

## ORIGINAL RESEARCH ARTICLE

# The contribution of urban climatology is the introduction of sustainable eco city development knowledge of the capital ministry, Katamaka Province, Argentina

Uriel Flores\*, Belén Fernández, Dana Navarro

National University of Catamarca (Universidad Nacional de Catamarca), Catamarca K4700, Argentina. E-mail: geourieflores@gmail.com

### ABSTRACT

Temperature is one of the meteorological variables that can best represent the climate of urban areas. It shows obvious sensitivity to urban growth and expansion, resulting in the so-called urban heat island. “Urban climatology has made remarkable progress in dealing with problems in the process of urbanization”<sup>[1]</sup>. It serves elements such as learning contents and initiatives for environmental order or climate comfort suggestions. In recent years, the development trend of ecological cities has been greater, which aims to follow the ecological principle. As a new way of sustainable development, there is more vegetation to balance the heat regulation of the city. Using different statistical data from meteorological stations, data recorder button measurement data, and temperature and humidity sensor data with an environmental probe, a hot city comparison between the capital and adjacent rural and semi-rural areas is carried out. These data have produced the results of encouraging sustainable development initiatives. This has led to better population habitat conditions for the next generation over the years.

**Keywords:** temperature; urban; eco polis; sustainable development

## 1. Introduction

“At present, the understanding of urban climate takes into account social perception in order to integrate research into the social study of climate change.” The perceived climate is important because it includes the experiences and life experiences of residents. Urban climate perception is relevant because residents live in an artificial environment, which is often different from natural conditions. “At this point, it is worth noting that urban terrain pro-

duces an artificial climate that affects people’s comfort.” Cities need planning that integrates the concept of sustainability. The participation of public and private social actors in their initiatives can change spatial dynamics through active participation and perception, and provide the necessary information for urban re-planning to improve environmental conditions and quality of life.

“Cities are usually warmer than the surrounding rural environment<sup>[2]</sup>. The magnitude of these thermal differences is highly variable and depends on a va-

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riety of factors, but the building area usually shows a higher air temperature. This phenomenon is called an urban heat island. This is the most obvious example of human impact on the urban climate.

## 2. Urban climatology and its significance

Urban climate research has recently been more widely developed in North America and European countries. “Significant progress has been made in urban climatology to meet the challenges posed by the growing process of urbanization.”

Urban climatology contributes to more rational urban and ecological planning, especially the mitigation, elimination, or creation of adaptation actions to deal with unnecessary changes caused by urbanization.

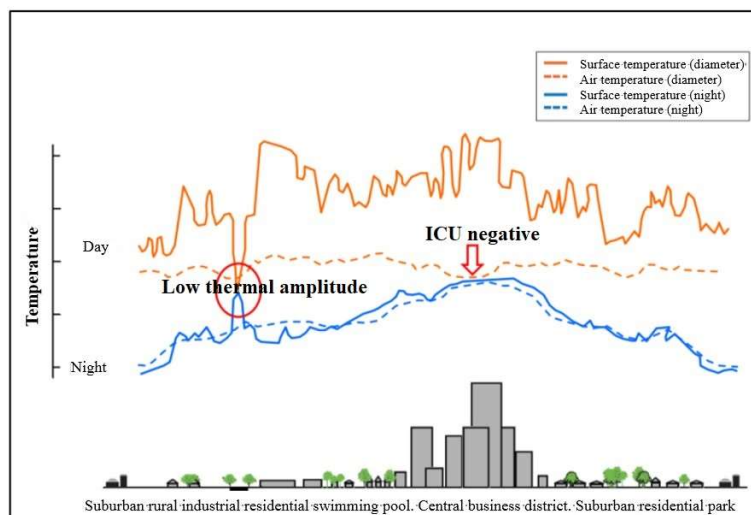
Their main research object is the analysis of the “heat island” phenomenon and its temporal and spatial changes. “Among all the climate changes caused by cities, the thermal effect is the most studied, felt and perceived.”

Define rosemary: “Urban climate is traditionally regarded as an integral part of nature and is therefore dealt with by physical sciences such as meteorology and climatology. However, when considering its causes and consequences, people immediately realize that the great changes in temperature,

humidity, or air quality in the city are related to the socio-economic processes and characteristics of the community in space and time, so it is an environmental and geographical problem.

