MODE_Bios: A Bioclimatic, Adaptive, Urban Design Tool

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ABSTRACT: Contemporary city planning and urban living policies reflect the urgency of coping with past practices and planning responsibly for the future. MODE_BIOS (MOdel for DEsign of BIoclimatic Open Spaces) proposes a tool for enhancing the sustainability and comfort levels of open public spaces through design operations, adaptive to the specific conditions. The tool will associate ecological guidelines and design practices with place-based inputs in order to generate cost-effective bioclimatic design guidelines for open urban public space. MODE_BIOS presents a hybrid methodological approach, taking into consideration functional, aesthetic, social, technological and political requisites, which are elaborated and prioritized in order to fulfil bioclimatic comfort and sustainability in urban living. The paper presents the stages of MODE_Bios: 1) a targeted Digital Database for urban bioclimatic design principles and case studies is created, based upon bibliographical research and analysis of bioclimatic requirements in urban environments; 2) a Mathematical Model that uses the bioclimatic requirements and the design operations so that through ordering it may suggest the best combination of elements; 3) a Digital Tool that generates guidelines to be used by planners and decision-makers for the improvement of the bioclimatic features of urban public spaces. The suggested operations because of their dynamic and adaptive character can provide a certain level of responsiveness at the integrated elements, depending on the climatic conditions, the crowd concentrations and other variable factors. A case study, for the city of Ioannina, in Greece, will be analysed and presented in the paper. From the case study, conclusions will lead to examine the transferability and scalability, in different contexts of design, of the hybrid methodologies of the MODE_BIOS and also evaluate its links, strengths and weaknesses to other research, tools, projects and policies that address the subject of sustainable urban planning.

KEYWORDS: bioclimatic, adaptive, urban, hybrid, design
PAPER SESSION TRACK: Global Sustainability: Mitigation and Adaptation

INTRODUCTION

Contemporary city planning and urban living policies reflect the urgency of coping with past practices and planning responsibly for the future (Larco, 2015). City planning and urban living policies are difficult to redirect but their importance is crucial for the quality of life of their inhabitants as well as for the global footprint (Bibri, Krogstie, 2017, Gauzin-Müller, Favet, 2002).

Digital technologies have come to the service of the research, by providing sophisticated tools and models that are able to provide guidance, simulate actual physical conditions and predict the impact of interventions to the urban environment (Tsitoura, Michailidou, Tsoutsos, 2017, Angelidou, Psaltoglou, Komninos, Kakderi, Tsarchopoulos, Panori, 2018, Attia, Lacombe, Rakotondramiarana, Garde, Roshan, 2019). These tools, ranging from simple formats to complex models, have been dealing, separately or conjointly, with various aspects of bioclimatic design and comfort requirements, providing approaches that are centered in the quantifiable aspects. Planning is often seen as an additive process of discrete solutions to separate problems regarding thermal comfort, wind environment, radiation, energy efficiency etc., and not as a synthetic one (Katzshner, 2002, Chatzidimitriou, Yannas, 2016),

Additionally, the interventions proposed by many bioclimatic tools are inflexible and can be implemented only in the initial design phase of open public spaces as they do not allow corrective actions in current urban conditions (Allegrini, Orehounig, Mavromatidis, Ruesch, Dorer, Evins,2015). This aspect constitutes a major drawback for decision-makers and authorities as the cost and/or the inconvenience generated from large-scale interventions is extremely high (Gaspari., Fabbri, Lucchi, 2018). Adaptability in sustainable planning offers resilience to the urban environment, and this is a field of study that needs to be further researched.

MODE_BIOS aims to create a tool for enhancing the sustainability and the comfort levels of open public spaces through design operations adaptive to the specific conditions. The tool will associate ecological guidelines and design practices with place-based inputs in order to generate cost-effective bioclimatic design guidelines for open urban public space. The project's goal is to create links with previous research, tools, projects and policies that address the subject of sustainable urban planning, exploiting previous knowledge and experience, and providing a novel holistic approach.

