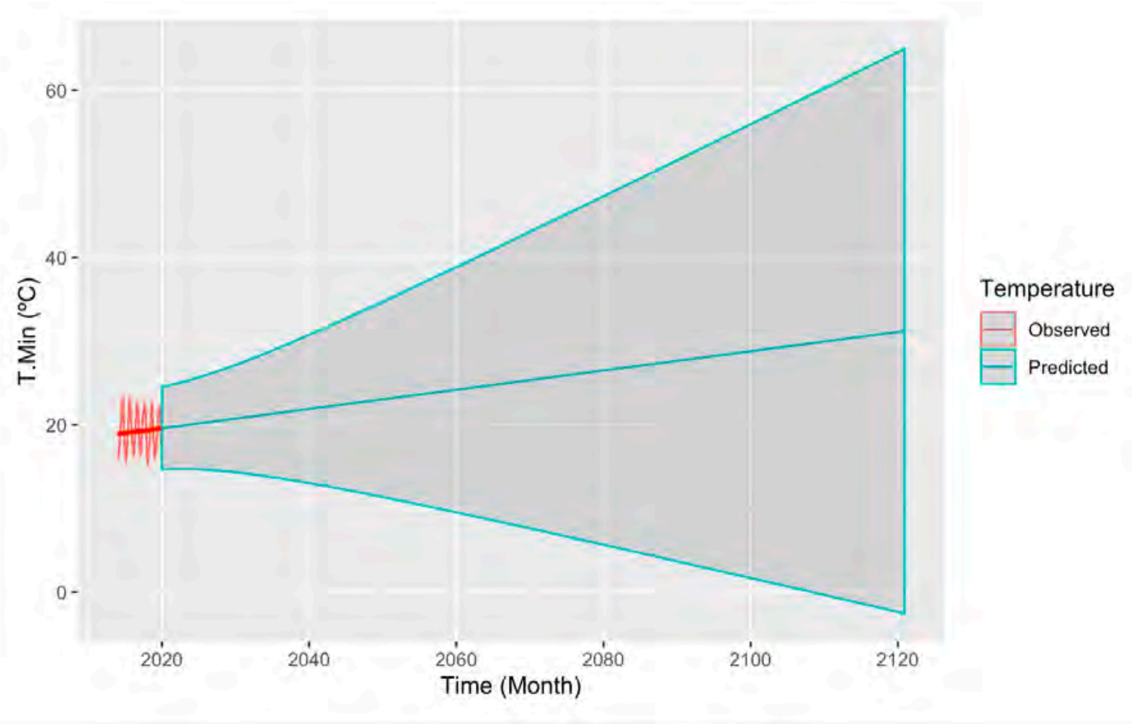

Figure SM-13: Prediction of Minimum Temperatures (ºC) in the meteorological station of Plaza de la Feria for 2100. Temperature has been plotted as the average per month

2. GREEN URBAN AREA

Figure SM-14: Edited orthophoto of San Telmo with an approx. scale 1:2,511. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [458,919.94-459,366.90], y= [3,109,306.55-3,109,306.55] and Geographic: [28º06'31.07-28º06'48.37"] N [15º25'05.62"-15º24'49.30"] W

Figure SM-15: El Teatro (edited orthophoto) with an aprox. scale 1:3,232. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [459,068.99-459,644.29], y= [3,108,406.83-3,109,090.06] and Geographic: [28º06'01.84-28º06'24.11"] N [15º25'00.04"-15º24'39.04"] W

Figure SM-16: San Cristobal (edited orthophoto) with an aprox. scale 1:6,125. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [458,859.97-459,950.22], y= [3,106,624.10-3,107,918.90] and Geographic: [28º05'03.89-28º05'24.11"] N [15º25'07.48"-15º24'27.69"] W.

