Parametric modeling representation of the territory: the investigation of solar envelope as a parameter

S.Santana[1,2*], A.C. Moura[1], R. Hungari[2]
[1]Department of Urbanism, Architecture School of Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

[2]Geoconsulting, Belo Horizonte, Brazil

*Corresponding author: E-mail: shesantana@geoconsulting.com.br, Tel +55 31 83081659

Abstract
The sun is fundamental to all life. It is the source of our vision, our warmth, our energy, and the rhythm of our lives. Its movements inform our perceptions of time and space and our scale in the universe.The concept of solar access is an abstraction generalized from particular observations. Our cities are non-directional. Our buildings are undifferentiated by orientation to the sun. They stand static, unresponsive to the rhythms of their surroundings.

The Solar Envelope is a three dimensional envelope on a site which ensures adjacent neighbors a specified minimum direct solar access time per day throughout the year. The solar envelope was developed as a tool to give buildings in an urban setting the mutual opportunity to employ passive and active solar design strategies. The solar envelope is a way to assure urban solar access for both energy and life quality.

This study investigates the implications of a solar envelope zoning approach with respect to energy use and developable density. The results indicate that solar zoning for building has a limited, and sometimes negative, effect on energy use as well as a larger negative impact on developable density. We will show that, especially in Brazil, the solar envelopes are not used as a parameter of urban zoning and propose an assess whether the inclusion of the calculation of insolation in the master plan can be a gain in quality of life of citizens as well as a way to assist managers in making decisions about the city. We will propose a study that investigates the inclusion of the parameter of access to the Sun in the processes of urban planning and building design through a model that creates an interpretive portrait of the city according to the permissions granted to the landowners through the master plan. It was created a scenario of the landscape on the city considering building up all the maximum allowed by law. Then we carried out the calculation of insolation to assist managers in making decisions about potential zoning building that meets the city's social right and not just to the right of the owner of the land.

Now a days, Parametric computeraided-design (CAD) environments significantly ease the construction and visualization of solar envelopes across whole neighborhoods, facilitating its wider use as a prescriptive zoning tool. In this work we suggest the insertion of the solar envelope in a system that goes beyond the simple draw of the building through the Building Information Modeling logic, but the insertion of this in a spatially located system, the geographic information system. The BIM is still very recent, and do not has the same maturity of the GIS, but it will be a convergence and integration of these two models, concepts and systems that will bring to the geoprocessing a new way of thinking, the GIM – Geodesign Information Management within the Parametric Modeling of Territorial Occupation.

Keywords: urban planning, solar envelopes, GIS, Geodesing, MPOT.

1. INTRODUCTION

Zoning rules can preserve access to daylight through a buildable envelope established by setbacks and/or height restrictions. These rules constrain development of neighboring sites or development on the site itself. The English "right to light" easements of the 1800's are an example of the former while New York's 1916 Zoning Resolution is an early example of the later. The Solar Envelope is an alternative approach to zoning (Knowles 1974). Like New York's zoning envelope, the Solar Envelope follows a "good neighbor" approach by constraining development within the site. "I am my neighbor's neighbor" when it comes to solar access (Knowles 1981). But instead of static setbacks to ensure daylight, the solar envelope is latitude and orientation specific. Any building contained within the solar envelope will not cast a shadow outside the specified boundary for a specified amount of time during the winter solstice. In his early description of the solar envelope, Knowles stated a 'minimum period of six hours a day [to be] practical' (Knowles 1981, p. 56). Arguments in favor of ensuring solar access of a site include opportunities for active and passive solar design, aesthetics, and quality of life.

Traditionally, the generation of solar envelopes used to be a somewhat tedious process that required the use of paper charts and/or physical models combined with heliodons (Knowles 1981, Brown and Dekay 2001). This requirement probably slowed the adoption of the solar envelope as a zoning policy simply because the earlier described setback rules were easier to implement and enforce. The situation has changed in recent years with the widespread availability and use of parametric three-dimensional CAD environments that allow the implementation of the solar envelope. As an example, the authors developed a Grasshopper component for the popular Rhinoceros/Grasshopper program (Rutten 2010). Based on street plans, site latitude, and required solar access time, the solar envelope component generates in real time a neighborhood of solar envelopes.

The assignment was mastered by all students showing how simple the generation of solar envelopes has become. The premise of the exercise was to demonstrate how, on an urban massing level, the solar envelope could be used to increase developable density while ensuring solar access compared with traditional height restrictions.

