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Strategy for sustainable urban revitalization in a heritage tourist city with a Sub-humid Temperate climate

Estrategia de revitalización urbana sostenible en una ciudad turística patrimonial de clima templado subhúmedo

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Abstract

The environmental quality of urban public and tourist spaces affect the development of the activities of the large number of users in heritage cities, where the concept of sustainability continues to be one of the main interests for researchers around the world. Nowadays, numerous indices have been developed to determine the liveability of urban spaces; however, there are localities that, due to their topographical characteristics, tourist and social activities require methods to generate revitalisation strategies according to their characteristics. In this study, an exploratory longitudinal method was used in a central street of a world heritage city with a temperate sub-humid climate as a case study, with the objective of favouring, by passive means, thermal habitability conditions in a heritage urban space focused on promoting pedestrian mobility. As a result, an urban revitalisation strategy for the benefit of society and tourists in heritage cities was obtained to strengthen sustainable urban mobility strategies.

Historic Centres, Urban Revitalisation, Sustainable Habitability, Urban Mobility, Touristic Centres

Resumen

La calidad ambiental de los espacios urbanos públicos y turísticos afecta al desarrollo de las actividades del gran número de usuarios en las ciudades patrimoniales, donde el concepto de sostenibilidad sigue siendo uno de los principales intereses para los investigadores de todo el mundo. En la actualidad, se han desarrollado numerosos índices para determinar la habitabilidad de los espacios urbanos; sin embargo, existen localidades que por sus características topográficas, turísticas y sociales requieren de métodos para generar estrategias de revitalización acordes a sus características. En este estudio se utilizó un método longitudinal exploratorio en una calle central de una ciudad patrimonio de la humanidad con clima templado subhúmedo como caso de estudio, con el objetivo de favorecer, por medios pasivos, las condiciones de habitabilidad térmica en un espacio urbano patrimonial enfocado a promover la movilidad peatonal. Como resultado, se obtuvo una estrategia de revitalización urbana en beneficio de la sociedad y de los turistas en las ciudades patrimoniales para reforzar las estrategias de movilidad urbana sostenible.

Centros Históricos, Revitalización Urbana, Habitabilidad Sostenible, Movilidad Urbana, Centros Turísticos

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1. Introduction

Public spaces in tourist cities are key elements for sustainable urban development, especially in areas linked to the city centre where many tourists and inhabitants converge. Solar incidence in warm and temperate climates implies a decrease in the interaction of users with the public space, which could result in health problems such as headaches, sunstroke, among others. The absence of thermal comfort in public spaces is a stress factor for the organism that leads to chronic illnesses in the population [1], and an increase in vehicle traffic that generates high levels of pollution [2] and it is related to problems such as the Urban Heat Island, among others.

Management in urban heritage destinations considers tourism as an inherent component of territorial development. It promotes a balance between resources, the impacts of the activity, the quality of the tourist experience and the well-being of residents, i.e., the sustainability of development [3]. The strategic purpose of cultural heritage has not yet been fully exploited. Most projects still fail to take advantage of its cross-cutting nature, especially in terms of linking areas such as tourism, education and culture [4].

The objective of the urban approach is to ensure comfortable and safe environments [5]. It is common to find urban spaces with radiative gains that affect directly the user's thermal comfort, especially in historic cities, where the concepts of sustainability and thermal comfort in outdoor spaces were not considered from the beginning. This leads to uncertainty in the use of public space. Rosas et al. recommended the use of shading and vegetation as passive systems to reduce the incidence of solar radiation in urban spaces [6]. Kang et al. found that trees significantly improved pedestrian comfort in relation to wind, even in regions with high buildings, where comfort decreased quantitatively [7].

This issue has been studied from different perspectives and methods of study. From the increase and impact of public green spaces as part of the global interest in sustainable urban development [6–8]; or the relationship between urban sprawl [9,10] and environmental change [11].

Among other proposals focused on improving or preserving the environmental quality of urban spaces for the benefit of users. One of the main characteristics of the case study was the large number of users due to the constant occupation of tourist cities such as Guanajuato. According to the Ministry of Tourism in Mexico, a 56.47% occupancy rate was observed nationally in 2019. While in Guanajuato, it was 38.84% for the same year, with more than 5 million tourists [12].