Figure SM-17: Avenida Marítima (edited orthophoto) with an aprox. scale 1:30,091. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [454,454.54-459,810.73], y= [3,106,921.78-3,113,282.89] and Geographic: [28º05'13.04-28º08'40.38''] N [15º27'48.94''-15º24'33.46''] W

Figure SM-18: Hospital Militar (edited orthophoto) with an aprox. scale 1:7,162. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [457,984.50-459,259.34], y= [3,108,018.03-3,109,532.04] and Geographic: [28º05'49.09-28º06'38.43"] N [15º25'39.74"-15º24'53.21"] W

Figure SM-19: Las Torres (edited orthophoto) with an aprox. scale 1:2,268. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [455,907.90-456,311.61], y= [3,110,917.74-3,111,397.18] and Geographic: [28º07'23.08-28º07'38.70"] N [15º26'56.23"-15º26'41.49"] W

Figure SM-20: La Minilla (edited orthophoto) with an aprox. scale 1:4,610. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [456,615.87-457,436.45], y= [3,111,116.71-3,112,091.25] and Geographic: [28º07'29.63-28º08'01.39''] N [15º26'30.30''-15º26'00.35''] W

Figure SM-21: Las Canteras (edited orthophoto) with an aprox. scale 1:23,230. The UTM and geographic coordinates chosen for this scenario are: UTM: x= [454,398.07-458,533.01], y= [3,110,226.81-3,115,137.54] and Geographic: [28º07’00.44-28º09’40.51”] N [15º27’51.47”-15º25’20.54”] W

