RESHAPING THE CITY: CONTAINING THE URBAN SPRAWL AND REDUCING SOLAR ACCESS ON THE STREETS IN A HOT DESERT CLIMATE CITY

López-Ordóñez, Carlos [1]*; Crespo Cabillo, Isabel [2]; Roset Calzada, Jaume [3]

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Resumen

La mayor parte de los análisis sobre la evolución demográfica mundial apuntan a una previsión de crecimiento de la población de casi el doble para el 2050. Además, se prevé que la proporción de población urbana crezca, del 55% actual al 68% respecto del total. Esta perspectiva genera la necesidad de pensar el presente y el futuro de las ciudades, especialmente de las localizadas en latitudes medias, donde se acumula la mayor parte de esa población. Muchas de estas ciudades tienen un clima desértico y siguen, hasta ahora, un modelo de ciudad dispersa (una gran extensión de la mancha urbana y bajas densidades). Estas características las alejan de los objetivos de sostenibilidad por lo que se debe trabajar para revertir la situación. Uno de los objetivos de este trabajo es el demostrar que una densificación urbana, a través del remodelado y apilado de la ciudad, representa una manera inteligente para contener la expansión de la mancha urbana. Se pretende al mismo tiempo, y dado que el clima juega un papel determinante en este tipo de ciudades, mejorar la calidad de vida en el espacio público urbano mientras se da una respuesta a la creciente demanda de vivienda. Para llevar a cabo este trabajo se estudiará la ciudad de Hermosillo, que cuenta con clima desértico – cálido, localizada en el estado de Sonora en México. Actualmente cuenta con una población de aproximadamente 900,000 habitantes, se espera que para el año 2030 ésta haya aumentado a alrededor de 1, 100,000 y que su área urbana haya crecido de 17,500 ha a 23,000 ha, con una gran demanda de vivienda por satisfacer. La metodología en este trabajo es aplicada a un área de la ciudad de Hermosillo, la cual presenta un uso de suelo dominante, de tipo comercial, y otros usos en menor medida: de equipamiento y vivienda; este tipo de configuración, en conjunto con edificios de baja altura, da lugar a que esta zona cuente con una baja densidad. La metodología se divide en tres etapas: recolección de datos estadísticos, urbanísticos y climáticos; el procesamiento de estos datos y la creación de mapas GIS mediante el software ArcMap, para la tercera etapa, la de evaluación del acceso solar a nivel de calle, se elaboran modelos 3D para su simulación y evaluación por medio de la herramienta de cálculo Heliodon2. Los resultados han demostrado que el llevar a cabo una densificación urbana a través de estos enfoques, y teniendo en cuenta las normas de planificación de Hermosillo, se favorece un aumento de la vivienda en el área de estudio, así como una mejora en el uso del espacio público. Al mantener el promedio actual de m² de espacio de vivienda por persona se alcanza una densificación de población 6.5 veces mayor a la actual, al mismo tiempo se logra una reducción considerable del acceso solar directo a nivel de calle, lo cual favorece al confort térmico del peatón, traduciéndose en una mayor calidad de vida urbana. En este trabajo se llega a la conclusión de que la densificación urbana, mediante este tipo de enfoques, genera la posibilidad de brindar vivienda de calidad (en cuanto al espacio habitable de cada vivienda), mientras que al mismo tiempo se logra contener la expansión de la mancha urbana. En cuanto a la mejora de las condiciones del espacio público, se consigue que la generación de sombra sobre el mismo sea mediante el uso de la misma forma de la ciudad.

Abstract

Most of the studies on world demographic evolution point to a population growth foresight of almost double by 2050. Also, the proportion of the urban population is expected to grow, from the current 55% to 68% of the total. This perspective generates the need to think about the present and future cities, especially those located in mid – latitudes,

[1] AiEM – ETSAB, Universitat Politècnica de Catalunya, https://orcid.org/0000-0002-4199-9813; [2] AiEM – ETSAV, Universitat Politècnica de Catalunya, https://orcid.org/0000-0002-2422-0935; [3] AiEM – Departamento de Física, ETSAB, Universitat Politècnica de Catalunya, https://orcid.org/0000-0002-0548-5524. * Correo de contacto: carlos.fernando.lopez@upc.edu

