

## The impact of urban heat islands on the elderly: role of vegetation and population

### تأثير جزر الحرارة الحضرية على كبار السن: دور الغطاء النباتي والسكاني

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#### **Abstract :**

The scientific literature concerning a studied phenomenon is always manifested by evolutions through recent studies. With regard to environmental sciences, it is necessary to update the various results that have been the subject of all climatic phenomena, in particular urban heat islands. The fight against urban heat islands was treated through a set of scientific research during the twentieth century, but the importance of the phenomenon in the eyes of researchers has been accentuated in the 21st century. It was necessary to update the results and references presented later. The literature review that will be presented in this article is characterized by a diversity of disciplines (climatology, urbanism, ecology and public health) that are related to the phenomenon studied. However, this article will be devoted only to the theoretical part of the study because the empirical part is at the beginning of realization.

**Keywords:** urban heat island, elderly, vegetation, population, literature review

#### **ملخص:**

المؤلفات العلمية لظاهرة مدروسة تتجلى دائماً في التطورات من خلال الدراسات الحديثة. فيما يخص العلوم البيئية، من الضروري تحديث مختلف النتائج التي كانت موضوع جميع الظواهر المناخية، ولا سيما الجزر الحرارية الحضرية. تمت معالجة الجزر الحرارية الحضرية ومكافحتها من خلال مجموعة من الأبحاث العلمية خلال القرن العشرين، لكن أهمية هذه الظاهرة في نظر الباحثين ازدادت في القرن الحالي، لذا وجب تحديث النتائج والمراجع الخاصة بها. تتميز الدراسات المعروضة هنا في تنوع التخصصات مثل علم المناخ وال عمران والبيئة والصحة المتعلقة بالظاهرة المدروسة. سيتناول المقال الجانب النظري تحديداً لأن الجانب التجريبي في بداية الإنجاز.

كلمات مفتاحية: جزر الحرارة الحضرية، المسنين، الغطاء النباتي، السكان، الدراسات السابقة

## **Introduction:**

Our planet remains exposed to several climate changes, especially the year 2023 when natural disasters were significant (earthquake in Morocco, floods in Libya, etc.). Today, it is undeniable that the ecological situation of the earth should receive more investment for its protection. Among the ecological phenomena that emerge more in this 21st century are the increase of urban heat islands. Indeed, the evaluation of temperatures in the world in recent years shows the heatwaves more and more frequent. Thus the forests are more exposed to the risks of fires. More particularly, several geographical areas that usually have a mild climate in summer record an emergence of urban heat islands. Sometimes the temperature has even exceeded 40°C (heatwave of 2003 in France). In this way a study of the University of Zurich published in the scientific journal "Plos One", which concerns 520 major cities of the world reveals that by 2050 temperate cities will experience climate change equivalent to their displacement 1,000 kilometres south. (Perrin, 2020, p. 5)

## **Research problem:**

The municipality of Oran is among the areas affected by the frequent heatwaves in summer. According to data from Infoclimat.fr the three weather stations of the wilaya of Oran (Oran-Port, Es Senia, Tafraoui) recorded monthly average temperatures of (29.8°C 35.5°C and 38°C, respectively) in July 2023 (highest temperature since 2014). Overall, the summer of 2023 measured by the three weather stations is also the highest in average temperatures compared to the previous nine years. This heat growth is certainly reflected by global warming but several urban and demographic determinants can also participate such as the degree of urban vegetation or population density. Moreover, the first victims of this phenomenon are undoubtedly the elderly who are. It is from this reflection that the question arises: ***What are the characteristics of older people most vulnerable to urban heat islands in Oran municipality? And how do vegetation and population density change the evolution of these urban heat islands?***

## **Hypotheses:**

This study turns into two hypotheses to try to answer this problem:

**H1-** Age is an obvious determinant to measure vulnerability and even more against heatwaves, but there are also other characteristics such as: social isolation, health status, housing, level of resilience and adaptation, adding to other specific variables.

**H2-** increasing population density – often unevenly – appears to have indirectly a high impact in forming urban heat islands. The rate of urbanization and the extension of housing areas to neighbouring rural areas have accelerated the warming process. Regarding vegetation, the small plant area in a highly urbanized city like Oran massively increases heatwaves.