## 3. Characteristics of urban climate and heat island

The change in urban climate is the product of urbanization, which produces the heat island effect (**Figure 1**). There are several classifications of heat islands: surface heat islands and atmospheric heat islands. Urban space is the regulator of regional climate because it replaces the natural surface with architectural space (surface heat island). This changes the physicochemical properties and aerodynamic, thermal, hydrological, and mass exchange processes occurring in the atmosphere, resulting in the so-called urban climate. This climate is generated by comparing cities with the natural environment or rural areas (Atmospheric Heat Island), according to the differences caused by their functions and urban background, as well as the terrain and site characteristics and urban structure. The intensity and characteristics of these changes often vary depending on their constituent elements (road network, building type, and structure, the presence of trees, etc.). The radiation and electrical conductivity of new materials are very different from the original medium, which increases heat retention and generation.



**Figure 1.** Temperature changes during the day and night.

#### 4. Normal daytime thermal behavior: Improvement and comparison of heat island cycle

The higher the thermal conductivity of urban materials, the greater the difference between urban and rural land surface temperatures during the day, and the smaller the difference at night. In contrast, the thermal difference in the air observed during the day is opposite, non-existent, or even negative (especially in the morning, due to the thermal inertia of urban materials and the shielding of buildings), while it is very high at night. During the day, due to the influence of the earth's rotation, the temperature record changes from a very low value to a very high value. This is because the solar light tilts at dawn, reaches its maximum at noon with the increase in solar light intensity, and then drops to zero at dusk, resulting in daily temperature changes. This phenomenon is called the daily variation or cycle of temperature (similar to the earth translation effect, which leads to the annual variation or cycle of temperature). The thresholds of daily solar activity intensity do not match the records of minimum and maximum temperatures because they are after the minimum or maximum incidence of solar radiation (Figure 2).

With the emergence of the urban heat island phenomenon, the daily thermal cycle of the city is affected, especially since cooling is slow in summer. "The existence of heat islands within cities has been widely documented, mainly because the soil covered by vegetation is covered by asphalt, concrete, bricks, and other urban soils," said Alberto Ramirez Gonzalez of the Pontificia Universidad Javeriana of the Department of Ecology and Territory.

Due to the heat released during combustion and the presence of man-made materials different from soil and/or natural vegetation, urban temperatures are higher in terms of heat storage, solar radiation absorption, evaporation, filtration, runoff, and water storage.