1.0 MODE_Bios

MODE_BIOS (MOdel for DEsign of BIoclimatic Open Spaces) proposes a tool for enhancing the sustainability and the comfort levels of open public spaces through design operations adaptive to the specific conditions. The tool will associate ecological guidelines and design practices with place-based inputs in order to generate cost-effective bioclimatic design guidelines for open urban public space. MODE_BIOS presents a hybrid methodological approach, taking into consideration functional, aesthetic, social, technological and political requisites, which are elaborated and prioritized in order to fulfil bioclimatic comfort and sustainability in urban living.

MODE_BIOS is based on a hybrid methodology that interconnects abstract and non-measurable qualitative design aspects and bioclimatic, measurable, quantifiable requirements. This enables complex, multifactorial, architectural aspects and their environmental impact to play a role in the prioritization of desired requirements and consequently to the configuration of the MODE_BIOS proposed guidelines.

Design from scratch is a utopian and almost impossible condition in the often-historical European cities. MODE_BIOS provides guidelines for enhancement of the environmental conditions in open urban spaces by suggesting easily implemented and lightweight interventions in pre-existing urban spaces. Adaptability and responsiveness are key elements of the MODE_BIOS, as it offers the possibility of design guidelines that are able to address the changing conditions of the urban environment and adjust correspondingly. MODE_BIOS long-term feasibility is guaranteed by its malleability and resilience and also by its scalable character. The produced tool of the project, related to the implementation of a responsive bioclimatic environment on a certain case study in the city of Ioannina, Greece, and specifically a public square, could be further developed for many urban environments and spatial contexts, after necessary adjustments. MODE_BIOS is both scalable and adaptable and therefore could be adjusted for different scales and typologies of open public space.

Furthermore, it uses dynamic elements of design, as opposed to conventional fixed design features, related to factors such as water, vapor, air, light, shadow, wind, temperature etc. in order to allow a capacity of wide range response to the variable urban conditions. Therefore, the guidelines provided by the MODE_BIOS have a dynamic and shifting adjustment to the changeable needs of the urban environment.

The project's aim is to utilize the shared knowledge on the subject of how design can enhance sustainable urban living in order to provide a decision-making tool for authorities and an operative set of site-specific guidelines for responsive and localized urban interventions.

MODE_BIOS suggests that rethinking our urban living doesn't imply redesigning and reconstructing urban public spaces from scratch, but rather, that it is possible to amend specific features and opt for localized, responsive and easily implemented interventions that can have an amplified repercussion. MODE_BIOS focuses on the creation of a tool capable of generating an operative set of site-specific, cost-effective, bioclimatic, design guidelines for sustainable urban planning and provides a decision-making module for policy-makers.

2.0 METHODOLOGY

MODE_BIOS presents a hybrid methodological approach, taking into consideration multiple factors such as social, economic, technological, political, as well as functional and aesthetic requisites, which are elaborated, classified and prioritized in order to fulfill bioclimatic comfort and sustainability in urban living. It is destined to architects and urban planners but also to authorities and policy-makers, and generally it can be a useful tool to all those involved in environmental design.

The MODE_BIOS methodology divides the actions that will take place and the work that is planned in distinct and discrete phases. Each of them separately reflects a clear-cut methodological approach but all of them together constitute a rather hybrid approach. The proposal's actions are divided in three discrete but interconnected phases, the Digital Database, the Mathematical Model and the MODE_BIOS Tool, which combine clear-cut methodological approaches through a holistic perspective. These three phases cover the requirements for research and theory construction, its shaping into an operative model and user-friendly digital application and finally its testing in a pilot implementation.