### **Objectives and motivations:**

Urban heat islands are among the environmental themes that are not sufficiently treated in the scientific research community. Adding to this the phenomenon is not well acquainted with the population. What interests us in this work are the demographic and urban determinants that play the role of a barometer to mitigate or increase heatwaves in cities. This extreme heat is not only more frequent than before but also more intense and lasts longer. It would be interesting to know how demographic variables such as population density and distribution or urban vegetation cover interact with urban heat islands in the summer period.

The scientific objective is to measure how often urban heat islands impact the health of the elderly between 65 and 80 years. Also to measure the influence of vegetation and population density on the evolution of these same heat islands especially in a dense region such as the municipality of Oran. In support of the scientific objective of the study, other objectives are considered:

- Take more account of the phenomenon of urban heat islands, which is not very well treated and understood.
- Simultaneously involve authorities and citizens to invest more in environmental protection and the ecosystem.
- Indirectly participate in the intelligent development of territorial and urban cities through the concept of «smart city».
- Promote thermal mitigation and cooling actions in high density urban areas.
- Protection of the elderly and children against climate warming with the production of cool spaces during the summer.
- To improve public health, mainly for respiratory diseases with urban air purification.
- Raise awareness and inform the elderly and vulnerable people by giving them recommendations to better act in case of heatwave.

## Materials and method:

We will collect data through several sources and works that have been done in connection with this theme. First, statistics prepared by national organizations, as is the case with weather data from the Infoclimat site. Also demographic statistics on population change published by the Algerian ONS. The third category of statistics was urban, specifically on the frequency of vegetation in urban areas drawn from the database of the Algerian Ministry of the Environment. A fourth source is health data for the elderly will be collected from the hospital.

Climate changes especially with urban heat islands can be caused by several natural sources, but also anthropogenic, nevertheless the processes produced by humans increase their frequency. For this reason the analysis of this phenomenon must be in the first place in a spatial and temporal aspect: the first to see the propagation in space and the second aspect to evaluate its evolution over time. A descriptive analysis seems appropriate to start this kind of study.

### 1. Literature review:

#### 1.1. Collection of bibliometric documentation:

A bibliometric research was carried out in order to situate this study project among the pool of studies and subsequent scientific research on urban heat islands. The usefulness of this step is firstly to collect and synthesize the key themes that have devoted a significant treatment with urban heat islands. Secondly, this bibliometric collection will clarify the characteristics and give us more knowledge about the phenomenon. Finally, this step will allow us to know the little explored fields and thus locate the relevance of this study.

This sample contains articles dealing with differentiated approaches to urban heat islands. The fields of study are varied because the phenomenon is attached to a vast entanglement of disciplines (meteorology and climatology, urbanism and environment, epidemiology and public health, geography and demography, etc.) Although the process of this study concerns the impact of heatwaves on the elderly with the role of vegetation and population. It is important that the bibliometric collection be made up of all the disciplines mentioned above. In addition, a sample of representative sources will undoubtedly help to understand the mechanisms of the urban heat island. The constitution of the final bibliometric sample is passed through several stages:

- First, a classic search (by keywords, by title) on different libraries and platforms to have a good number of documentations (54 sources).

- Secondly, and a sorting operation through the reading of the abstracts and the objectives of the collected articles. This procedure is useful in order to eliminate the sources that evoke the heat island, but within a single field (e.g.: climate) or sources that have a very distant approach (e.g.: heat island chemical processes). The number of sources is reduced to (46).
- After excluding 08 ineligible sources a second sorting took place to take into account only the sources that deal with at least two of these three concepts simultaneously: (heat islands, vegetation, and population). The choice was to take one source instead of two that have the same context, the same methodology and the same objectives).
- At the end of the initial documentation it was found among the (18) selected sources that heat islands were not analyzed deeply with a social or demographic aspect. Also the literature in the field of public health was not as rich. This is not sufficient as long as one of the main components of our study is the health of seniors and population density. So a second bibliometric collection is done precisely before finding (08) sources dealing with both heat islands and the elderly population. The size of the final sample is (26) sources.