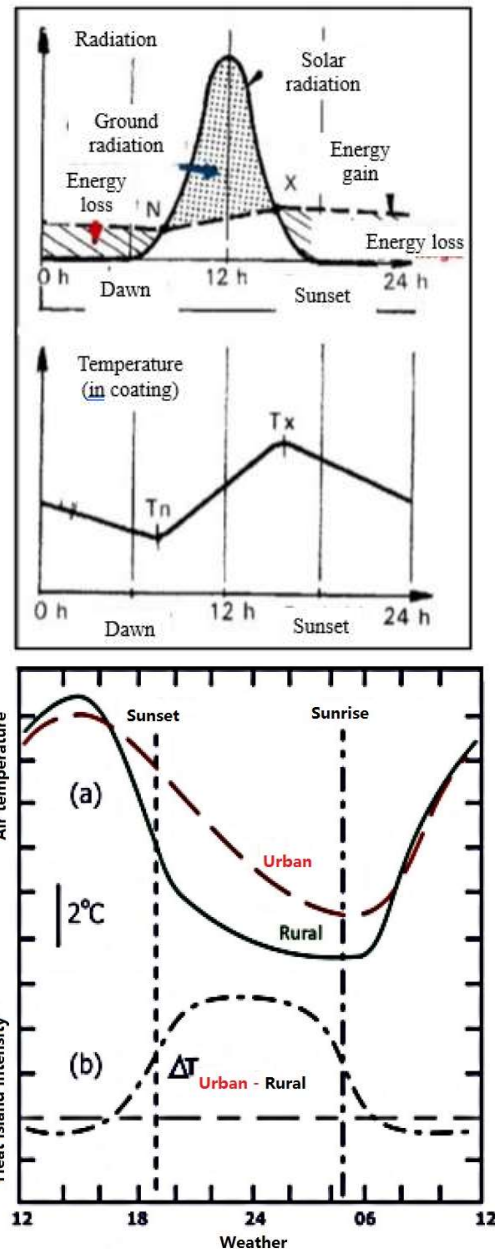


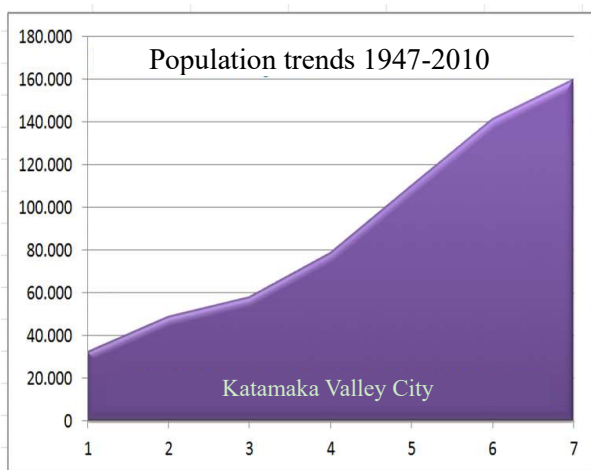
Figure 2. Hourly variation of urban temperature and heat island intensity.

#### 5. Analysis of climatic conditions and urban temperature changes in San Fernando del Catamarca Valley

"Under the influence of semi-arid climate advantage, reference geospatial is a part of the arid diagonal of South America and a part of the arid sub advantage of the Sierra and Balsos. The precipitation is a rainstorm and occurs in summer, which is characterized by short duration and strong erosivity; the evaporation exceeds the annual average precip-

itation, and the thermal amplitude is large”<sup>[3]</sup>.

Taking Capelli’s<sup>[4]</sup> model as an example, the daytime heat distribution of typical summer days in the city coincides with the areas with few trees when the temperature in the commercial center is 45 °C on 25 January 2019. The temperature (44 °C) in the eastern and southern periphery near the valley river is lower than that in the microcenter and Felipe Varela airport is 15 km (Tmax) away from rural areas. 43.2 °C). The distribution during the day shows that the city is warmer than expected. In the south and southwest of the city, the temperature is the lowest. At night, the rural environment near the city is warm. This phenomenon is called heat island intensity (**Figure 3**).



**Figure 3.** Population evolution from 1947 to 2010.

Experiments conducted on a typical winter day help to study the shape of the San Fernando heat island in the Catamarca Valley and link the results with observations in the summer. The city shows different thermal behaviors before dawn, and there is a typical “thermal reversal” phenomenon, that is, the typical “thermal reversal” phenomenon of “Valley”. When the temperature in the central part decreases, the influence of decompression wind. It’s normal, day after day. At night, a heat island will be generated, which will respond to the ideal model in both seasons. In other words, due to the increase of commercial activities, population density, means of transportation, etc., the center becomes hotter. The intensity of heat island in the two seasons is

similar. If the daytime heat distribution is analyzed, the difference between the two seasons in a year is more relevant. In winter, it produces a heat island with a small temperature gradient ( $D_{tu-r} = 1 \text{ }^\circ\text{C}$ ). In contrast, in the summer experience, the city has produced a heat island without the so-called “cold island” ( $D_{tu-r} = + 3 \text{ }^\circ\text{C}$ ).

The development of the city has changed the local atmosphere and may affect people’s quality of life. In recent years, the population and construction area of San Fernando del Valle Catamarca have increased significantly. The urban built-up area has expanded from 35.19 km<sup>2</sup> in 1984 to more than 65.56 km<sup>2</sup> in 2019, and the population has increased by 50.4% in the past 40 years. The change in urban space and the increase in building density led to a change in summer temperatures. The city center is warmer than the suburbs. In 2015 and 2017, the temperature in the city center was the highest, and the most comfortable areas were suburbs and parks (**Figure 4**).

There was no significant difference between the winter measurement and the night measurement. The results show that the growth of buildings and the increase in population (index data) change the spatial distribution of temperature.

## 6. Contribution of new terms of urban climatology to case studies

Some terms and new concepts.

They are used in this new branch of urban climate, which “should be used as an input to a detailed analysis of current phenomena”<sup>[5,6]</sup>:

Urban boundary layer (**Figure 5**): The air layer closest to the surface in the atmosphere, and its local weather characteristics are affected by the heat and dynamics of the surface. (In this city, there are about 16 stored buildings, most of which are low.)

Urban air layer: The air layer existing on the ground, marked with the height corresponding to the roof of the building. It is also used for the parts be-



tween buildings, which are inferred from the recent environmental conditions in the form of microclimate.

