Bio-climatic Design Handbook: designing public space to reach urban sustainability.

Abstract: *The "Bio-climatic Design Handbook: guidelines for the development of planning regulations" is a tool for urban planning and design professionals planning for the construction of public space taking into account bioclimatic and environmental standards. Based on environmental conditions assessment, urban design guidelines are given. These take into account various scales; from the territory to the microclimatic reality. From these general keys for the design of public space the handbook performs recommendations on specific case studies. The application of bioclimatic techniques in urban design promotes comfort in the public space and the respect for the existing environment, while it influences the energy consumption of buildings that conform this open space. The tool was developed in the context of BIOURB project, where Spain and Portugal cooperate writing this bilingual handbook. The case studies are located in this cross-border region.*

Key words: public space, bio-climatic techniques, urban design, environment, urban microclimate, comfort.

Introduction

This Handbook is a tool for the design of public space through bioclimatic techniques and environmental criteria. It was developed as a part of the BIOURB project, a proposal aiming to work on the Bio-constructive Diversity in Spanish-Portuguese Border, Bioclimatic Construction and its adaptation to contemporary Architecture and Urbanism. The Handbook was developed within the project action "Urban Climate". Sustainable and bioclimatic design considers environmental parameters to intervene in the Urban Climate, in order to influence the microclimate conditions, and therefore hygrothermal comfort both in buildings and open spaces. The bioclimatic design of public space is a requirement to achieve sustainability in our cities, both in new urban development and urban retrofitting and regeneration.

Various scales of design are covered: from the environmental conditions of the territory to the microclimatic scale. The Handbook explains and develops specific methodologies for environmental studies providing guidelines, graphics and specific recommendations for the design of comfortable public spaces and environmentally friendly urban interventions.

Aims and objectives

The main objective of this Handbook is to create a professional-oriented tool for planning and urban design based on bioclimatic and environmental criteria, aiming to create comfortable and sustainable urban environment and public space.

Climate regulation in public space is gradually becoming an important issue when approaching urban design. The Handbook is a tool for the development of future urban planning of the municipalities belonging to the selected climates, in order to incorporate improvements that increase the comfort of urban space and minimize energy demand of buildings, but specially focused on public space design as a key element to reach these

goals. It also aims to serve as a tool to guide rehabilitation, conditioning and improvement of existing urban spaces.

This Handbook is well aimed at everyone involved in the design of public space in cities at all scales, from government technicians to planning professionals and urban designers. It becomes a tool for professionals whose discipline influences can contribute to create a more livable and sustainable city.

Part 1: Territorial support

In this section, we classified, developed and explained a number of tools to make an urban plans, regulations or projects. These tools were organized according to the following topics: hydrology, soil potential for agriculture and forest, possibility of soil urbanization, topography, land orientation, landscape units and vegetation.

The hydrology section discusses water cycle with special reference to two problems that climate change looming will set as top priority in the territory covered by the Handbook. The first relates to the water supply. How can we cover the future water needs with a lower rainfall and with a much more concentrated in space and time rainfall pattern. Guidelines for water balance analysis and groundwater aquifers protection are given, and water supply and sewage are analyzed. The second relates to the likely floods that such rainfall patterns will cause, so basic recommendations for flood risk areas detection are given.

In a context in which the recovery of local livestock and agriculture is gradually becoming a necessity, the analysis of agricultural and forest land soil is essential. Preserving this kind land and soils is essential if we are thinking in local productive activities. After preservation of this lands, it is necessary to activate the production. The tool outlines the guidelines to determinate the agricultural and forest soil suitability, taking into account different factors, explaining them and providing tables to establish the classes of agrological suitability of land uses.

However, although it is a commonplace that the land allocated to urban development should be the residual one, not all residual soil is suitable to be urbanized according to the ecological and economic cost that this could entail. Guidelines for soil mapping and suitability determining for being urbanized are given, analyzing excavation ease, the absence of aggressive chemicals, the bearing capacity of the soil, the possibility of differential settlement and soil contamination .

Topography and orientation of land is a priority for the organization of territories and the design of cities that consume less energy, taking advantage of environmental conditions and achieving comfort for citizens. The Handbook makes recommendations about appropriate slopes for each uses of cities, prioritizing accessibility. Furthermore, the relationship between orientation and slope is described providing guidelines for the analysis and identification of outstanding sunny and shady areas.

Landscape is not only important as cultural heritage or tourist resource, but as a key for understanding the ecological functioning of the environment in which the city is located, besides being its most important value is to create identity. Therefore, a synthetic landscape analysis methodology is proposed aiming to brings together these factors to constitute an assessment tool.

Vegetation provides valuable services to urban areas . It is almost the only physical element that the designer can use to modify urban microclimate, creating shade where needed, letting the sun pass, performing functions as a barrier against wind or modifying evapotranspiration. A study of different properties of local vegetation and green areas and their understanding is proposed: major ecosystems, ecological corridors and their size or the capacity of local vegetation to climate control.