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where most of that populations accumulates. Many of these cities have a hot desert climate and follow, until now, a dispersed city model (a large extension of the urban area and low densities). These characteristics move them away from the sustainability objectives, so work must be done to reverse the situation. One of the objectives of this work is to demonstrate that urban densification, through the reshaping and stacking of the city, represents an intelligent way to contain the urban sprawl. At the same time, and given that the climate plays a decisive role in these types of cities, in this study is intended to improve the quality of life in the urban public space while answering the growing housing demand. To carry out this work, a hot desert climate city was selected, Hermosillo. The city is located in the state of Sonora in Mexico. It currently has a population of approximately 900,000 inhabitants, it is expected that by the year 2030 it will have increased to around 1,100,000 inhabitants. Therefore, its urban area will go from 17, 500 hectares to almost 23,000 hectares, all of this will create a great housing demand to meet. The methodology in this work is applied to an area of Hermosillo. In this area, the dominant type of land use is commercial, but it also presents other uses to a lesser extent: urban equipment and housing. This type of configuration, together with low-rise buildings, results in an area with low density. The methodology of this study is divided into three stages. The first is the collection of statistical, urban and climatological data. Second, the processing of this data and the creation of GIS-based maps using the ArcMap software. The third stage is the assessment of the solar access at street level, for this, 3D models were elaborated for simulation and evaluation using the Heliodon2 calculation tool. The results have shown that carrying out urban densification through these approaches, and taking into account the planning regulations of Hermosillo favors the increase, favors the increase of housing in the study area, as well as an improvement in the use of public space. A 6.5 times higher density than the actual is achieved by maintaining the current average ratio of square meters of living space per person. At the same time, a considerable reduction of direct solar access at street level is produced. This favors the pedestrian's thermal comfort, resulting in an improvement in the quality of urban life. This paper concludes that urban densification through these types of approaches generates the possibility to provide quality housing (in terms of habitable space of each dwelling). At the same time, it makes possible the contention of the urban sprawl. As for the improvement of the public spaces conditions, the generation of shade upon the urban space is achieved by using the form of the city itself.

Palabras Clave: Dispersión urbana; Ciudad de Clima Desértico; Densidad Urbana; Acceso Solar

Key words: Urban Sprawl; Hot Desert Climate City; Urban Density, Solar Access

1. Introduction

Urban space livability is a key aspect for the quality of the citizen's life. In a dispersed city this kind of livability is difficult to obtain, one of its causes is that the urban sprawl has extended excessively and created distances too long for pedestrian use (Frumkin, 2002; Gehl, 2010; Pozueta Echavarri, Lamíquiz Daudén, & Porto Eschettino, 2013).

According to the United Nations (United Nations, Department of Economic and Social Affairs, & Population Division, 2019), by the year 2050, the world's population in expected to nearly double, making urbanization one of the twenty-first century most transformative trends. Populations, economic activities, social and cultural interactions, as well as environmental and humanitarian impacts, are increasingly concentrated in cities, and this poses massive sustainability challenges in terms of housing, infrastructure, basic services, safety and natural resources among others.

This scenario, together with the current environmental crisis, justifies the need to think about the future of cities. This reopens a debate that has been going on for more than a century between the supporters of the compact city model and those of the disperse city model (García-Nevado, 2019).

1.1 The urban density and the hot desert climate city

Urban density is one of the most used parameters to measure life quality in a city (Dovey & Pafka, 2014). High density and compact city morphology are often seen as prerequisites for sustainable urbanization and economic growth (Berghauser Pont & Haupt, 2009).

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In this study, when talking about urban density, it is referring to urban population density (inhabitants per hectare).

Even though high density seems to be the ideal to follow, the current pace of urban growth is leading us to lower densities by increasing open spaces in cities, fracturing them and creating great distances to cover (Angel et al., 2016).

The cities located in medium latitudes, between 20º and 33º north and south latitude, are where the greatest amount of world population is concentrated (Datagraver, 2016). A big number of these cities present a hot desert climate and follow the dispersed city model: single-story dwellings and low densities, all this boosted by the use of the automobile. This leads to a poor public space and a continuous demand for land for housing developments (Jacobs, 1961; López-Ordóñez, Crespo, & Roset, 2018).

In the American continent, cities such as Phoenix, Tucson, Las Vegas in the US (Ewing & Hamidi, 2014) and Hermosillo, Mexicali or Ciudad Juarez in Mexico, follow this growth pattern (López-Ordóñez, Crespo, Roset, & Coch, 2019), and it is in this framework that the study on how to densify takes big importance due to its relation with the quality of the urban life and housing.