In contrast to public urban spaces in cities with minor restrictions, sustainable urban strategies in world heritage cities with high tourist occupancy rates throughout the year, require a strategic analysis to reduce the possible uncertainties according to the climate in which they operate. For the intrinsic historical and cultural value, and to ensure the preservation and revitalisation of public urban space in terms of pedestrian mobility directly related to central areas. To address this issue from the perspective of revitalisation, a concept commonly used in projects that seek to repopulate central areas, especially those with important historical heritage [13], a preliminary study to promote sustainable mobility as a key planning instrument was determined to be conducted, especially in tourist cities, due to its economic and social impact [14].

Therefore, a sustainable urban revitalisation study was conducted as a strategy for thermal improvement and reduction of solar gains during the summer period (season of greatest discomfort due to solar radiation). To increase pedestrian use in a central street with a temperate sub-humid climate; such as the city of Guanajuato, providing users with a more thermally convenient space to promote pedestrian and sustainable mobility, in hours with greater period of occupation and vehicular traffic.

Climatic conditions are a key element in the proposal for sustainable urban revitalisation due to the variations that a temperate climate presents throughout the year and do not correspond to extreme climates, where the need for cooling or heating is more punctual according to each season. The variations of temperate climates, which are not extreme, represent a challenge for sustainable revitalisation in a tourist city such as the one determined in this study.

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Therefore, the objective was to analyse the current conditions of the public urban space to generate a revitalisation strategy that promotes pedestrian traffic for local users and tourists in a heritage city with a temperate sub-humid climate focused on reducing thermal discomfort. To achieve this objective, the strategy was studied from passive systems that meet sustainability parameters, since it contemplated the social, ecological and economic aspects, generating a viable project for the benefit of users and the locality.

The particular characteristics of the benchmark case, its materials and construction systems, which imply limitations related to its preservation, and which were not considered to respond to climate-related changes such as those occurring today, were considered the first limitations for completing this manuscript. The scope corresponds to the realisation of a revitalisation proposal analysed from a heritage urban space, whose findings will be extended with field measurements in different seasons, and thermal simulations to expand the social impact and results in this study.

2. Background

International organisations and communities recognise that human interventions impact climate, ecosystems and human health [15], and proposed the generation of studies that contribute to the improvement of the quality of the urban environment with passive systems. Such is the case of sustainable urban revitalisation, defined as actions and processes in a city that address interrelated spatial and socio-economic problems to reduce environmental impact, mitigate environmental risk and improve the environmental quality of systems, lifestyles with an emphasis on inner city areas of older cities [16].

Awad et al. assessed the importance of sustainable urban revitalisation with surveys of experts in the field and found that improving existing physical conditions is the top priority, not only focused on improving transport infrastructure, but also more inclusive urban infrastructure such as streetscape, open spaces, among others [17]. The development of sustainable studies that favour mobility and encourage intra-urban travel is an objective of the Decalogue of tourism competitiveness of urban destinations [14].

However, the study by Tumini et al. [18] in relation to urban spaces with temperate and warm climates found that the thermal assessment for outdoor spaces in the steady state, is not very representative for representing the thermal sensation of users.

Heritage cities that are also tourist cities have urban spaces that should necessarily be accessible to pedestrians. Sara et al. showed the role of pedestrians and their behaviour towards mobility capacity for a good development of public space [19].

With this background, we addressed the strong international need to improve the conditions of public urban space to achieve or maintain the user's comfort, under elements of sustainability; generating a strategy of urban revitalisation in a tourist heritage city with high occupancy rates throughout the year to promote pedestrian mobility; and thus, propose sustainable solutions.

The main innovation of this study consisted in making a proposal focused on improving the current conditions of a public urban space in a world heritage city with high levels of tourist occupation in a sub-humid temperate climate, and with the potential to expand to a mixed study and thus replicate in other climates and increase the social impact.

3. Methodology

To achieve the objectives of this preliminary study, an exploratory longitudinal method was used [20]. As it is one of the first approaches to the proposed phenomenon from a sustainability and pedestrian mobility perspective, which consisted of pedestrian routes through the study area in different climatic seasons during 2021.