**Graphic 1**

*Representation of the method of selecting articles from the corpus.*



**Source:** BELAIDOUNI, 2024, p5

**Note:** We have made this graphic for the first time in this study

**1.2. What more I bring to the subject:**

The originality of this study lies in the complementarity of the two factors. Indeed, there is a probable link between the population density in urban area and the occupancy rate of green spaces in the same area. At the same time, each of these two parameters impacts in its own way on the frequency and intensity of urban heat islands.

### **1.3. The point that has not been studied in this field:**

As mentioned before, among the aspects least used in the Algerian context of subsequent studies: the social aspect and the «demography of health». The health of the Algerian elderly population has not been sufficiently highlighted about the health risks caused by summer heatwaves.

### **1.4. New issues addressed:**

Knowing that global warming has become a global issue for some time, many public policies tend to fight against urban overheating with the extension of vegetation cover to benefit from protection for its population (particularly vulnerable groups such as the elderly). Algeria is one of the countries that are characterized by hot periods during the summer in densely populated cities. This study measures at what level, vegetation and urban population density each modify in their own way the vulnerability of older persons in an area exposed to urban heat islands.

### **1.5. Network of authors who raised the issue:**

The network of authors was classified by sub-themes that were distributed according to the nature of their work. These sub-themes are: vegetation, heatwaves, mortality/morbidity and urbanization. This procedure is intended to read frugally all researches which apprehended the central concept of our study.

#### **1.5.1. «Vegetation» sub-theme:**

Debizet identified the health risk of “over-heat” related to urban planning. He located refuge areas by assessing factors influencing temperature. The unexpected fact in his study is that the temperature peak of the green curves is higher than that of the grey curves (37°C instead of 35°C). That’s due to the cessation of evapotranspiration of the vegetation at the hottest moment of the day: in botany, this is explained by the reaction of plants that protect themselves so the vegetation ceases to cool the ambient air. (Debizet, 2011)

Bertrand and G. Simonet proposed a reflection on the possible overlap between two emerging themes: Greenways (1) and the adaptation of urban systems to the effects of climate change. The aim is to highlight identifiable convergences between these emerging objects of collective action. Overall, they point out that: the world population explosion coupled with the improvement of life quality and the increasing urbanization are all factors producing environmental crises. The Urban Green Trams participate in a broader movement in order to reintroduce nature in the city: The development of Greenways would oppose the tendency toward densification of urban fabrics.

This would therefore help to curb the reduction of greenhouse gas emissions per capita. Conversely, the development of Greenways would have climatizing effects, reducing the consequences of heatwaves. (Bertrand & Simonet, 2012)

Merrouche attempted to verify the role of vegetation within the city and its impact on the urban heat island. She showed that due to the activity of photosynthesis the vegetation modifies the urban climate by rehydration and cooling the air in green spaces. That contributes to a better ventilation of the city. However greenspaces that are embedded in densely built districts without green zones are polluted spaces. They are not only ineffective in improving the air condition but act as dust extractors. (Merrouche, 2012)

Hebert can use his results to improve the methods already used to locate urban heat islands for any city and follow their evolution in time and space. In his opinion, urban heat islands can only be caused by humans because he is the last who develops territories. Urban heat islands are undeniably the result of the spatial organization of cities and the density of greenspaces they offer. Moreover, built-up areas that are not revegetated become heat sinks. In areas without industrial activities he has defined the significant heat sources from anthropogenic activities in summer are transport and air conditioning of buildings. He sees a direct link between surface temperatures and vegetation cover: green spaces not only offer a lot of shade, but they capture a large part of the heat and contribute significantly to the reduction of air conditioning in buildings. Also evapotranspiration which corresponds to the loss of water from leaves or roots contributes directly to the drop in air temperatures by capturing latent heat. Finally, urban heat islands affect the morbidity-mortality rate of the population by creating heat stress by the accumulation of heat in the human body. This exacerbates a chronic condition that can cause death. Rising temperatures also aggravate air pollution which increases the harmful effects on human health (acute respiratory problems). (Hébert, 2014)

Pascal and al., synthesized the main knowledge on the interest of revegetation in cities as a preventive tool for the health impacts of heat and the associated potential benefits, particularly on air quality. According to the study, the vegetation must have a large leaf area allowing the passage of air and must be close to the sources of pollutant emissions. This proximity increases locally the concentrations of pollutants and therefore the amount of pollutant trapped. At the micro level, the vegetation around the home has a protective effect: homes whose surrounding environment (100 m) completely vegetated have a three times lower risk of death compared to homes without vegetation. (Pascal, Laaidi, & Beaudeau, 2018)