Mohamed Amer (Amer, Mustafa, Teller, Attia, & Reiter, 2017) indicates the existence of different approaches to densify and how they are implemented. The first method is the densification by filling the “backyards” of existing buildings. The second method is the infill development, this is the process of closing the gaps and vacant lots between buildings in the city. The third method is reshaping, meaning the demolition of existing low-density buildings and replacing them with higher-density constructions.

A fourth method is densification through roof stacking, this is simply the addition of stories to existing buildings to accommodate dwellings. All of these methods have its advantages and disadvantages. The selection of how to densify is responsibility of the local authorities and must be implemented while taking into consideration geology, climate, urban morphology, types of buildings, mobility behaviors, transportation networks, etc.

A study carried out in the Saudi city of Jeddah concludes that, in these types of urban layouts, is not possible to provide shade with the existing urban morphology. Therefore other solar radiation strategies should be considered (Masoud, Coch, & Beckers, 2019). Since the city of Jeddah has areas with a similar layout to the cities mentioned before and considering that not only a high urban density must be achieved, but also an improvement in urban life, reshaping and stacking are the approaches of this work.

For this study, a formal model similar to the city blocks of Barcelona’s Eixample district has been proposed. In this model the original layout was conserved within the study area: the width and orientation of its streets were not modified, both the historical heritage buildings and public squares were maintained, as well as its urban equipment (the municipal market, schools, hospitals, etc.)

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2. Objectives of the study

This study aims to demonstrate that urban densification through reshaping and stacking the cities in hot desert climates represents an intelligent and efficient way to contain the growth of the urban sprawl and to enhance urban life, using the morphology of the city as a generator of shade. This is important in cities with water shortage problems, and it has been the traditional answer in hot desert climate cities created before the use of automobile (Ali-Toudert, 2005; Coch & Serra, 1995).

At the same time, it could be an answer to the problem of providing quality housing to a population in constant growth in these cities. Densification could contribute to reduce the distances, therefore the use of the automobile, and increase pedestrian transit improving safety in public space. The increase in the skyline height that this densification entails reduces solar access at street level.

Even though that a high density may present some important risks, such as increasing air pollution and congestion, increasing the heat island intensity and wind discomfort (Amer et al., 2017), the principal problem for cities in this type of climate is the direct solar radiation. I.e., if the air temperature hits the 40ºC, the people could benefit at least of an adequate urban public space that provides shelter from the sun.

3. Methodology and data

The methodology used in this study considers two approaches to carry out a population and building densification in a specific area of a city, hence, is not meant to be used for an entire city. In this work the methodology is applied to an area that presents mainly a commercial use, meaning a low urban population density.

The methodology followed is divided into three phases, and each is explained in the next lines. The two first phases consist in data collection and processing, the third assess the solar access at street level of the proposed layout.

3.1 Data collection

The statistical data used is from the National Institute of Statistic and Geography (INEGI): the population data at local level, the mean of m² of housing per person in the city, etc. The urban data is from the municipality of Hermosillo: the regulations, the distribution of dwellings, public squares, commercial premises and urban equipment in the study area. The climatological data of the National Meteorological Service (SMN) and the Energy, Environment and Architecture Laboratory (LEMA), located next to the study area.

3.2 Data processing

In this phase takes place the creation of different GIS-based maps with the information processed, this is made to improve the comprehension of the data collected, the data clustering method used for the classification of urban density is the Jenks natural breaks. A suitable for the densification approach area is selected, in this case, the city center. The software used is

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ArcMap (ESRI, 2015). Only after taking into consideration these two phases, the kind of approach to densify can be selected and applied in the study.

3.3 Solar access assessment

Finally, the solar radiation calculation program Heliodon2 (Beckers, 2009) helped to assess the solar access at street level in the selected area, both actual and proposed situation, for this assessment, 3D models must be built and simulated.