Urban canyon: It includes the street ground between two buildings and their walls. Take Esquire and St. Martin Street as examples (**Figure 6**).

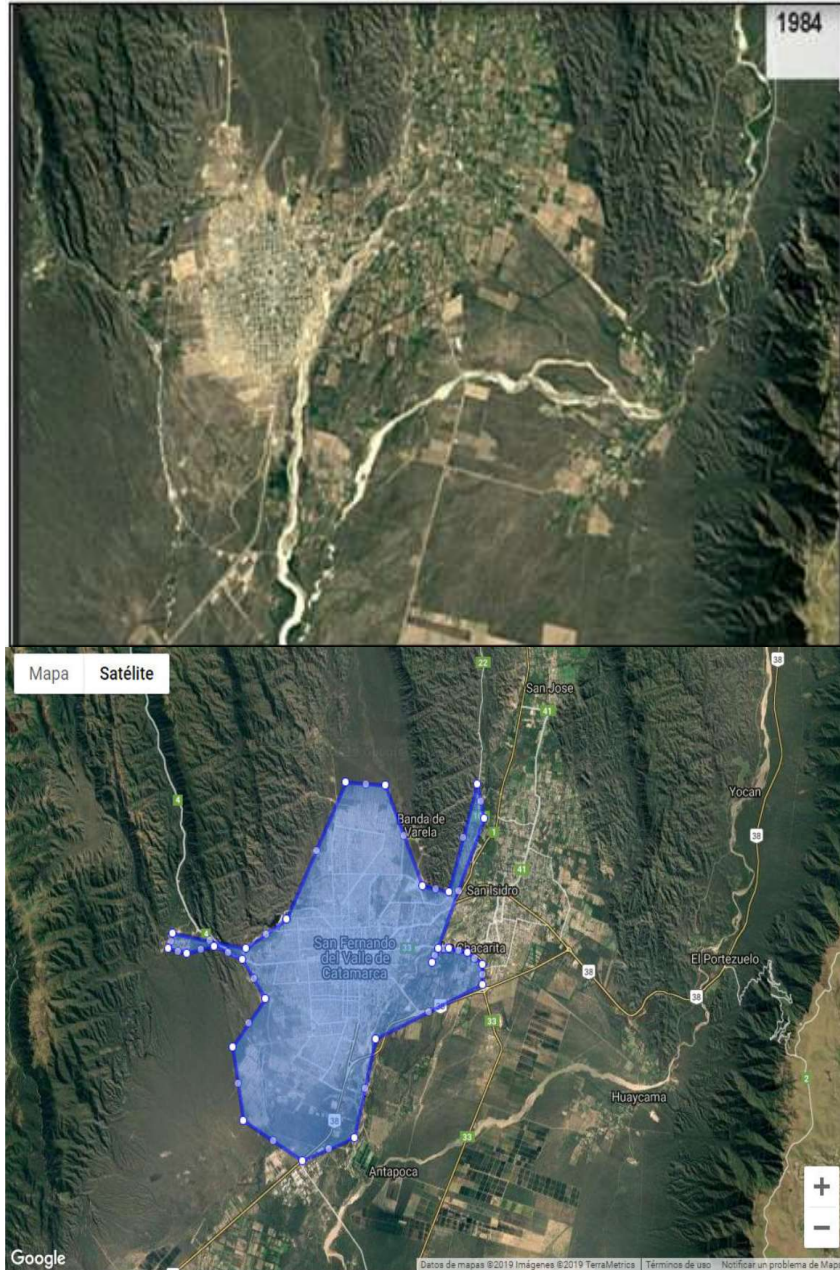


Figure 4. Calculate area on map.

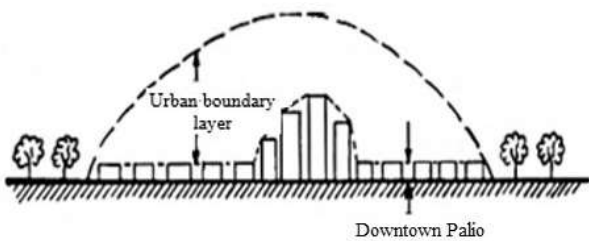


Figure 5. Urban boundary layer.