Gramond identified the vegetation role in the compensation strategy of urban heat islands. She put into perspective the vegetation role as a control variable for climatic conditions. Gramond linked directly the potential mitigation of urban heat islands with the role of plant spaces. It has shown that vegetation acts effectively on the urban heat island by absorbing solar radiation. (Gramond, 2019)

Gherraz and Alkama (2020) assessed the impact of vegetation cover on urban climate to mitigate urban heat island. In their study, built surfaces are characterized by low albedo (2), high impermeability and favorable thermal properties for energy storage. In the other angle, trees regulate the urban climate and mitigate the spread of urban heat islands:

- creating cool effect by giving oxygen,
- absorbing carbon dioxide,
- intercepting solar rays,
- shading and absorbing radiation streams.

The type, density, size and shape of green spaces and shaded areas are all important parameters to determine the effect of freshness and to reduce temperature in a wooded urban environment can reach up to 4°C. Temperature peaks are registered in bare lands, impermeable and deforested. While low values are recorded at the level of dense forests. So the increase in vegetation cover decreases the surface temperatures of the soil. Also, high humidity caused by water is considered as a risk for health. So the implantation of vegetation at the edges of the lake can increase the intensity of the freshness islands and thus reduce the humidity rate. (Gherraz & Alkama, 2020)

Amieur and al., analyzed the impact of vegetation during summer in the hot and arid city of Ghardaia through an in situ (3) measurement campaign. They looked at how the characteristics of urban sites influence the urban microclimate in particular the effect of vegetation. Their results showed that the vegetation produces a maximum "urban freshness island" of 5.61°C. The moderating effect of the vegetation during the day is mainly due to the shade provided by the tree canopy. It also turns out that a denser and irrigated urban vegetation cover would further improve comfort conditions in the city. (Amieur, Rouag Saffidine, & Weber, 2022)

Le Mentec quantified: the impact of vegetation on temperature and the ozone concentration in the street as well as the heat flows. She mentions that the absence of vegetation induces a lesser dissipation of energy by the latent heat

flow in favor of the sensitive heat flow. Vegetated surfaces improve air quality: ozone diffuses into the plant during periods when the stomata are open and is deposited continuously on the surface. Moreover, vegetation promotes the deposition of ozone on surfaces through evapotranspiration of plants that increases locally air and surface humidity. However, it is necessary to pay attention to the arrangement of trees that can make a barrier effect: in the street, the speed of wind decreases with the vegetation which stimulates the accumulation of pollutants on the road. (Le Mentec, 2022)

Cravero conducted a state of the art on experimental studies and numerical models used to study the effects of vegetation on the urban microclimate in order to understand the thermal role of vegetation. The main result is: the vegetation limits the urban overheating by acting on the radiative exchanges by modifying the urban geometry and the physical properties of the materials that pave the city. Also it brings the dissipation of energy in latent form (evapotranspiration) rather than in sensitive form. Studies show that vegetation often reduces air temperature but this reduction seems small. These studies think that vegetation concerns more the improvement thermal comfort by reducing radiation on humans (for example: shading) than reducing the air temperature. (Cravero, 2023)

Perrin gave the keys to action for cities and local stakeholders who wish to improve the summer comfort of cities and fight against heatwaves. He traces the evolution of urban heat islands over time in the world with projections up to year 2050. The causes of the increase of thermal waves in the city can be: (mineralization, harmful material's ex: concrete, overpopulation and human activity). About vegetation, the benefits of the tree are guaranteed by the diversification of its species to fight against gaseous pollutants and fine particles. Evapotranspiration is essential to have urban comfort in summer as long as the trees climatize naturally its space. But the host soil must be well laid out to facilitate the absorption of water by the plant and produce a healthy tree. (Perrin, 2020)