In principle, such computer-based tools now allow the wide-spread implementation of the solar envelope concept as a prescriptive zoning tool. Before embracing this approach, the authors asked whether this should indeed be done and what solar access times should be recommended for different climates? A concern of the authors was that increasing solar access comes at the cost of a decreased envelope volume, particularly at higher latitudes, and hence lower developable densities which result in increased vehicle miles travelled (VMT) and thereby increased energy use. Research has demonstrated that land use and transportation patterns, especially the inclination of local zoning in the U.S. towards automobile dependent and low density detached residential housing, play a major role in the rate of gasoline consumption (Newman and Kenworthy 1989).
The tradeoff between the transportation energy benefits of residential density on an urban scale compared to its reduction in a site's available solar energy has been explored for specific locations and housing types. A recent study showed that residential energy use in Toronto is closely tied to the transportation energy use of households living in neighborhoods of varying densities (O'Brien et al. 2010). For three building types of varying densities, the available solar energy was compared with household and transportation energy (O'Brien et al. 2010). Those living in the densest housing types used the least energy, even with the diminished potential for solar conversion. Interestingly, the medium density type, attached condominiums, showed the highest energy use because it combined reductions in solar availability without the offsetting benefits of reduced transportation energy typical of higher residential densities.

However, in a scenario where every residence maximizes solar collector coverage and the entire transportation fleet is upgraded to plug-in hybrid electric vehicles, the model showed a reversal of the trend favoring density. (O'Brien et al. 2010). Under current and hypothetical future scenarios, the model suggests a significant tradeoff between solar access and transportation energy. Zoning tools like the solar envelope may be particularly useful in minimizing energy use through the maximization of solar access and developmental density if used in the right ituations.

The magnitude of the effect on density depends on how the solar envelope is implemented in a neighborhood. Knowles proposed that the solar envelope concept can refer to different parts of a building site, i.e. it can be concerned with the whole site, the whole building, or the rooftop only (Knowles 1981). Providing solar access to the whole site obviously leads to the lowest urban density, whereas access to the rooftop results in the highest.

This study presents an attempt to how to create models, specially the solar envelopes, in this new context of the geoprocessing in the urban planning in order to give planners and government tools to support the decisions.

2. GEOPROCESSING IN THE URBAN PLANNING

The decisions in urban planning bump in political, operational and structural questions that unroll in so many variables and choices of difficult definition, if it is done without a systematic study.

Knowing the territory is the first step to decision making in conscientious actions to promote that the objectives defined in planning may be performed. In this sense, we defend that the best way to analyses and manage the information for a good municipal management is through the application of geoprocessing techniques, because they favors the integration of information, the composition of variables in a systematic way, and proposition of possible scenario and the construction of portraits of the reality according to different optics and values.

On the importance of construction of a preview, or many previews that can demonstrate the urban complexity before initiate the process of proposition of his ordination, Niccola (1991, p. 20) defends: "Leggere il territorio prima di progettare, prima di programmare". This thought is completed by Van Der Berg e Van Der Meer (1991, p. 41) when they state that "É passato il tempo dela pianificazione programmata. Si deve dare spazio ala flessibilità e alla creatività".

The information organized, correct and available with agility is a strategic resource, indispensable to adequate decision making timely. Moura (2010) states that the geoprocessing is an important management tool, because it is a set of technologies for information processing, whose geographic localization is an inherent characteristic, indispensable for analysis. It becomes possible to automate the production of cartographic documents. The utilization of techniques of geoprocessing helps the production of analysis according with the recent tendencies, overall when the objective is the production of data synthesis and mapping the information obtained. By this way, the geographic information system (GIS) is capable not only for store, cross and analyze a gamma of data from distinct sources and with differentiated formats, but also to represent the urban ambient in all his complexity. It is relevant to say that the GIS produces multiple look over the territory and allows not only to plan, in order to manage the urban ambient, but also to allow the simulation of sceneries and the large and interactive disclosure of the knowledge acquired about the reality.

With the strength of the World Wide Web, the Geographic Information Systems has been made accessible to the large public through WebGis. The WebGis brought with him the necessity of dealing with languages and access form to the data and construction of information endowed with communicability and encouraged the use by non specialist public.

The rapid and growing diffusion of information allowed by the network brought with it the necessity of evaluate the quality, origin and the access to the information and to the collection of data. They soon instituted the normative that regulated the process, in order that it appeared in Europe the INSPIRE network and in Brazil, has been published the Law 6666, in 27/11/2008, from the Planning Ministry defining rules and parameters for the structuring of the National Spatial Data Infrastructure (INDE). The purposes of INDE need to divulge for the various instances of management and diffusion of spatial information, between them the state and the municipalities. (BRASIL, 2008).