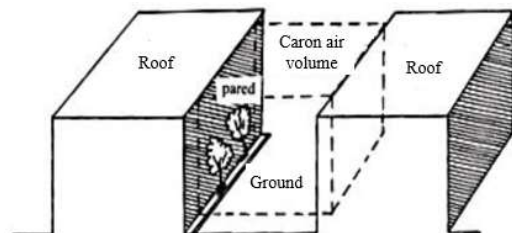
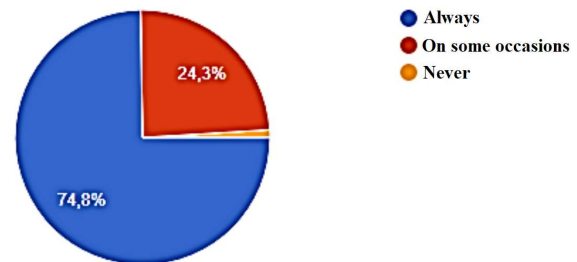


Figure 6. Schematic diagram of urban streets, including the air volume therein.

## 7. Interpretation and analysis of the survey results of urban residents' perception of heat island

The survey provides a simple form of probabilistic or random online sampling (participation: 105 people) represented by the population of different genders and ages living in the city of San Fernando del Valle Catamarca as a tool to understand the differences between perceived and actual climate (measured by temperature records) (**Figure 7**).

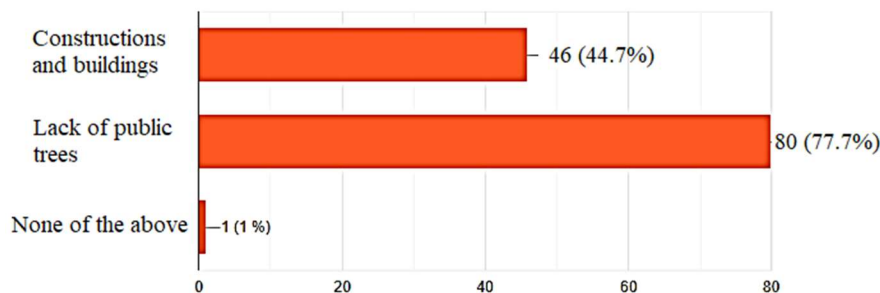
The following saved slogans mark the thought and ideology of this theme:



**Figure 7.** Random online sampling probability distribution.

What causes do you think can intensify heat islands in the city?

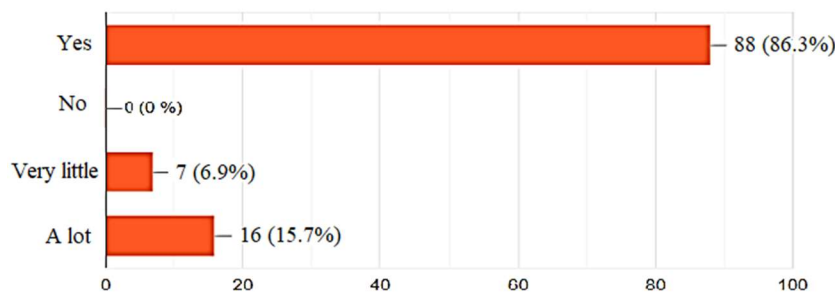
103 answers



**Figure 8.** Factors that aggravate the heat island of the city.

Do you believe that the high temperatures in the city are detrimental to the quality of life and comfort?

102 answers



**Figure 9.** Findings on whether high temperatures in cities have an impact on quality of life and comfort.

At this meeting, people have a reasonable and important view that the trend of temperature growth is greater in areas close to the city center and urban core area (74.8%) (**Figure 8**).

Many people question the reasons for the high temperatures in cities and the thermal impact of

high temperatures on buildings, but people also realize the need for more public trees (**Figures 9–10**). In addition, because this situation is not only natural but also in line with the geographical characteristics of the region, coupled with local factors, people have a very unfavorable view of the quality of life and comfort.

In summer when temperatures are very high in the city, what alternatives do you choose to withstand the heat?

103 answers

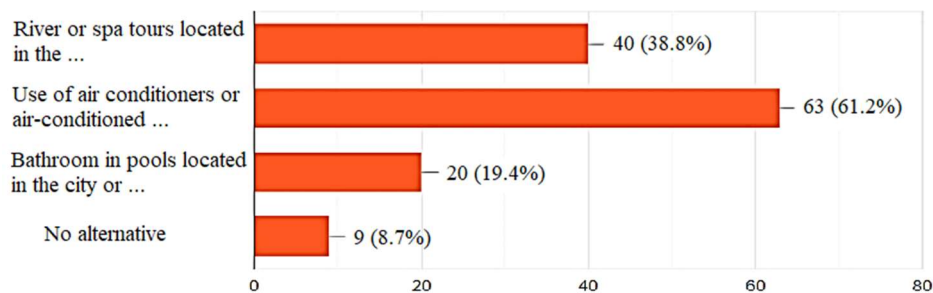


Figure 10. Alternative solutions for people to cope with the heat in summer.