Part 2 : Location and climate

As an approach to the relationship between city and climate, this Handbook outlines theoretical basis by explaining three concepts: The climatic scales, the physical basis of climate research and the physiological basis of comfort.

When it comes to the mechanisms of heat exchange between users and their environment, solar radiation is the dominant variable in open spaces. Urban development strategies focus on the definition of the environmental conditions conducive to sun exposure or shading of outdoor spaces, depending on the needs identified through the climate study. Thus, strategies for sun protection and exposure are explained while the influence of orientation and slope are defined as essential parameters.

Despite the difficulty of analyzing air flow in the urban environment, wind is a determining factor for comfort in open spaces, both its mechanical and thermal effects. Variations in air flow produced by the built environment is discussed, wind obstructions produced by topographical obstacles, the influence of surface finish and texture, the microbreeze creation and the possibilities of pollution dissemination. Urban design recommendations are offered in each of the different sections, firstly distinguishing between the needs of wind protection or ventilation, secondly recommending actions to increase microbreezes and to diminish the negative effects of air pollution .

Water in its different phases and through different phenomena plays an essential role for defining the urban microclimate and for achieving the hygrothermal comfort in cities. Thus, the possible strategies of drying and wetting the environment are analyzed. Water cycle in the city is a key element to achieve an environmentally sustainable city, by reducing runoff water and increasing soil permeability. This Handbook goes beyond the bioclimatic parameters to achieve an environmental approach. This fact has led to the inclusion of specific recommendations for water management, considering alternative solutions.

Vegetation has an important effect on the urban microclimate at all scales and plays an important role in the urban energy balance. It is analyzed focusing on its interaction with aforementioned variables: air temperature, humidity, radiation, air velocity and air and noise pollution. Specific recommendations are explained and different scales are considered, from the opportunities provided by the distribution of vegetation at urban scale to the effects of a single tree, including the effects of small plant masses.

Finally, the finishing materials of the city influence both thermal and hydric balance in cities, producing a direct impact on the heat island effect and the sustainability of water management, as well as the hygrothermal comfort. Therefore, this materials are the elements that are in permanent contact with citizens. Parameters such as albedo, emissivity and absorption, permeability (Fig.1.3.), texture and thermal inertia are analyzed, studying its influence on the hygrothermal conditions and producing design recommendations.

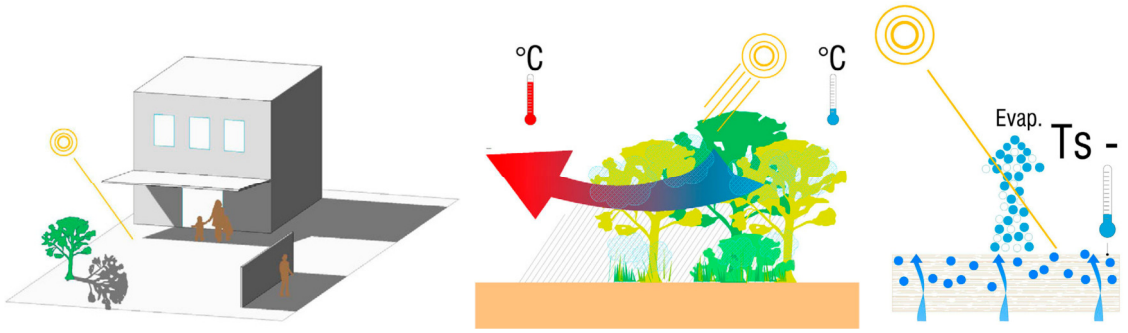

Fig.1. Recommendations: 1.1. Solar protection, 1.2. Micro-breeze creation, 1.3. Permeability of materials.

Part 3: Case study: Portugal - Spain border region

This Handbook is completed through a study developed in the Portugal-Spain cross-border region, suggesting specific recommendations on urban bioclimatic design on this area. The analysis of the recommendations has been carried out in a series of steps, starting territorial and climatic descriptions, proposing then specific design recommendations for the selected cities and finally applying these recommendations to two public spaces. General recommendations were developed for the region and specific ones for each location.

The analysis and interpretation of topography and hydrology allow us appreciate the importance of orientation, slopes or nearby water sources in sustainable urban design and planning. Adding water balance analysis allows to know when and where interactions are critical and how to use them to mitigate the adverse effects of climate.