To empirically observe occupancy levels and the feasibility of a sustainable urban revitalisation strategy. With this preliminary data, the benchmark case and its main characteristics were defined. Due to the topography of the locality, the study transect was divided into sections, to analyse the shadows produced throughout the year and finally determine passive strategies with potential for thermal improvement and increase of habitability conditions, prioritising sustainable pedestrian mobility in a world heritage city with a sub-humid temperate climate.

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3.1 Benchmark case

The benchmark case corresponds to Del Padre Belaunzarán street in Guanajuato city, Mexico; inaugurated in 1951 (see commemorative plaque in Figure 1). And one of the most important cities during the viceroyalty for its production of gold and silver in the 18th century [21]. The Guanajuato River used to flow through this street, which was redirected with an underground pipe that is located underneath it. During the second half of the 19th century and the first third of the 20th century, most of the infrastructure, housing construction and equipment works were carried out in Guanajuato city [22]. This street connects the west with the city centre.

Walking along this transect, part of the oldest houses that discharged their sewage into the Guanajuato River can be appreciate. Unique features that generate expectations among the millions of national and international tourists that have been visiting this world heritage city since 1988 [21].

Figure 1 Commemorative plaque on Del Padre Belaunzarán Street

The determined street was chosen as a benchmark case because it is one of the most heavily trafficked by cars (between 10 and 12 cars per minute on slower days), due to the thermal stress that reduces its pedestrian use during most of the day, even with pavements of 2 and even 3 metres at some points. Between Figure 2a (taken in 1955) and 2b (from 2021), some variations are observed, such as the incorporation of electric power and the increase of buildings in the background.

Figure 2 Del Padre Belaunzarán Street
Source: a) [23], *b) (Martínez, 2021)*

Figure 2 shows in one section, the organic form of the selected street; the height of the adjacent buildings and a comparison at two points in history, the first in 1955 and the second in 2021. This figure also demonstrates a minimal variation of the public urban space with a difference of 66 years.

According to the climatic normal of the National Meteorological System [24], and to the climatic characterisation developed by Gómez-Azpeitia [25]; The climatological data for Guanajuato city correspond to a sub-humid temperate climate. With two seasons, a warmer one (Season A) from April to September, with an average temperature of 20.6 °C and, a season with temperate characteristics (Season B) in January, February, March, October, November and December with an average temperature of 17 °C. In Season A, a higher heat stress is present. An average horizontal s/p radiation level on a typical cloudy day of 8469 W/m² was observed, while in Season B this value decreased to 6402 W/m², so it was determined to focus the urban revitalisation on Season A, which corresponds to the period with the highest sunshine.

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As it was planned in another era, the construction of this street did not contemplate a thermal study or the need for sustainable strategies to promote urban and tourist mobility developed over the last few decades. Therefore, the analysis carried out could benefit other case studies with particular characteristics such as those presented in this research using the methods presented below.

3.2 Methods

To analyse the given street, pedestrian walks were carried out periodically during one year; and it was decided to divide the transect into four sections (S1 to S4) indicated in Figure 3. Where the organic form of this street and the point of connection with the central area of this locality were also observed to propose the methodology in the following sections.

Figure 3 The transect of Del Padre Belaunzarán Street. *Own elaboration with data from* [26].

The shape of the transect itself, with different orientations, implied differences in heat transfer along this street, so the proposed sections allowed the analysis of shadows at different points.

With the route divided into sections for the pedestrian route to the city centre, a shadow study was generated for each section (S1 to S4) in Sketchup® from the urban layout (Figure 4). This study was analysed for one year.

Guanajuato (benchmark case) has an old urban layout, which in some places has narrow streets with variable dimensions, as well as organic shapes with different levels of sunlight. The development of the buildings along the route analysed is of double height, generating conditions that affect the projection of shadows.

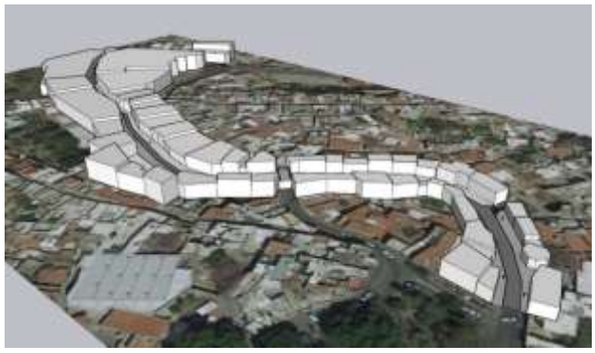

Figure 4 Digital model drawn for the benchmark case *Own elaboration with information from* [26]

The digital model made it possible to analyse the shadows cast at different times of the day and at different times of the year, to generate more effective decisions for the benefit of pedestrian use.