It highlights an option in the above question, namely, that a considerable proportion of the population chooses option 2 (Figure 11). This also implies another disadvantage related to the heat island

phenomenon. In a study at the University of Phoenix, Francisco Salamanca explained: “Using air conditioning during the day leads to an increase of more than one grade at night (Figures 12–13).

Do you know or do you consider if there are political managements or not, related to this problem of improvement of the living conditions and contort in the city of San F. de V. de Catamarca? What is your opinion? Describe a brief opinion.

83 answers

- I think that more public management is needed, mainly to raise awareness about the care of the environment, starting with public cleanliness and hygiene. We also need to increase green spaces and build parks and green areas to try to improve the temperature.
- For me there is no management and there is a lack of improvement to put more trees in Catamarca.
- I do not feel that there is a politics in the city, nor in the province oriented towards this topic.
- Nobody does anything
- As far as I know, no political steps are being taken to deal with this problem. My opinion is that measures should be taken to try to achieve a decrease in temperatures.
- I did not see any real action on the case.
- They do not do anything.
- They do nothing.
- Never care about the people.

Figure 11. People’s opinions on measures to improve living conditions.

Near your neighborhood or home: Which polluting or environmentally damaging action do you think is most frequent? you can choose several options.

103 answers

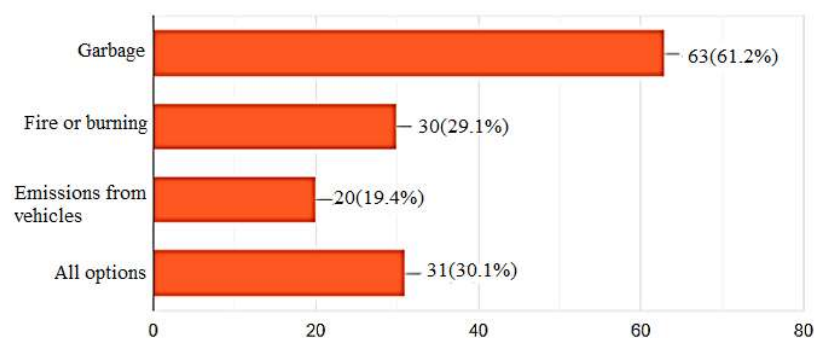


Figure 12. Findings of the most common polluting behaviors.



The temperatures recorded in the official data do not coincide with the conditions actually felt and perceived in the city. Do you notice differences?

102 answers

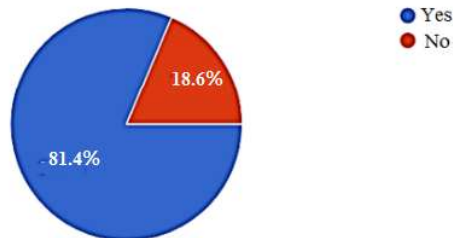


Figure 13. Survey on the perception of urban temperature.

## 8. Analysis and interpretation of urban climate characteristics and ambient temperature data in San Fernando Valley

The method was developed by using data obtained from inclinometers (Figure 14), datalogger buttons using thermal sensors (Figure 15), and comparisons between automatic and traditional weather stations located in the city center, adjacent areas, and adjacent rural areas.



Figure 14. Inclinometers.



Figure 15. Thermal sensor.

Master station location (Figure 16–Figure 17):

- 1) UNCA (city center)
- 2) Cape (adjacent)
- 3) Felipe Varela Airport (rural areas)

Temperature record comparison is shown below (Table 1).

In the above heat map and data sheet, the temperature difference and contrast can be clearly seen. These differences and contrast are significantly affected by  $ICU < 3-6\text{ }^{\circ}\text{C}$  ( $Dtu-r = + 3-6\text{ }^{\circ}\text{C}$ ) near the city center. A frequent problem is that, due to the large number of cars and 235,000 residents, traffic congestion affects a narrow geographical space. This is a medium-sized small city. In many cases, due to the interruption of departmental traffic, it will eventually affect the whole system in an interlocking way. A microcenter of  $0.5\text{ m}^{2[7-10]}$ .