3. PUBLIC PARTICIPATION

A. Localization and characterization of people.

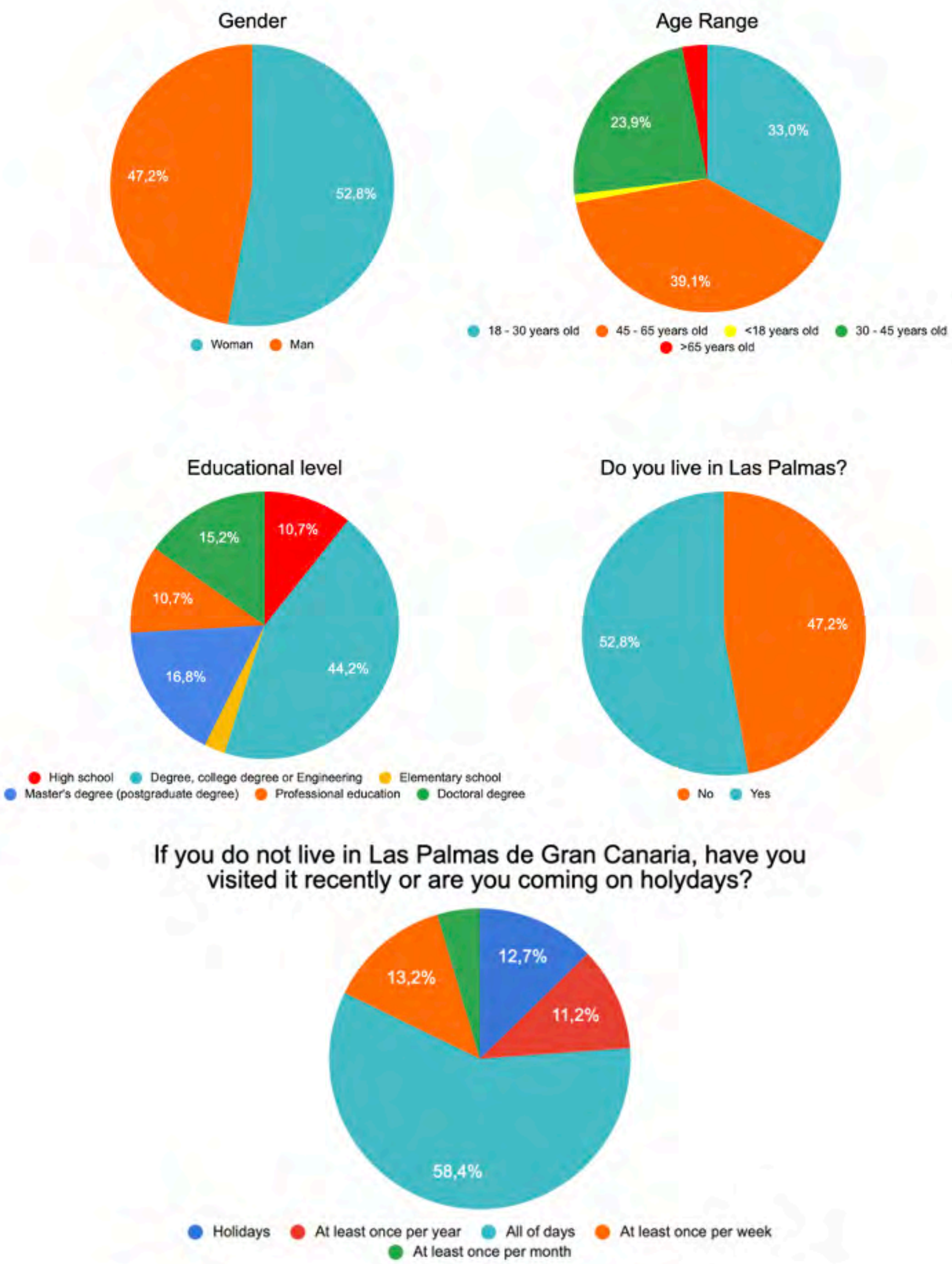

Figure SM-22: Answer on the first block of the survey. Localization and characterization of participants.