To determine the months of analysis, pedestrian walks were conducted during 2021, in the two seasons described in the previous section, which included the months with the highest and lowest sunshine. With this information, March, June and September were defined as representative months. To propose the sustainable urban strategy, each month was analysed at midday to visualise the results of the shadows at the zenith at 87 degrees in the selected location.

Finally, it was reviewed the passive strategies with the greatest potential for preserving the World Heritage status of the study site; with the least possible intervention, while influencing the public urban space by reducing the thermal discomfort caused by solar incidence, to promote pedestrian mobility in a tourist city with a sub-humid temperate climate.

4. Results

In this section, the results were analysed according to the layout of the four sections described above. The route started from east to west, and the heights of the buildings flanking the street were considered. The proposed division into sections corresponds to the organic shape of the street with several curves, which influenced the projection of shadows in different parts of the street. The results correspond to the representative months, March, June and September in each section. It was decided to present the results at 12:00 pm.

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Figure 5 shows the results in S1. In this section, a minimal variation in the shadow projection was observed during the study months, which corresponds to the topography and height of the adjacent buildings. This expected result increases the need for passive strategies to reduce thermal stress. There were no significant variations.

Figure 5. Section 1 (S1), shadow projection in a) March, b) June, c) September

However, S2 in Figure 6 showed a difference in shadows for each month analysed, in which a level of shadow covering the entire pavement and part of the stream is observed for March; which decreases as the month goes by, and where greater sunlight is observed on the north-facing pavement in the three representative months. Here, the organic form of the street analysed presents the advantage of a higher level of shadows, and an area of opportunity on the north side of this section to encourage pedestrian use.

Figure 6. Section 2 (S2), the shadow projection in a) March, b) June, c) September

Figure 7 shows S3 of the most open street, which results in more direct solar incidence during the representative months. The open public spaces, strategically present an area of opportunity to implement passive systems to promote pedestrian mobility.

Figure 7 Section 3 (S3), the shadow projection in (a) March, (b) June and (c) September

Finally, section four (S4) depicted in Figure 8 shows the results for the section of the street that connects to the historic centre. In this part, the shadows cast vary and in some parts, they are cast onto both pavements of the street.

In this section, the need for passive systems to increase pedestrian use decreased.

Figure 8 Section 4 (S4), shadow projection in (a) March, (b) June and (c) September

The shadow analysis showed a diversity of projections according to each section of Del Padre Belaunzarán Street, and the sections where the decrease in shadows is accentuated (see Figure 9). To promote and increase pedestrian mobility at this point of connection with the downtown area of the city, passive thermal conditioning is proposed. Based on natural elements, in this case deciduous trees to filter solar radiation, functioning as a thermal cushion and thus revitalising and contributing to the reduction of the solar incidence that occurs in some parts of the street analysed.

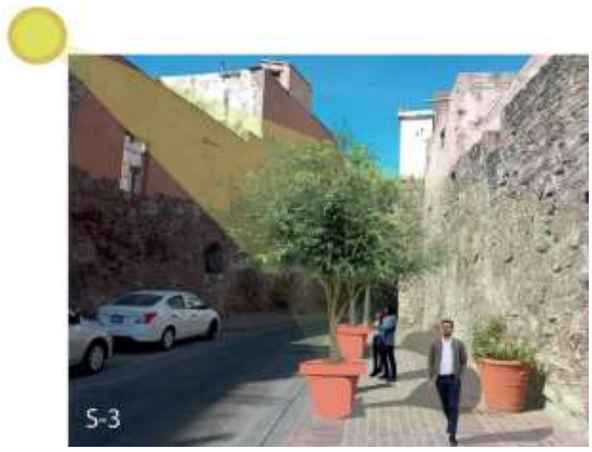

Figure 9 Current state of Belaunzarán Street (Section 1)

One of the main characteristics of deciduous trees is that their leaves fall during the coldest season, which would provide more sunlight in winter, benefiting solar gains during this season. In summer, the leaves produce a solid shade, providing a reduction in heat stress due to solar radiation.