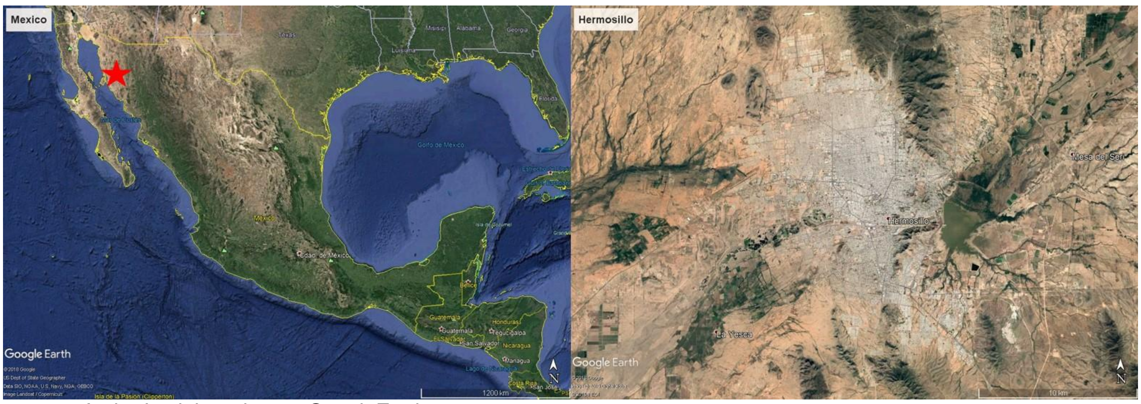
For this study, the *aspect ratio*[2] of the streets is increased to *h/w*= 1 as a fixed value. This translates into a reduction of the *sky view factor* [3] *(svf)* of the streets, which leads to a decrease in solar access at street level. This decision was made after reviewing previous studies about direct solar radiation on the streets of Hermosillo (López-Ordóñez et al., 2018), in the city of Barcelona. (Coch, Crespo, & Serra-Coch, 2016; García-Nevado, Pages-Ramon, & Coch, 2016; López-Ordóñez, 2015; López-Ordóñez, Roset, & Rojas-Cortorreal, 2017) and authors such as Arnfield (Arnfield, 1990) and Oke (Oke, 1988).

A network of the most representative and busy streets in the area is analyzed to perform this study. This assessment is carried out during the hot season (from May to October). This period presents high temperatures and levels of direct solar radiation, which directly influences the comfort in the urban public space, conditioning its use by pedestrians during the day.

4. Case study: The city of Hermosillo, Mexico

Hermosillo (29º LN) is located in the Mexican state of Sonora, within the Sonoran Desert. It follows a scattered pattern of urban growth. It has a hot desert climate (BWh, Köppen climate classification) with an annual mean temperature of 25ºC and a mean relative humidity of 43%, during the hot season, Hermosillo presents extreme temperatures of 40-45ºC. It presents an annual mean solar radiation of 5.84 kWh/m^2·day.

Figure 1. **Location of Hermosillo in relation to Mexico (left), a satellite photo of the city spreading through the desert (right)**



Source: Author's elaboration on GoogleEarth, 2019.

[2] Aspect ratio is the geometric proportion that exists between the height of adjacent buildings in a street and the width of it (h/w).
[3] Sky View Factor (SVF): Percentage of the sky seen from a point located in any Surface.

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Table 1. **Monthly data of average maximum temperature (AMT), mean temperature (MT), average minimum temperature (AmT) and relative humidity % (RH), and global horizontal radiation (kWh/m²)**

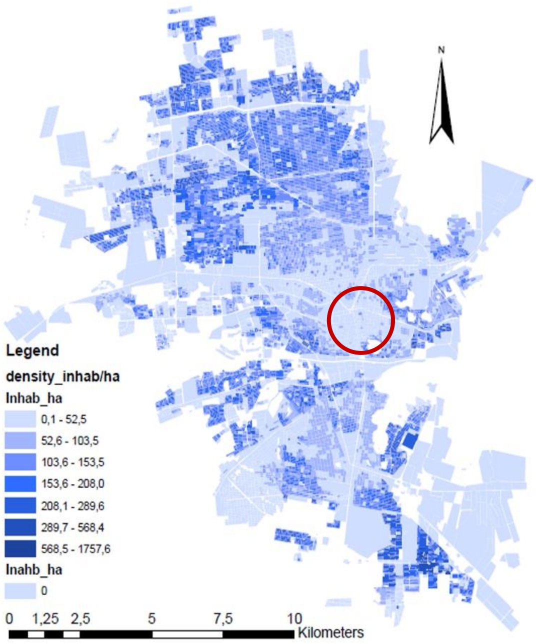
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AMT ºC	24.2	25.8	28.7	32.3	36.3	39.8	39.3	38.3	37.5	33.9	28.6	24.0
MT ºC	17.2	18.5	18.5	24.1	27.9	31.8	32.5	31.9	31.0	26.9	21.3	17.1
AmT ºC	10.2	11.3	11.3	15.9	19.4	23.8	25.8	25.6	24.6	19.8	14.0	10.2
HR (%)	48	44	40	34	31	34	48	53	48	42	43	49
kWh/m²	3.88	4.76	6.34	7.45	7.73	7.59	7.07	6.88	5.74	5.23	4.11	3.25

Source: The National Meteorological Service (Servicio Meteorologico Nacional (SMN), 2019) and the Energy, Environment and Architecture Laboratory (LEMA, 2019).