### **1.5.2. «Heatwaves» sub-theme:**

Valleron and Boumendil (2004) began by citing the work of Semenza and al (1995) on the Chicago's heatwave which showed the importance of social risk factors in excess mortality: people living alone were 2.3 times more likely than others to die during the heatwave and those living on the top floor of their building 4.7 times larger. Also, this work clearly showed the role of air conditioning: people living in an air-conditioned place had five times less risk of

dying than others. From the data collected it is estimated that 50% of deaths would have been prevented if all subjects had had an air-conditioned home. According to them, excess mortality affects vulnerable populations already suffering from diseases especially heart and mental failure. For the elderly population, they observed that excess mortality was particularly pronounced among people over 75 years of age who made up 82.5% of excess deaths. (Valleron & Boumendil, 2004)

Drapeau and al., identified the main means of combating urban heat islands in the scientific literature from 2009 to 2020 according to the 4 main categories of *Giguere's* review (2009): vegetation measurements, measures related to sustainable urban infrastructure, stormwater management measures and soil permeability, measures to reduce anthropogenic heat. The main results are related to mortality. In Quebec, heatwaves in the summer of 2010 were responsible for 280 deaths. The summer of 2018 was the warmest in 146 years in southern Quebec with 86 additional deaths. Researchers estimated the increase in deaths linked to heat events in Canada from (2031 to 2080) compared to (1971 to 2020). It ranged from 45% to 455% based on different scenarios: Greenhouse Gas Emission rate, population growth and the implementation of adaptation measures. In general, the additional morbidity-mortality associated with urban heat islands is estimated at 20-25%. (Drapeau, Beaudoin, Vandycke, & Brunstein, 2009)

Dubreuil and al., highlighted the increase of the urban heat island with the extension of agglomeration in Rennes and climatic changes in neighborhoods concerned by changes in land use will be the most significant. They made a comparison between the city of Rennes and the city of Brest to illustrate the contemporary global warming: the two curves show the alternation of years hot or cold. The increase being stronger in the continents of the Northern Hemisphere (+0.9°C for France) than it is for the whole planet (+0.74°C). (Dubreuil, Quénot, Foissard, & Planchon, 2011)

Sakhy investigated the relationships between: heatwave of 2003, urban morphology and mortality in August 2003. Among the main results, daytime temperatures have weak relationships with morphometric (4) variables and rather strong with vegetation. Also, due to the vast implantation of vegetation, night surface temperatures are lower in some spaces with the help of a less dense urban geometry (well-off suburbs). Conversely in the poorest areas where residential buildings are numerous, night surface temperatures are warmer. (Sakhy, 2016)

Eloi studied how social logics determine environmental degradation and in turn the social consequences of these violations on the human. He mentions

that 90% of the 14,000 victims of the 2003 heatwave were over 65 and whose death was linked to social causes (isolation, poverty). The three heatwaves episodes of summer 2015 were less intense but caused 3,500 additional deaths. (Eloi, 2017)

### 1.5.3. «Mortality/morbidity» sub-theme:

M. Bungener tried to measure excess mortality and characterize it at least broadly by identifying the factors involved. According to the results excess mortality is particularly concentrated in large cities (agglomeration of Paris). The least affected regions are coastal and southern regions traditionally the warmest in France. Only 30% of these deaths are due to causes directly related to the heatwave: (heat stroke, hyperthermia, dehydration). High temperatures can contribute to the very rapid worsening of pre-existing pathologies or to abruptly trigger latent pathologies. The cardiovascular system may be most affected before respiratory diseases and various metabolic disorders. Regarding air conditioning, it is not relevant in the long term because it is pathogenic by strengthening the urban heat and it causes the spread of legionella with sometimes fatal consequences. (Bungener, 2004)

G. Rey and al., stressed both the importance of mortality risks related to heat and the role of populations against these risks as was the case after the heatwave of 2003. There is good agreement between daily variations in temperature and mortality for each heatwave, a gradual increase in mortality as long as temperatures are very high is followed by a rapid decrease as soon as the temperature becomes close to the reference temperature. Heart and respiratory diseases, cancer, violent deaths are a significant part of the excess mortality during the six heatwaves, the proportion of heart diseases in overall excess mortality decreased from 41% in 1975 to 23% in 2003. (Rey, Fouillet, Jouglu, & Hémon, 2007)