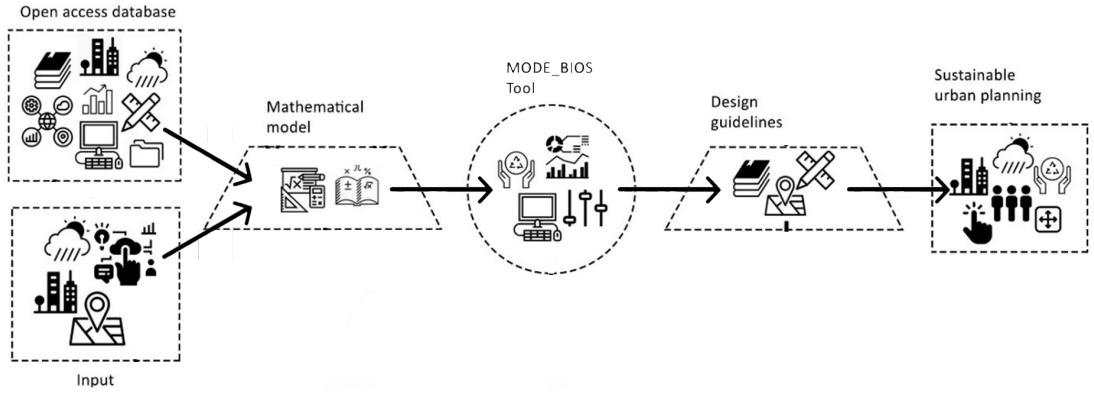

Figure 1: MODE_Bios Concept Diagram. Source: (Mantzou, Floros, 2021)

2.1. Phase 1

In the first phase a targeted Digital Database for urban bioclimatic design principles and case studies is created, based upon bibliographical research and analysis of bioclimatic requirements in urban environments. This initial review and analysis of requirements for environmental comfort in open urban spaces is connected to the research on design case studies creating the basis upon which the next phases will be supported. This analysis and evaluation are indispensable in order to configure the necessary data that will shape the prioritization and ordering of the involved parameters. The construction of a targeted database will associate bioclimatic requirements with design approaches and specific operations in urban spaces that will feed the process of ordering necessary for the mathematical model.

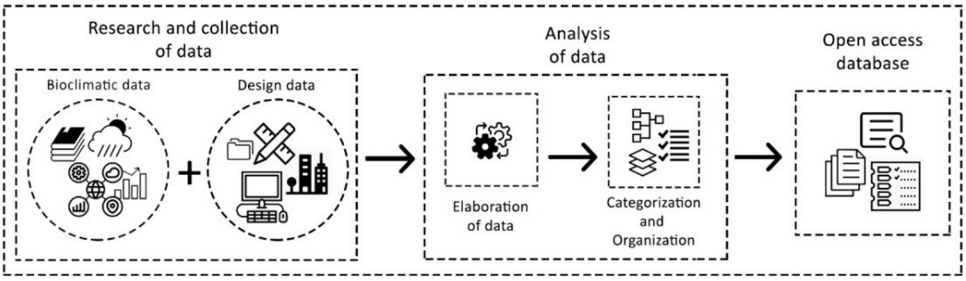

Figure 2: Phase 1: Research, Collection and Analysis of Data. Source: (Mantzou, Floros, 2021)

2.2. Phase 2

The next phase is the design of the Mathematical Model, which will use this prioritization in order to define the least distance from all desired requirements. This will provide guidelines for differential results in a variety of conditions which will take into consideration the site-specific design. The design operations are focused on lightweight interventions, with a dynamic character and a wide range of changing values, such as water, air, etc. The comfort requirements are described for specific urban spaces such as the pedestrian alleys and for the hottest months of the year. The variability factors depend on the site-specific parameters that the mathematical model takes into consideration, as well as the changing conditions referring to people concentrations and climatic data. Following the development of the mathematical model, a digital tool will visualize and make widely possible its use to architects and decision makers.

2.3. Phase 3

The last phase of MODE_BIOS is the creation of a user-friendly Digital Tool, destined to architects as well as decision makers. The tool will generate guidelines for planners and decision-makers to use for the improvement of the bioclimatic features of urban public spaces. The suggested operations will be dynamic and adaptive and therefore, will provide a certain level of responsiveness at the inserted elements depending on the climatic conditions, the crowd concentrations and other variable factors. The tool will put emphasis on visualization techniques in order to achieve a user-friendly interface. Furthermore, it will include a decision-make module that will facilitate stakeholders in strategic planning by taking political, financial, social, environmental and technological parameters into consideration. The design guidelines proposed by the tool will support the targets set by the European 2030 Climate and Energy framework.