Hermosillo is the capital and biggest city of Sonora, since the 20th century it has maintained an accelerated rate of urban and population growth. In 1990 the urban area was close to 7,500 ha with a population of almost 450,000 inhabitants, in 2015 the new urban area was approximated to 17,500 ha (+134%) and a population of around 900,000 inhabitants (+97%), most of this area is housing (H. Ayuntamiento de Hermosillo, 2014, 2016; Instituto Nacional de Estadística y Geografía (INEGI), 1990, 2016). Hermosillo is expected to have in 2030 a population close to 1,100,000 inhabitants. If the city continues its growth rate, the new urban area will be around 23,000 ha, with a high housing demand to satisfy.

As mentioned, the growth of Hermosillo in the last 30 years, together with a housing policy that has favored the construction of single-family dwellings in closed neighborhoods, has cause the city to present an irregular distribution of the population. Usually, cities follow the same trend: urban density begins to decline as the distance from the city center increases. In the case of Hermosillo, an opposite behavior takes place, which means that its urban center has a very low urban density. The growth of Hermosillo has been mainly in north and south direction. It is in these areas of the city where the highest levels of urban density are found.

Figure 2. **Actual distribution of the urban population density in Hermosillo**



Source: Author's elaboration on ArcMap with data from the INEGI, 2019.

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The current urban population density of the city is that of 47 inhabitants per hectare. This value is at the bottom when compared at a global scale of urban population density and pales when compared to cities considered as examples of sustainability, e.g. Barcelona 159 inhab/ha, Paris 203 inhab/ha or Manhattan 282 inhab/ha. At the same time, this value is far from what historical cities in the same type of climate present, e.g. Cairo 157 inhab/ha or Alexandria 143 inhab/ha. It is also important to indicate, that in the frame of this work, the average dwelling in Hermosillo is located on a plot of 120 m², while the average family varies between 3 and 4 members. The mean ratio of housing space per person is 35 m².

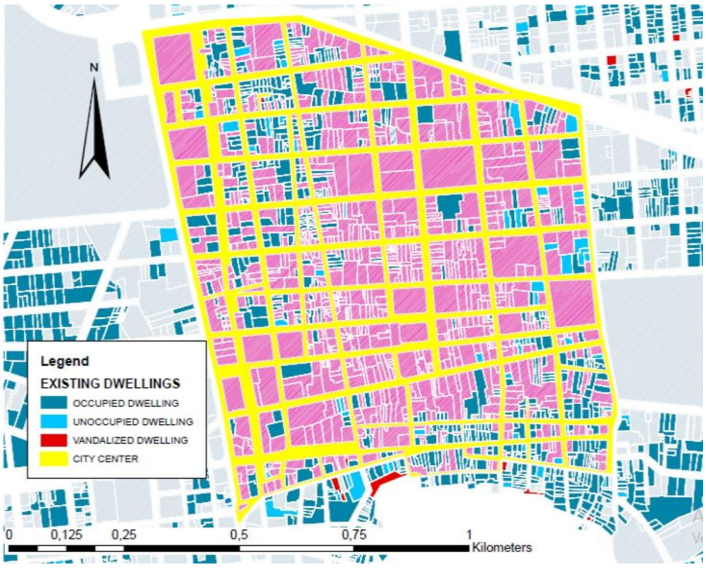
It is from this situation that interest to study different approaches of urban densification in the city center area arises. As mentioned in the objectives of this work. The effect of the stacking approach has been studied in the city of Hermosillo (López-Ordóñez et al., 2018). It was an exercise to enhance the quality of urban life by reducing direct solar radiation on the street level. Although this theoretical approach proved to be interesting, at a practical level it presents some limitations.

When using only this approach, some difficulties come to light: the irregular type of construction that is present in the study area, a large number of buildings that have metal roofs, others buildings do not have the structural capacity to support the stacking of new stories. These are not the only issues the urban area has. It exhibits a highly irregular plot distribution, with city blocks that are completely covered by various types of construction, leading to other kinds of problems such as soil permeability, lack of green areas, etc.