B. Climate change and effects.

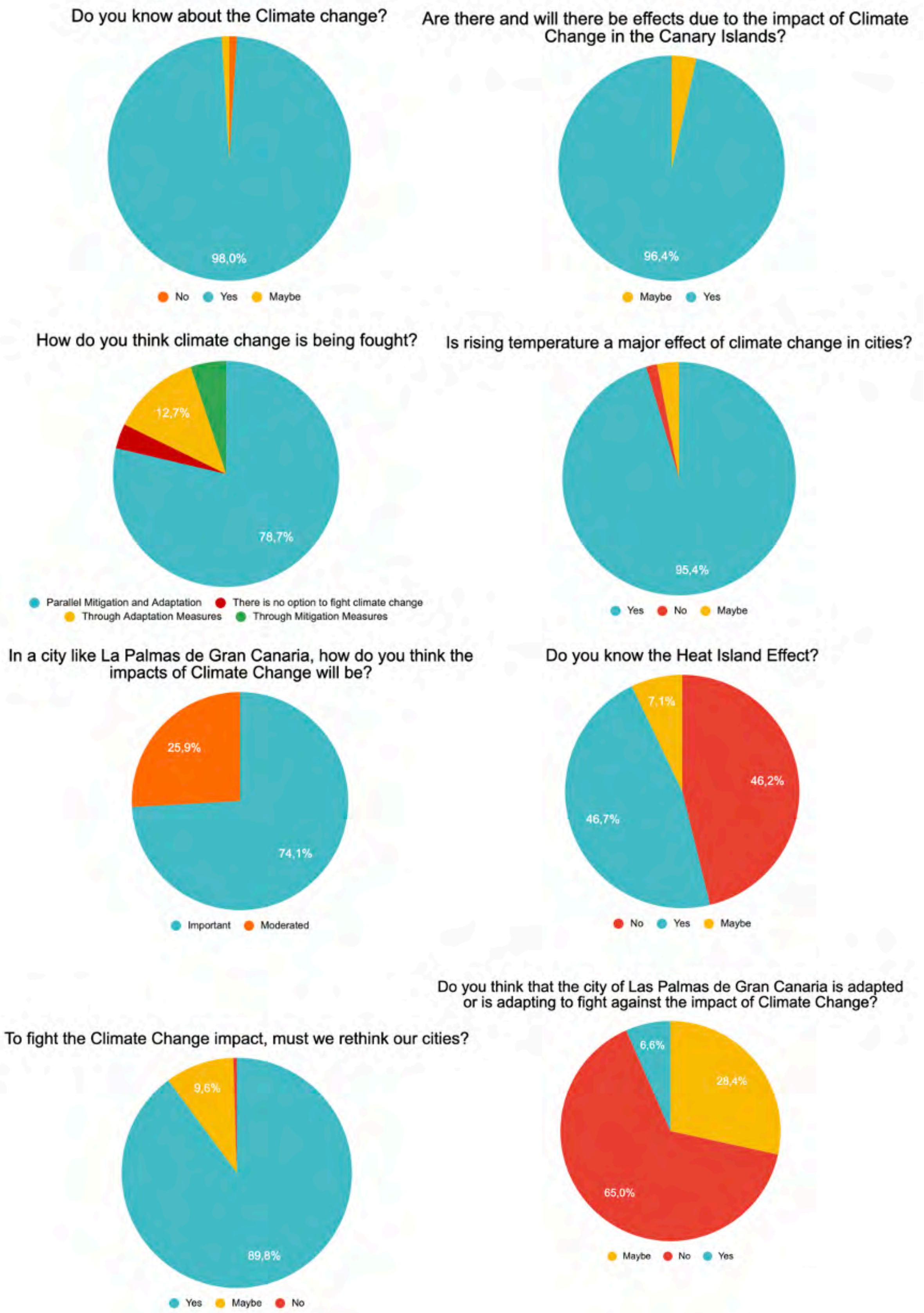

Figure SM-23: Answer on the second block of the survey about climate change and its effect.