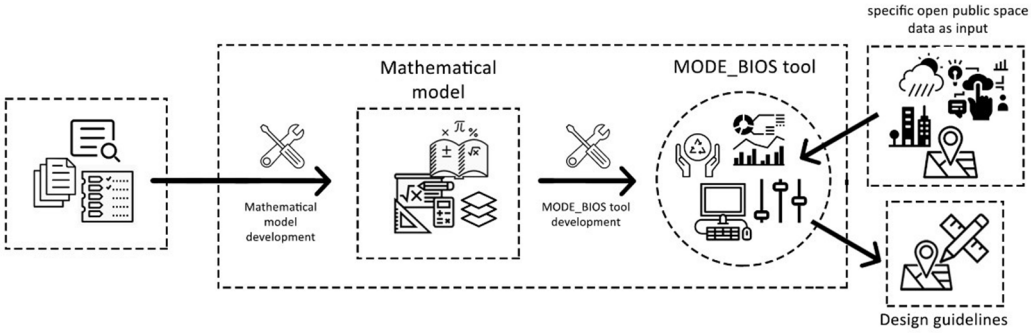

Figure 3: Phases 2 and 3: MODE_Bios Model and Tool development. Source: (Mantzou, Floros, 2021)

3.0 CASE STUDY

A pilot action in the city of Ioannina, Greece, which unfortunately has been delayed due to the pandemic, has been planned and will be used as case study in order to provide the necessary testing of the mathematical model and the digital tool and the required fixing and calibration. Deficiencies and failures of the guidelines provided by the digital tool will be assessed but more importantly the capacity of the lightweight elements to adapt to different requirements and respond adequately will demonstrate their operability and efficiency.

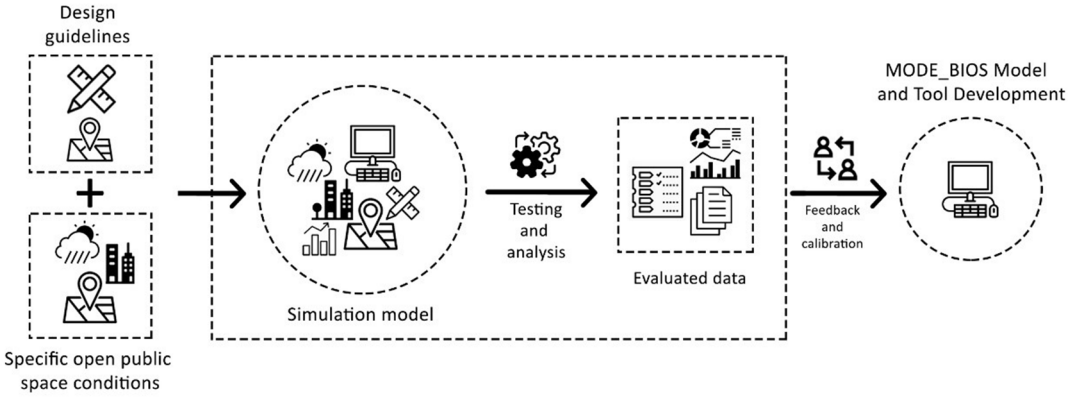

Figure 4: MODE_Bios pilot actions Methodology. Source: (Mantzou, Floros, 2021)

The case study will adopt specific guidelines provided by the mathematical model in real-life conditions and test them in the central square of Ioannina. For this, a set of different apparatuses will be used, in order to better accommodate guests and respond to external circumstances. Temperature, airstreams, humidity, sunlight are conditioned and, simultaneously, electric energy is produced, and Wi-Fi is offered. Integrated sensors will be used in order to dynamically evaluate and adapt the devices to the current environmental conditions.