5. Outcomes of densifying the city center of Hermosillo

The city center is characterized as being a busy shopping area during the day. It works as a nerve center and concentrates most bus lines, so it has a high number of pedestrians during the day. However, this changes during the night after the stores close. It becomes an unsafe area for walking, and this could be due, in part, to the lack of inhabitants in the area.

Figure 3. **Location of dwellings within the city center**



Source: Author's elaboration on ArcMap with data from the Municipality of Hermosillo, 2019.

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As shown in the figure 3, the area for housing is small in comparison to the total area of the city center (is the 13%, 10 ha for housing against a total of 82 ha). The remaining 72 ha are divided into 42 ha for mixed-use (51%) and 20 ha (36%) for public space and urban equipment (roadways, sidewalks, squares, schools, etc.). The public space, the streets, are shared with cars. The streets have a geometry with adjacent 1 or 2 story buildings and widths that vary between 9 and 27 meters. Thus, its streets have a small aspect ratio, therefore, a high sky view factor. This translates into a high degree of solar access at street level, increasing the radiant temperature on the surfaces that define public space. The radiant temperature of a surface has considerably different values if it receives solar radiation directly or if it is in the projected shadow of a building. It is a dynamic condition that changes during the day and throughout the year. This, added to the elevated air temperature, increases the level of thermal discomfort of the pedestrian and inhibits its use for walking.

Figure 4. **Photographs and stereographic diagram of two of the analyzed streets**

Source: Author's elaboration with Google Earth and Heliodon2, 2019.

5.1 Urban regulations and configurations

The maximum allowable building height in Hermosillo is defined by the construction regulations. In this regulations, it is specified that "no building may have a height greater than 1.5X the width of the street. In the case of being on a corner, the widest street will be considered". As can be seen, there is no maximum number of levels specified. In the urban development plan, it is specified that in the urban center the maximum allowed *GSI*[4] is 0.9 m^2/m^2, while the maximum *FSI*[5] is 2.7 m^2/m^2. When analyzing at the city block scale, in most of the cases, these density indicators are not met. The GSI is rarely below the maximum value, and by being in an area with low-rise buildings, the FSI has considerably low values.

Since the city center is one of the oldest zones in the city, there are some heritage buildings, such as the municipal market, schools, squares, and parks. These places are protected, so for this work, they will not be considered for densification, yet, they will be mapped. It is important to indicate that there are abandoned buildings which can be incorporated into the line of this work.

In this type of work, it is important to keep public parking lots that already have a solid structure, since having enough parking spaces is a requirement for the acceptance of this type of planning. Parking lots that are outdoors, usually in unoccupied plots, should be integrated into the planning to avoid the proliferation of this type of parking. Although each case could be

[4] GSI, Ground Space Index: it is the relationship between the built space and the unbuilt space. The coverage of the floor. (building footprint m^2/ plots area m^2)

[5] FSI, Floor Space Index: it reflects the intensity of the space built over a given area. The building intensity. (total built area m^2 / plots area m^2)

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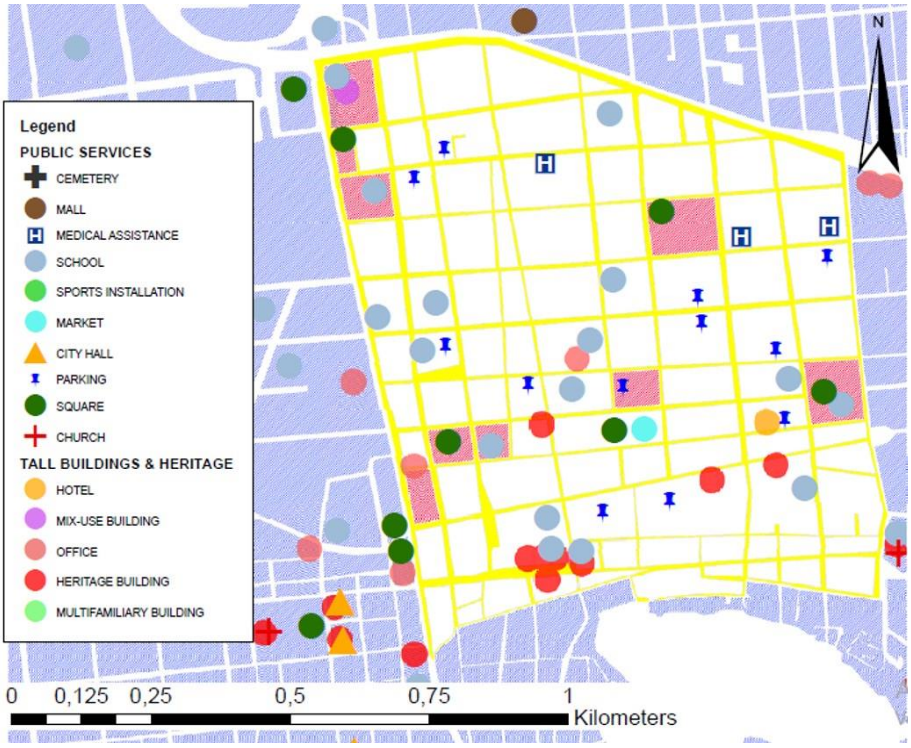
treated independently, the municipal authorities could increase or provide parking lots (by concession to third parties) and thus be able to meet the new demand.