Lerch and al., described geographically the evolution of mortality in the last quarter of the 20th century. They had showing that the mortality gradient between rural and urban areas has changed significantly over time. They also analyzed the mechanisms that allowed residents of peripheral areas of large cities to benefit from the lowest levels of mortality. According to their work, urban populations can suffer negative health effects due to air pollution and traffic accidents also lack of time for physical activities. Studies in Western countries have shown that urban populations have particularly high rates of respiratory diseases, lung cancers, obstructive pulmonary diseases and ischemic heart disease. Finally, the elderly with chronic illnesses are particularly vulnerable to heat effects. (Lerch, Oris, & Wanner, 2017)

Chaix and Slama put public health issues at the heart of the climate change research agenda. They suggested that the relationship between temperature and mortality generally follows a U-relationship, with increased mortality at the lowest and highest temperatures for most causes of death. (Chaix & Slama, 2022)

#### **1.5.4. «Urbanization» sub-theme:**

Versini showed that increasing urbanization consumes natural areas. It leads to a reduction of infiltration and evapotranspiration due to the increase of impermeable surfaces (roofs, car park, roads). The result is a great hydrological vulnerability of these territories with the emergence of many risks: floods, saturated sanitation networks and vectors of many pollutants that can spill into waterways, contamination of groundwater, etc. (Versini, 2019)

#### **1.6. Results that are directly related to my problem:**

These results are about the vulnerability of the elderly during heatwaves:

For Pellerin and Hamard, the deaths of elderly people living in their homes showed that for many of them, hyperthermia had as consequence: a rapid and unexpected worsening of early Alzheimer's disease, a depressive conditions that making them unable to make simple gestures and lead to deaths. The National Academy of Medicine recommends paying particular attention to the increase in the longevity of the French population. This fact will lead the elderly to representing soon nearly one third of the population. Also, it is necessary to set up a system of vigilance and receive specific training in geriatrics. (Pellerin & Hamard, 2003)

Bungener evokes that the deaths occurred during the heatwaves are in addition almost exclusively concern elderly people (more than 75 years) and their proportion increases with age (+ 120% at 95 years and more). Their vulnerability depends in part on the adequacy of available medical responses to their specific needs and living conditions. About social vulnerability, it questions more directly: the way of life and take charge the population, the presence of the entourage and the collective solutions installed. Social and financial inequalities increase at the end of life and the individual resources of the elderly constrain them to have a house. It is then located often in places where the convergence of heat islands occurs. (Bungener, 2004)

Delarozière and Sanmarco compared excess mortality of persons over 65 years of age during summer heatwaves before and after an intervention in Marseille. According to their result heatwaves increase mortality for various causes mainly by lung and heart pathologies. For the elderly the gradual

disappearance of perspiration exposes when the heat persists to heat stroke. Before reaching this stage, a fragility is observed linked to the frequent polyopathy (5) at this age. Mortality reached 88 on July 27, when there were 27 deaths per day that same year: 391 more deaths in three weeks than in the previous three weeks, the older women were the most affected. (Delarozière & Sanmarco, 2004)

According to G. Rey and al., the proportion of excess deaths during the 6 heatwaves among people over the age of 75 increased from 62% in 1975 to 80% in 2003. The very high proportions of death related to heatwave among those aged 75 and over reflect both the usual mortality pattern and the increase in excess mortality ratios. The observed and expected over-mortality rates concern more particularly the elderly (unisex). For those aged 75 and over, the observed excess is close to 1,300 deaths while the expected excess mortality reached 5,100 deaths. The excess mortality observed is therefore lower than expected, by nearly 3,800 over the 18 days of the heatwave. (Rey, Fouillet, Jouglu, & Hémon, 2007)

Eady and al., attempted to understand how the elderly perceive the risks of extreme heat. The results indicate that in Waterloo the perception of the risks to the elderly from a heatwave has been realistic. Their real risk and resilience were more influenced by their social situation and their adaptation resources. Even among those with higher incomes and high social support, resilience depended heavily on access to adaptation resources such as air conditioning and tap water. Also, good information on local resources (refreshment centers, water access) could help them to be well prepared for a prolonged extreme heatwave. Showing that the elderly are efficient and active partners in heatwave interventions will reduce vulnerability and increase the ability to cope with such challenges. (Eady, Dreyer, Hey, Riemer, & Wilson, 2020)

Saleh and Buxeraud proposed in their research how to anticipate the heatwave: Through thematic press releases distributed throughout the summer. It allows informing the populations on the health consequences of a heatwave and how to protect themselves from it. They mention that high temperatures are difficult to bear by fragile people especially the old persons who are often polymedicated (6). Some treatments may worsen dehydration syndrome or heat stroke. Exposure to high temperatures can also affect the preservation of medicines. (Saleh & Buxeraud, 2020)

## **2. History of the evolution of knowledge on the phenomenon:**

- It was in (1818) in London that L. Howard made the measurement and the report of this phenomenon. He has specified the causes of a difference in temperatures between the city of London and the countryside.