Köppen-Geiger climate classification has been used to choose case study cities. Five cities have been selected León, Zamora and Salamanca in Spain and Mirandela and Bragança in Portugal, representing the three main climates detected in the area. Climate data was analyzed in relation with the spatial location of cities. In the absence of measurements in the inner cities with sufficient spatial and temporal coverage, data provided by weather stations located around the city has been used for climate analysis and the establishment of general recommendations for planning. The climate description has been developed through

analyzing basic climatic variables (temperature, precipitation, relative humidity, etc.), radiation and wind (wind roses separating months according to the need of ventilation or wind protection). Bioclimatic Olgyay diagrams are performed and compared to identify conditioning requirements necessary to reach comfort in free spaces. (Fig.2)

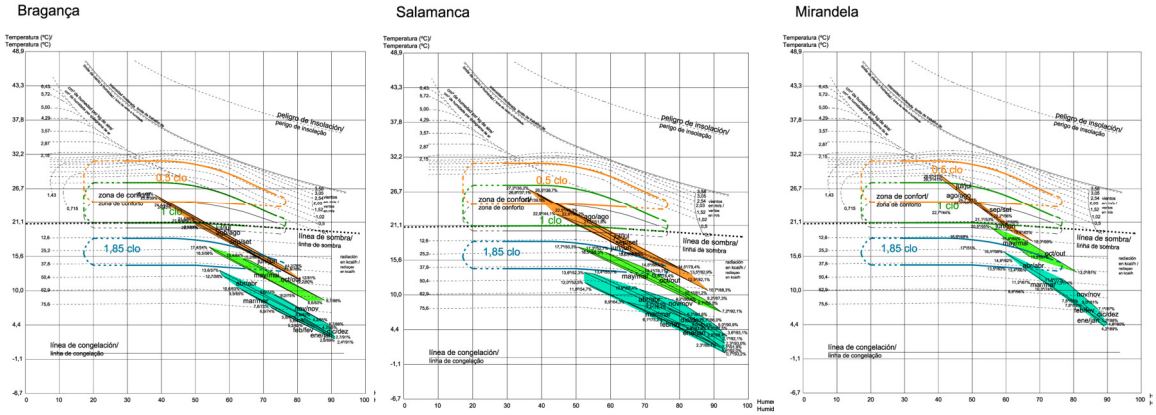

Fig.2. Olgyay diagrams of Bragança, Mirandela and Salamanca.

The information represented on these diagrams leads to identify a seasonal pattern unlike the conventional one. Sun exposure is necessary to reach comfort during most of the year, while shaded areas are only needed in the central hours of the hottest summer months (July and August). Deciduous trees are therefore needed to allow solar radiation to reach public space. Spaces which are sheltered from the wind in autumn, winter and spring will allow comfort during most of the year. When it comes to materials, high thermal inertia and emissivity will be necessary for paving and other surfaces. However, street furniture (benches, children's games, etc. .) should present low thermal inertia.

Once the design strategies are defined, specific design recommendations are established. Given the similarity of the needs on climate conditioning in the analyzed cites, global recommendations for the area have been made, later describing the specific needs of the regions when necessary. Based on the climatic recommendations developed in the first and second part of this Handbook, suggestions applied to the region have been made for three different periods: winter, spring and summer-autumn. Specific sunlight studies for different types and sizes of spaces in the urban fabric have been developed , simulating examples of square spaces and streets north-south and east-west oriented. Each city´s wind roses have been interpreted exemplifying main wind directions and strategies to place wind barrier for wetting or protection. Selected strategies were linked to wetting, vegetation and the various materials used in the design of public space.

Finally, an example of a public square is developed to propose solutions to get to the synthesis and discussion of the strategies proposed in the Handbook (Fig.3). This case study exemplifies the way to combine the different strategies that so far have been brought separately. Thus the relationship between the various parameters of sunlight, wind, water,

vegetation and materials applied in the urban morphology and design of open spaces can be observed.