Figure 5. **Public services, heritage buildings and existing tall buildings**



Source: Author's elaboration on ArcMap with data from the Municipality of Hermosillo, 2019.

6. Findings and discussion

The urban and building regulations of Hermosillo, together with other density indicators (FSI, GSI, number of dwellings per hectare) were taken into account for the densification approach, enabling a significant increment of potential dwellings therefore of inhabitants.

The population density of the city is 47 inhabitants per hectare. By maintaining the current mean ratio of m^2 of housing space per inhabitant (35 m^2 per person) and by carrying out densification by re-shaping and stacking, it can be achieved in the city center a densification 6.5 times higher (325 inhabitants per hectare), this value is similar to the one in the Eixample district in Barcelona (360 inhabitants per hectare).

Two paths were considered to calculate the new density of the area. The one used in this study (case A) was to work with the ratio of space housing per inhabitant (35 m^2). The other (case B) is through the relation between square meters of new housing and the number of possible average dwellings (120 m^2) that can be obtained. Once this, the number of inhabitants can be calculated (considering the average family size, 3- 4 persons). The selection of the method was made considering that the population density should not be conditioned only by the size of the new dwellings, thus providing a greater range for the calculation.

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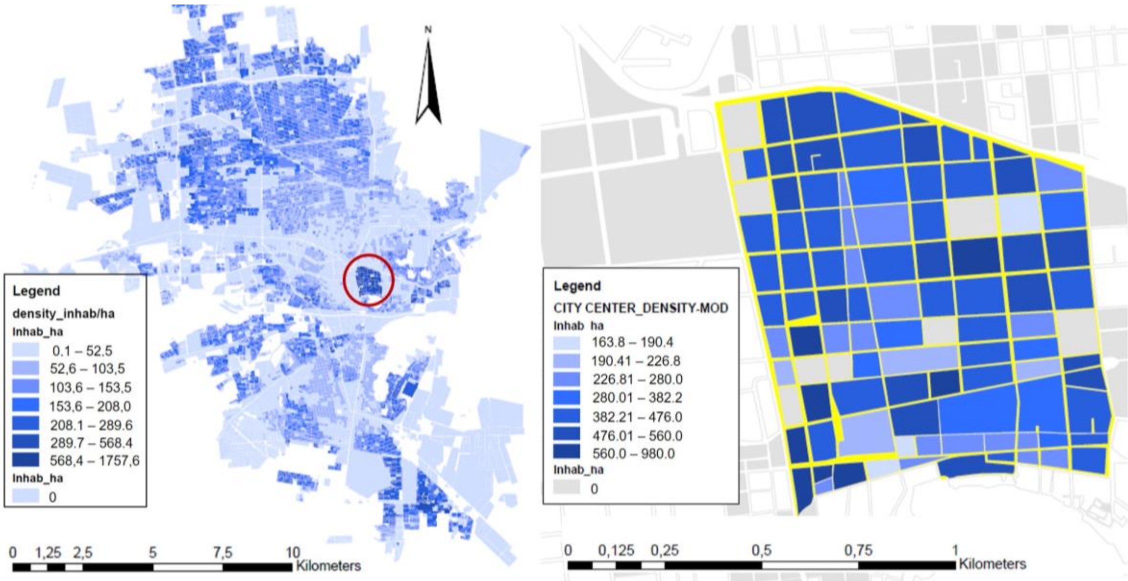
Figure 6. **The new city center urban density values (Inhabitants per hectare)**



Source: Author's elaboration on ArcMap with data from the INEGI, 2019.