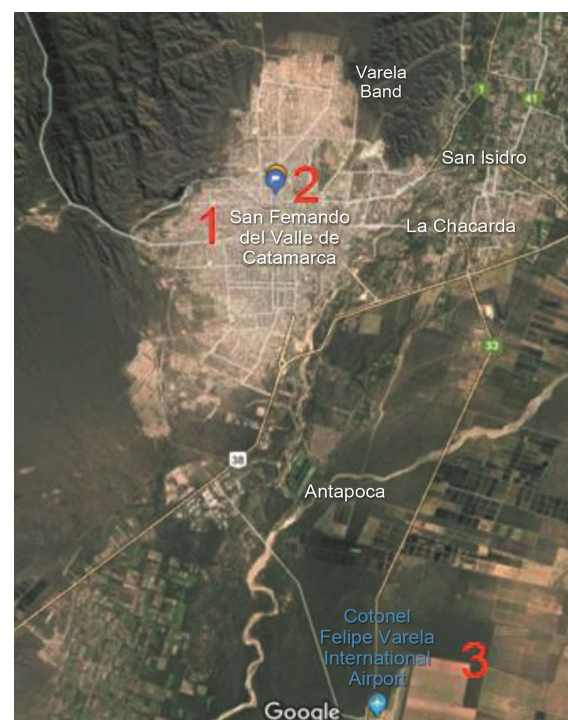


Figure 16. Master station location.



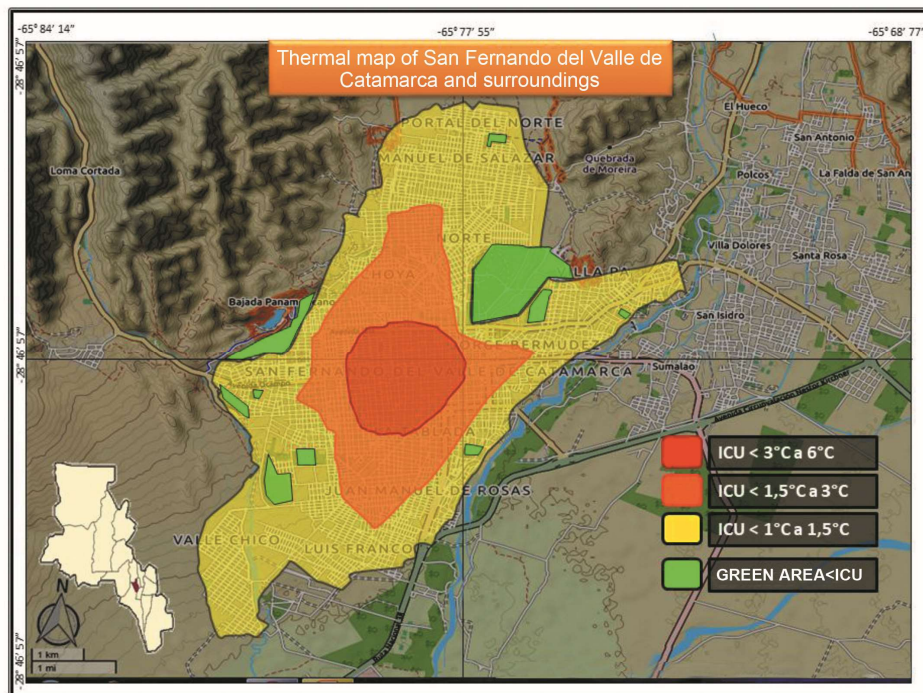


Figure 17. Temperature map.

Table 1. Temperature record comparison

Year	Month	Day	Hours	United Nations University	Deputy Minister of Science and Technology (DMST)	Airport
2016	12	31	15	43.2	42.9	41.6
2016	12	30	21	35.2	34.0	33.4
2017	11	15	14	44.7	43.6	42.7
2017	06	19	12	15.2	15.0	14.7
2018	07	03	09	10.1	10.0	9.5
2018	01	02	18	34.6	33.1	32.5
2019	03	15	22	21,8	20.3	19.0
2019	7	22	07	13.1	14.9	14.6

In a 2019 report, the Transportation Bureau of San Fernando del Valle Catamarca said that 90,000 vehicles enter the urban microcenter of “Angosto” every day (1 km radius, 60 blocks in one direction, 30 blocks) (Figure 18). In 2009, according to the

daily estimates of the same agency, this figure decreased by 40% and increased every year. The annual territorial growth rate is 7%, one of the highest in the country.