Criteria applied will be based on the guidelines and adjusted to the variations of climatic occurrences. Users will be able to connect to an app and give feedback on the level of comfort that they feel in the specific environment and suggest personal preferences and possible improvements. Once this testing period is concluded and results are evaluated a second testing period will follow during which users will be able to control and regulate, through the app, the function of the devices and determine the resulting environmental conditions. The devices will perform the users' choices and a record of those preferences associated with the original exterior climatic measurements will be documented. A comparative analysis of the original guidelines, the users' feedback and later on the users' preferences will be executed.

The case study will provide a demonstration of the MODE_BIOS concept and test its application in the actual conditions for a selected time period and for the chosen place. The results of the testing and the subsequent comparative analysis will enhance the tool in terms of functionality through an interactive cyclic process (design-development-evaluation-design). The case study is expected to offer conclusions that will lead to examine the transferability and scalability, in different contexts of design, of the hybrid methodologies of the MODE_BIOS and also evaluate its strengths and weaknesses to other research, tools, projects and policies that address the subject of sustainable urban planning.

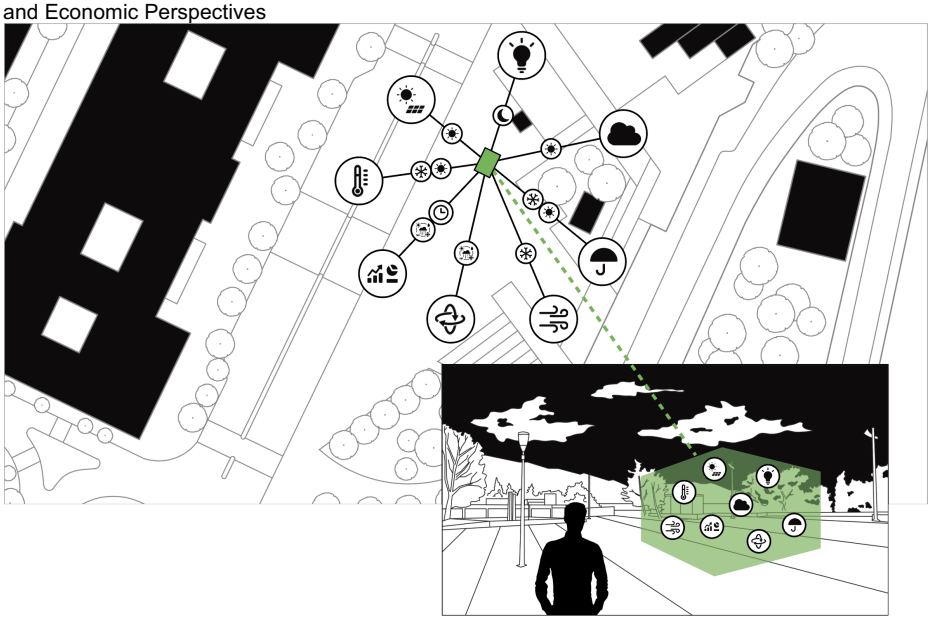

Figure 5: MODE_Bios planned pilot action in the city of Ioannina, Greece. Source: (Mantzou, Floros, 2021)

CONCLUSION

MODE_BIOS proposes a tool for enhancement of sustainable urban living with localized, lightweight and low-cost interventions. It addresses both the design from scratch and the design for particular, restricted interventions to already configured spaces, which are, in many cases, the sole option for improvement of the bioclimatic aspects of an urban space. It presents a primarily design-oriented scope in the fulfillment of environmental requirements for a sustainable urban living.

MODE_BIOS' short- and long-term impact is important on both scientific and social level. As MODE_BIOS brings an innovative methodology in designing sustainable urban places, it advances on current proposals and attempts a hybrid methodological approach that inserts qualitative parameters, such as optimized design practices in correlation to quantitative requirements such as the microclimate measurements. Its scientific impact is relevant for interconnecting specific architectural design practices and sustainability outcomes in open urban spaces. Researchers and scholars will benefit from the new possibilities that the MODE_BIOS opens to shape, access and study sustainable urban design in open public spaces. This can lead to a great impact on the architectural and urban creative processes as it standardizes and visualizes immaterial nuances of the design practice, into quantitative guidelines with measurable results. MODE_BIOS database and Tool demonstrate the multifactorial character of design and raises awareness in the importance of prioritizing quality design as a key to sustainable urban living.