Table 2. **Urban density parameters applied to the city blocks in the area**

Case	GSI (avg)	FSI (avg)	Mixed-Use ha	Housing ha	Inhab/ha (avg)	Height (levels avg)
Actual	0.77	0.80	42.13	10.21	17.30	1
Case A	*0.70*	*2.85*	*39.63*	*93.65*	*325.00*	*PB + 5*
Case B	0.80	3.17	45.29	107.03	371.80	PB + 5
Case C	0.70	2.85	39.63	93.65	284.70	PB + 5

Source: Author's elaboration with data from the Municipality of Hermosillo, 2019.

Some of the values shown in Table 2 were given by the guidelines of the municipal authorities: GSI ≤ 0.90, building height ≤ 1.5x the width of the street. However, it was considered that the established value of FSI ≤ 2.70 is insufficient for an urban block scale. Therefore, it was decided to raise it accordingly to each city block and to compensate its raise by using a GSI= 0.70, thus leaving 30% of permeable soil.

However, it can be decided to increase the GSI parameter and thus obtain a larger mixed-use and housing area (case C). All this at the cost of sacrificing open space, that is, a permeable area capable of being used as public urban space.

The total area of new housing that could be located in the city center instead of continue the sprawling is 83.5 ha. Considering that the actual housing area in the city center is 10 ha (12.4%), the new total of housing space would be 93.7 ha.

Concerning the network of streets studied, there is a significant solar access reduction during the proposed analysis period (the hot season: May – October). There is a reduction of 26% (from receiving 5.10 kWh/m² per day to 3.80 kWh/m² per day). This is due to the increase in the height of the adjacent buildings in the street. Therefore, there is a greater aspect ratio and a lower value of the sky view factor. This can be seen in the following graphs.

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Figure 7. **Results of the hot season simulations. Figures 1A (actual situation) and 1B (case A) show the behavior of direct solar radiation at street level. Figures 2A and 2B show the number of hours of direct sunlight**

Source: Author's elaboration with Heliodon2, 2019.

These graphs are the result of simulations carried out in Heliodon2. The hot season has been simulated, from May to October (184 days), and the calculation was made with a grid precision of 15 minutes. As it is a street network, the results of the received direct solar radiation are expressed in kWh/m² per day. The results of the number of hours of direct sunlight are expressed in an average of daily hours.

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As mentioned before, the raise of the building's height translates into a significant reduction of the amount of energy received during the hot season. This translates into 32% fewer hours of direct sunlight; it goes from receiving 8:33 hours a day at 5:51.

The same procedure was applied to analyze the month of June, a month with high solar radiation and temperatures. It is possible to reduce the number of direct sunlight by 25% (from 9:16 to 6:56 hours), while the received direct solar radiation goes from 6.10 kWh/² per day to 4.95 kWh/m² per day, which is a reduction of 19%.

According to measurements taken during June (19/06 – 23/06) in the study area, the difference in temperature between a shaded surface and one that receives direct solar radiation can reach 37ºC at noon. An asphalted surface that is shaded throughout the day presents a temperature at noon of 32ºC – 35ºC. A surface that receives direct solar radiation at different times of the day presents temperatures at noon that range between 37ºC – 69ºC.

7. Conclusions

This approach gives possibility of providing quality housing without increasing urban sprawl and improves urban life by shading the public space. The city is expected to go from 900,000 to 1,100,000 inhabitants in 2030, an increase of +22%. By carrying out the densification of the urban center, such as the one proposed in this work, it could accommodate 13.5% of the 200,000 new inhabitants.

By providing shade to the streets with the city itself, the radiant temperatures of the surfaces can drop from 70ºC to almost 30ºC. This could mean an improvement for the urban life. It is important to emphasize that the hours of shade that are gained in cities located in a hot desert climate are potentially hours of use of the public space for leisure.

As an urban planning strategy, this type of studies could be useful to city planners and municipal authorities. The approach addressed in this work could be used and repeated strategically in different areas of the city, thus leading to the creation of urban sub-centers. These new sub-centers could act as shelters against solar radiation in cities with a hot desert climate, thus creating a network of key spaces with good urban life quality. This could be considered as a type of urban acupuncture.

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