C. Urban green zones.

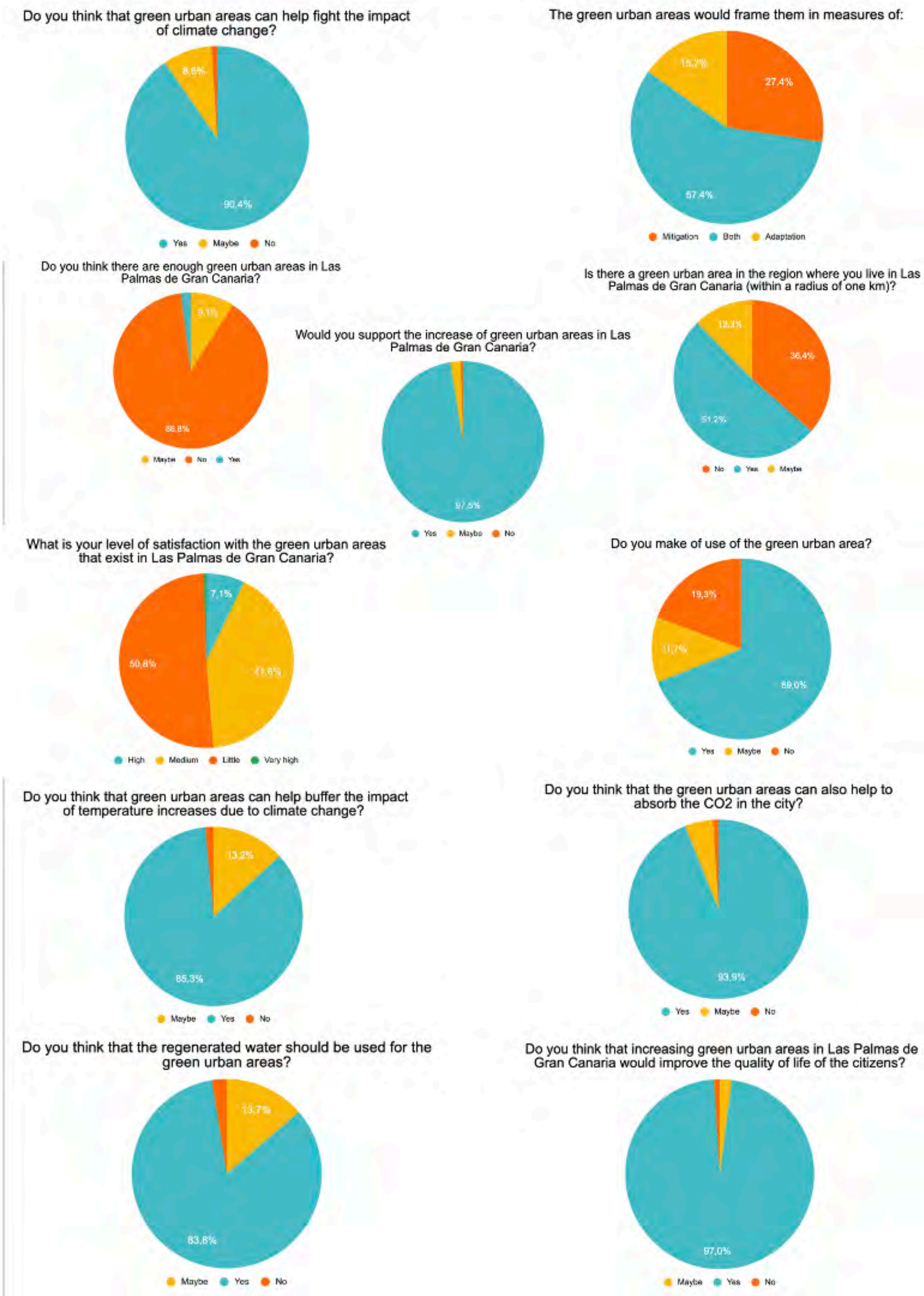

Figure SM-24: Answer on the third block about green urban areas.

a. DEVELOPED ACTIVITIES

My TFG covered from the review of literature, data-base locations, data treatment, map projections and social participation actions. Then, I started with a review of the Greenhouse Gasses Emissions in Canary Islands, Spain and Europe, followed by the temperature evolution in the islands. The next step was to study the use of green urban areas to ameliorate the temperature effect in cities within the climate change adaption actions. Finally, I organized, together with my supervisors, a survey for the population in order to know the degree of knowledge and acceptance of green urban areas in Las Palmas de Gran Canaria.

I treated all these data with the R-Studio program where I had to ask for help from a professor at the Universidad de Las Palmas de Gran Canaria, Dr. Ángelo Santana del Pino.

b. TRAINING RECEIVED

In order to do this current work, I received many lessons from my supervisors in the context of climate change analysis and interpretation, the use of data bases, bibliography, etc. In addition, I also received training in the context of R-studio software.

c. LEVEL OF INTEGRATION AND RELATIONSHIP WITH STAFF

The relationship I had with my tutor was very good. I felt so comfortable, at ease and have learned so much from him and about the topic. I would like to continue working with him on similar projects, especially in order to learn more.

At the beginning of the TFG, I was very nervous because it was my first research activity, however I became comfortable soon with all the people I contacted to work and obtain information for this TFG. I found very cooperative people that really helped my during this time.

d. POSITIVE AND NEGATIVE ASPECTS

Taking into account the COVID-19 situation since March 2020, the developed plans had to be modified with all the inconvenient. Until that time, all the work was based on face-to-face meetings and trainings. However, after March we moved everything to virtual mode. Then, for example, the social participation was less than the expected. In addition, I have learned a lot, such as how to look for detailed information in studies and reports, how to make the graphs in R-studio, how to interpret the climate change impacts, the role of society in the climate actions, how to differentiate the discussion and the conclusion, how to look for the data in the official pages, among others..

e. PERSONAL ASSESSMENT OF THE LEARNING ACHIEVED

Despite all the difficulties I have had, my disorientation and my lack of knowledge in some topics, I think I have managed to adapt and have achieved good results. Besides, I am so proud of my TFG and I would love to learn more and carry it out as I consider it too important a topic to pass on.