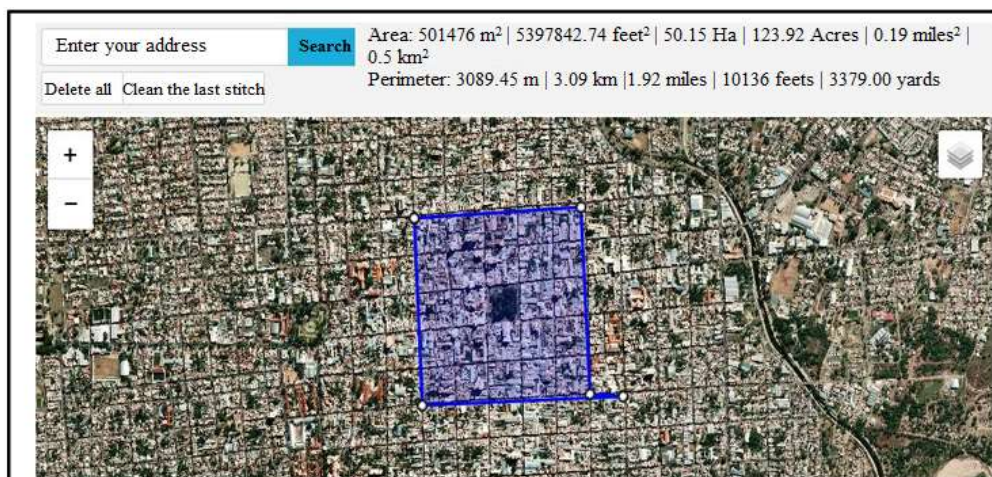


Figure 18. Transportation map of San Fernando, Catamarca.

## **9. Can it become a sustainable ecological city?**

Ecocity is a city designed according to ecological principles. Ecocity has several characteristics, such as small-scale agriculture, maintained by communities and suburbs, to reduce the transportation distance of food production.

As an alternative teaching strategy in the process of urban design teaching, it is based on the principle of formulating a working method useful to the knowledge of urban design seminars, urban ecology, ecological urban design, and green planning. This strategy aims to be implemented at the level of discipline training in all areas.

We believe that it is essential to understand the interaction between social, environmental, and economic systems. This is why there is no ideal type of city because they vary according to the urban environment.

The idea is to encourage human society not to pollute or destroy our planet. In this sense, these three R's are to influence and educate people to reduce pollutants and avoid energy waste. Materials used for reuse without re-purchase and recycling waste components should not be mixed with liquid and biodegradable waste. We need to become global citizens.

Due to human industrial activities, environmental impacts began to appear at the end of the 20th century, followed by climate change caused by large-scale greenhouse gas emissions. Now, the proposal for sustainable cities is to stop the indiscriminate exploitation of natural resources, leading to the depletion of raw materials. Creating a new mode of industry, transportation, especially electricity, is a real challenge for contemporary mankind.

Key to achieving a sustainable ecocity:

(1) In addition to the protection of public spaces, such as parks and sports squares, it is also

important to improve the quality of sports.

(2) Integrating nature: The idea of coexistence with nature.

(3) Clean energy: The key is to have a new way to get energy, not as polluting as fossil fuels. Huge investments have been made in wind, hydro-power, solar, and geothermal power generation, each with its own needs.

(4) Restore the center, restore its identity, and maintain its vitality. It has been preserved in history so that it can provide its own culture and avoid the anonymity of big cities.

(5) Ensure air quality: Plant lungs and openings for air flow are the keys to urban life. This avoids the concentration of smoke.

## **10. Conclusions**

Local vegetation in public forests is an effective resource to control urban high temperatures, which is an important suggestion to improve the livability of urban external space in the study area and reduce the generation of "heat islands", as shown in the data and survey.

The suggestion of sustainable ecocity development and the key to shaping a sustainable ecocity are alternatives worthy of consideration. Due to the rising average temperature over the years, urbanization plays a key role in the heat island phenomenon. They participate in an enclave that needs public perception, which is coordinated and managed work to create new alternatives for future generations living in the capital of Katamaka.

## **Conflict of interest**

The authors declare no conflict of interest.

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