The implementation of the design guidelines proposed by the MODE_BIOS tool in the open urban public space will lead to improved environmental performance and better quality of life for the city's inhabitants. It will also be a useful tool for authorities and decision-makers to upgrade less developed urban public spaces and raise employability for practitioners of sustainable design. The responsive and adaptable character of the MODE_BIOS interventions to the changing environmental and social conditions will lead to resilient, energy-efficient and cost-effective urban public spaces. These lightweight interventions will have a considerable impact upon areas dealing with low quality urban conditions and neglected public spaces. Their revitalization and the consequent enhancement of social interaction will raise awareness on the matter of sustainable urban living and amplify citizens' understanding of the importance of urban planning.

Furthermore, MODE_BIOS is a scalable proposal which can be further developed. Its scalability is both in relation to the type of spaces involved as to the requirements attended. Its impact span can be defined as long-term in regard to its temporal aspect and also easily amplified, in regard to its field of application as it can generate consecutive modules. The lightweight and cost-effective design interventions proposed by the MODE_BIOS are feasible and easily implemented in any open public space and therefore can provide a mitigation of economic and social class distinctions and guarantee social inclusion. This aspect will ameliorate the possibility of all citizens to enjoy high quality urban living without exclusions.

The important challenges that MODE_BIOS addresses are i) the standardization of design practices that help fulfill bioclimatic requirements in open public spaces, ii) the construction of a model that associates design practices to amelioration of environmental conditions, iii) the identification of lightweight, easy to implement design operations that can impact the sustainability and comfort of open public spaces, iv) the creation of a user-friendly digital tool that allows decision making on moderate urban interventions with important environmental impact and v) the testing of the

adaptability and the responsiveness of these interventions in the variation of values relative to climatic and social conditions.

REFERENCES

Angelidou, M., Psaltoglou, A., Komninos, N., Kakderi, C., Tsarchopoulos, P. and Panori, A. 2018. *Enhancing sustainable urban development through smart city applications.* Journal of Science and Technology Policy Management, 9(2).

Allegrini, J., Orehounig, K., Mavromatidis, G., Ruesch, F., Dorer, V. and Evins, R. 2015. *A review of modelling approaches and tools for the simulation of district-scale energy systems.* Renewable and Sustainable Energy Reviews, 52.

Attia, S., Lacombe, T., Rakotondramiarana, H.T., Garde, F. and Roshan, G. 2019. *Analysis tool for bioclimatic design strategies in hot humid climates.* Sustainable Cities and Society.

Bibri, S.E. and Krogstie, J. 2017. *Smart sustainable cities of the future: an extensive interdisciplinary literature review*, Sustainable Cities and Society, Vol. 31.

Chatzidimitriou, A. and Yannas, S. 2016. *Microclimate design for open spaces: Ranking urban design effects on pedestrian thermal comfort in summer*. Sustainable Cities and Society, 26.

Gaspari, J., Fabbri, K. and Lucchi, M. 2018. *The use of outdoor microclimate analysis to support decision making process: Case study of Bufalini square in Cesena*. Sustainable Cities and Society, 42.

Gauzin-Müller, D. and Favet, N. 2002. *Sustainable architecture and urbanism: concepts, technologies, examples.* Basel; Boston: Birkhauser.

Katzshner, L. 2002. *Bioclimatic characterization of urban microclimates for the usage of open spaces*, Proc.: Architectural and Urban Ambient Environment, Nantes.

Larco, N. 2015. *Sustainable urban design – a (draft) framework*. Journal of Urban Design, 21(1).

Tsitoura, M., Michailidou, M. and Tsoutsos, T. 2017. *A bioclimatic outdoor design tool in urban open space design*. Energy and Buildings, 153.