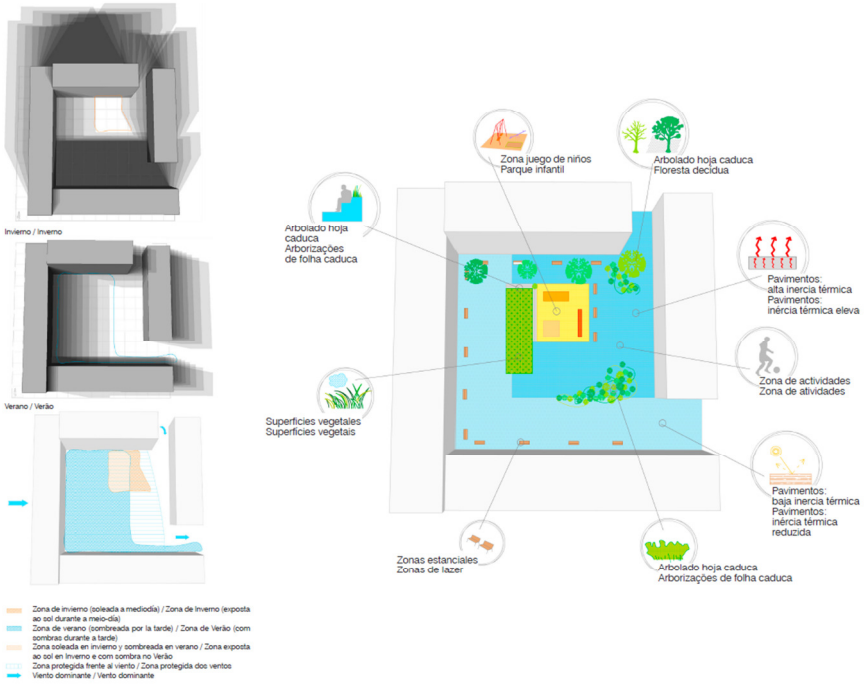

Fig.3. Public space analysis and proposal.

The final chapter of this Handbook reflects the intense work of documentation including a detailed bibliography with key words and abstracts of the main references, aiming to help professionals involved in urban planning and design to deepen their knowledge in the field.

Conclusions

This Handbook presents a comprehensive content organized in various scales as well as in different application degrees. Environmental conditions are the basis for explaining the relationship between urban environment and climate through the various scales of design, from the environmental conditions of the territory to the microclimatic weather reality. In addition to include this variety of scales, this tool provides guidelines and recommendations that go from the general to the specific, including general guidelines and recommended readings, application to the Portugal-Spain cross-border region and case study examples of public spaces.

This Handbook introduces many bioclimatic urban design environment collecting the latest advances in the field of urban climate and microclimate, as well as including literature from environmental planning recognized experts. The description of the information and recommendations is based on various theoretical sources and supported by multiple charts and graphs to help design comfortable public spaces for people while respecting the existing environment. It is therefore a tool that brings scientific knowledge to professionals in this area by proposing practical application in a direct and didactic manner.

The dissemination of the Handbook is key to help achieve more comfortable and sustainable cities. This tool is an Internet open access resource. It is available on the website of BIOURB project and the Open Access webpage of the Polytechnic University of Madrid. It has reached 2,000 downloads just in this last website. Communication events about the results of the BIOURB project have been held in which this Handbook and its contents have been presented, both in the geographical region of analysis and the Polytechnic University of Madrid. Also, this Handbook has been sent to city councils that took part in the BIOURB project, to become a useful tool for experts and urban planners of the study region.

It is ultimately a tool for more livable and sustainable, more comfortable and efficient cities, through the environmental design of public space.

Acknowledgments
This Handbook was developed within the BIOURB project, Cross Border Cooperation Programme Spain - Portugal, with the support of the EU and the co-financing of European Regional Development Fund (ERDF) and Cross-Border Co-operation Programme Portugal-Spain (POCTEP).

Bibliography
Baumüller, J.; Hoffmann, U.; Reuter U. (2008). *Climate Booklet for Urban Development*. [online]. Stuttgart. Ministry of Economy Baden-Wuerttemberg.
Eliasson, I. (2000). The use of climate knowledge in urban planning. [online]. *Landscape and Urban Planning*. Nº 48 (2000) [2012-04-25], p. 31- 44.
Erell, E.; Pearlmutter, D.; Williamson, T. (2009). *Urban microclimate: designing the spaces between buildings.* London. Earthscan.
Fariña Tojo, J. (2009). *La ciudad y el medio natural*. Madrid. Akal.
Hernández, A. (Coord.). (2013). *Manual de diseño bioclimático urbano. Recomendaciones para la elaboración de normativas urbanísticas/ Manual de Desenho Bioclimático Urbano Manual de orientações para a elaboração de normas urbanísticas.* Redacción: Fariña, J.; Fernández, V.; Gálvez, M.A.; Hernández, A.; Urrutia, N. Bragança. Instituto Politécnico de Bragança.
Higueras García, E. (2006). *Urbanismo bioclimático.* Barcelona. GG.
Landsberg, H. (1981). *The urban climate*. New York. Academic Press.
Luxán García de Diego, M. et Al. (2011). Diseño Bioclimático en Canarias. en AA.VV.: *Sostenibilidad energética de la edificación en Canarias. Manual de diseño.* Instituto tecnológico de Canarias. Neila González, F. J. (1999). Diseño de ambientes exteriores. *Cuadernos del Instituto Juan de Herrera*. Madrid. Instituto Juan de Herrera. Nº 45.
Nikolopoulou, M. Coord. (2004). *Designing open spaces in the urban environment: A bioclimatic approach*. [online]. CRES (Centre of Renewable Energy Resources). Greece.
Olgyay, V. (1963). *Design with climate.* New Jersey: Princeton University Press, Princeton.
Reed. *Arquitectura y clima. Manual de diseño bioclimático para arquitectos y urbanistas.* Barcelona. GG.