Figure 10 shows the revitalisation proposal to promote sustainable pedestrian mobility with vegetation placed every 2 m; which strategically contributes to the thermal improvement of the public space in accordance with the organic form of the street analysed. To conserve the materials of the street and reduce the impact of intervention in the locality, and as a rooting control strategy.

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It was proposed to incorporate vegetation in pots, which also influence the growth of the trees, allowing a maximum height of between 3 and 4m. Unlike evergreen trees, deciduous trees have lower maintenance costs for their leaves and roots, as well as higher respiratory efficiency due to the action of alternative oxidase and lower energy loss during periods of leaf fall and leaf renewal. The incorporation of vegetation and its irrigation would also increase relative humidity levels in the proposed sub-humid temperate climate, while improving the thermal sensation in the urban public space.

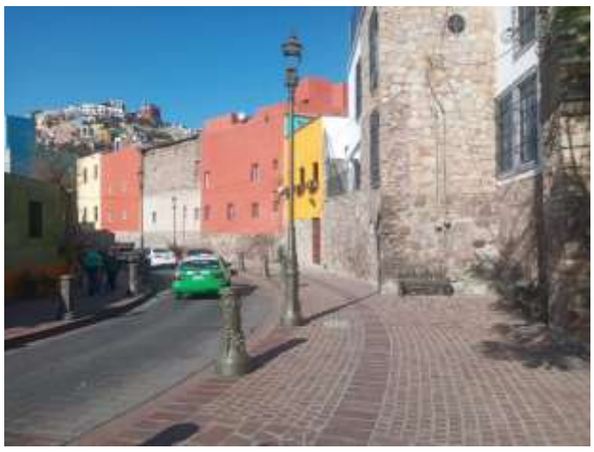

Figure 10 Proposal for sustainable urban revitalisation of public spaces in S3

Stache et al. demonstrated that vegetation such as moss converted 50% of radiative energy into convective heat, demonstrating that the strategic use of urban vegetation is an effective measure to increase climate resilience [27]. Marchionni et al. stressed the need for a sustainable balance between increasing urban ecology and water conservation with tree cover [28].

Figure 11 Proposed equidistant spacing between deciduous vegetation

In this study, the level of sunlight and shadows cast throughout the year were first investigated to determine a sustainable passive strategy to revitalise a street with the potential to increase pedestrian use; which is also a connection point to the downtown area in a heritage city with high tourism indices (see Figure 11). This qualitative analysis sought to significantly reduce the levels of uncertainty and increase the social impact on subsequent stages of this research.

Sources of funding

This research had no sources of funding

Conclusions

A sustainable urban revitalisation strategy was developed for a world heritage city with a sub-humid temperate climate. To make the recommendations, the shadows in Del Padre Belaunzarán Street, in Guanajuato, divided into 4 sections according to the organic form of the urban layout, were evaluated. This street connects the eastern zone with the central zone of this tourist city. As part of the results, strategic zones were determined for the revitalisation project, which consisted of using vegetation with a favourable thermal impact for the users.

It was determined to use deciduous trees that keep their leaves in summer and during the winter, as part of the energy saving and balance cycle; lose their leaves, which allows a level of sunlight appropriate to the needs of public space to promote pedestrian mobility and sustainable development. The findings shown in this study provide knowledge about revitalisation proposals in heritage cities considering the climatic characteristics and sustainable mobility needs that prevail globally. It also provides a solution to the needs of sustainable urban and public projects in heritage cities that were not designed according to the parameters of sustainability that have taken off in recent decades.

As a next stage of this exploratory longitudinal study, the outdoor dry bulb temperature and relative humidity will be determined by monitoring on different days of the months analysed in this study, with intervals of every 10 min, to analyse the outdoor environmental quality of public urban spaces using a numerical method.

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With these data, the revitalisation strategy in sub-humid temperate climate will be numerically validated; and as a next step, the increase in the social impact on other climates and other public spaces will be proposed. As an area of opportunity, a mixed study is recommended that also includes on-site measurements and recommendations in the cultural and educational sectors, as well as a study of uncertainties for open spaces according to the age range of the users and the endemic species that develop by climatic zones.

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