- In Paris in (1839) E. Renou measured the temperature difference between the city and the countryside, including at night. He said: "...the differences vary widely...so the diurnal curves are not parallel... the temperatures at nine o'clock in the morning at the Observatory are too high and those at nine o'clock in the evening much lower...."
- From (1860) the study of the phenomenon gained momentum in the world through meteorological stations. It evolved technically in the 20th century.
- The Urban Heat Island Study began a new cycle in the 1970s with Oke T. who analyzed well the design of an urban heat island. (Foissard, 2015, p. 10)

### 3. Urban heat islands: definition and concept:

The urban heat island can be defined as a local thermal anomaly at some point. It is dynamic, moving in space, discontinuous in time and depends on many complex parameters related to seasonal contexts but also to weather conditions. (Gramond, 2019, p. 52). Expert Boris Bailly defines urban heat islands differently as "The observed temperature difference between urban and surrounding rural areas..." (Perrin, 2020, p. 9)

It is a phenomenon that affects exclusively urban areas that are overcome by clouds of heat. Its measure differs according to the characteristics of each city (density, relief, architecture, materials, behaviour, etc.) However, it is often the densest urban area that is most exposed to urban heat islands. The perfect climatic period to observe an island of urban heat is characterized by an optimal meteorological state: during a night when the sky is clear and the wind is weak. (Dubreuil, Quénot, Foissard, & Planchon, 2011, p. 106).

### Conclusion:

The temperature threshold between a city and its neighbour varies according to the region and its climate. If we take summer of 2022 as an example the average temperature difference between Oran-Port station (urban area) and Oran Tafraoui station (rural area) is 7.6° (42.5 – 34.9). According to the results of all studies we have identified, age is a basic indicator, because the results show that the victims of heat waves are mostly over 75 years old, and even more if they have chronic diseases. To cope with heat waves, the elderly population must be resilient. Indeed, those with a high income and good social support aren't immune to having good resilience. Their resilience is highly dependent on access to adaptation resources such as air conditioning and water. Also it is necessary to educate the elderly how to behave better in case of severe heatwaves. For its part vegetation is an essential element to cool the city, because it absorbs heat as long as this vegetation must be wide and maintained in a dense city.

## Appendices:

Table 2

*Distribution of the average temperature of summer of 2022 according to the measuring station*

| Station       | Average max temperature |      |      |             | Extreme max temperature |      |      |             |
|---------------|-------------------------|------|------|-------------|-------------------------|------|------|-------------|
|               | Jun                     | July | Aug  | Mean        | Jun                     | July | Aug  | Mean        |
| Oran-Port     | 25,5                    | 26,6 | 28,9 | <b>27,0</b> | 36,2                    | 32,8 | 35,8 | <b>34,9</b> |
| Oran-Taфраoui | 32,4                    | 35,6 | 36,6 | <b>34,9</b> | 41,3                    | 41,9 | 44,4 | <b>42,5</b> |

Source: (Association Infoclimat, 2024)

Note: Means were calculated by us using excel

## Margins:

(1): Refer to an already distant history of the turbulent relations between "environment" and "development" (Bertrand & Simonet, 2012, p. 3). (2): Often used to characterize total reflectivity for solar radiation, therefore at short wavelengths (Cravero, 2023, p. 60). (3): It's about how the characteristics of urban sites influence the urban microclimate in particular the effect of vegetation (Amieur, Rouag Saffidine, & Weber, 2022, p. 1). (4): Such as density, height and volume (Sakhy, 2016, p. 202). (5): Frequency in the elderly (Delarozière & Sanmarco, 2004, p. 14). (6): frequency in elderly who use many medicines (Saleh & Buxeraud, 2020, p. 19).

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