Though, the recent scenario is the application of geoprocessing through actions of interoperability, integration of systems, and integration of different sectors of users. The urbanists always held the preoccupation in anticipate the result of their propositions through tools of graphic expression, initially through sketches and actually through the enlarged reality. It is born in the graphic representation of the areas of design and projection; among them is the Architecture, a new form of digital representation of objects called "BIM" - "Building Information Modeling". According to Moura (2012) the logic BIM is to compose for decomposing, what is the opposite of the logic of GIS, that is decompose in plans of information and alphanumeric tables in order to compose in process of synthesis or integration of information. In BIM the object is represented in three dimensional view, but can arrive to the fourth dimension (simulation and time changes), and from the existence of the object like an all it may be decomposed in their different plans, that are: plants, sections, facades, databases, and other.

As the object is represented as a system, any alteration in any of its characteristics results in alterations and actualization of visualizations in different levels of representation of the information. However, the focus of these tools remains on individual new building construction, of which the representation contains almost no information about their geographic context. Conversely, the representation to build forms with GIS remains simplistic overlay, usually consisting of 2d footprints. This makes it difficult to conduct neighborhood, city or regional scale assessments that take into account important characteristics of design proposals.

It is based on interest in more than modeling interpretative pictures, but also to generate simulations of the reality, that the Building Information Modeling took force within the context of the technologies of digital representation, and is in about to be incorporated to the geoprocessing, through the symbiosis BIM & GIS.

The BIM is still very recent, and do not have the same maturity of the GIS, but the convergence and integration of these two models, concepts and systems will bring to the geoprocessing a new way of thinking, the GIM – Geodesign Information Management.

> "We were then one step closer to living a new paradigm in geotechnology, to blend the SIGs conditions and interests of BIM, with extensive investment in technology representation, so that the tools favored the proposition of projects in real time (for augmented reality) and that users can compose their landscapes by processes of parameterization. The processes of applying parameters in the composition of an urban landscape are, ultimately, the translation of laws determinations and legal rules for the construction of the possible scenarios resulting from those established limits and references." (Moura, 2012).

This new paradigm, called Geodesign, is a design and planning method which tightly couples the creation of a design proposal with impact simulations informed by geographic context. Campagna (2012) affirm that in an ideal case, a planner or designer receives real-time guidance on performance at every phase of design from early site visit or conceptual sketch to final detail. The use of contextual geographic information means that design performance can be evaluated relatively

to local conditions, and that evaluation can and should consider off-site impacts. The focus is on supporting "human in the loop" design, providing continuous feedback on multiple aspects of performance and improving designs-in-progress rather than on post-hoc evaluation. The geodesign information management is a system that allows the sketching interface within GIS to connect this directly to geoprocessing models so as to support a new mechanism for rapidly generating spatial features with attributes, a tightly coupling design and assessment of sketch in the built georeferenced landscape and a design-time feedback. These first concepts guide the softwares Placeway's CommunityViz and Criterion Planner's INDEX.

Those new planning support system, that we will call GIM – Geodesign information Management, as support to the spatial questions, are based on support tools to the projects, but not only to the designs of the territory, but also to the propositions of simulation of urban landscape. The GIM can become more innovative if the modeling of data answers to the proposition of creation of parametric sceneries of the composition of territorial, what Moura (2012) has called "Parametric Modeling of Territorial Occupation".

The new way of the Geodesing Information Management added to the Parametric Modeling of Territorial Occupation can promote a full use of geotechnologies for analysis, simulation, proposition, detailing of projects and communication with different users. For that the needs are integrated systems modeling, building of interpretative representation and simulators of the reality, investment in visualization and best involvement of the community, interoperability among systems.

The conditions that now presents allow the urban planner to simulate, in expanded reality, the resulting on landscapes of their propositions of zoning, occupation models and tables of urban parameters. This employed more largely as tool by the urban planner will allow the bridge among technical, administrative and community languages. Everybody will be able to give opinions and to make decisions, democratically, favored by the best ways of communication.

3. MATERIALS AND METHODS

The solar envelope is one component of a comprehensive system of interpretive portraits of the city. This article is taken the test methodology for creating a model of shadows on ESRI technology for evaluation the insertion of this variable in the GIM system for simulations of composition of the city.

The concept of solar access can be set by varying the daily and seasonal path of the sun in their relationship with the land. Thus, it was considered important to evaluate this parameter as a limiter to the constructive potential of cities.

The first step was developed a tool to calculate the sun's position considering the time zone and latitude of the buildings. This script was created in pyton language and implemented in Arcgis 10 through the model builder.

After creating the position of the sun in a particular date and time, for example, 01/01/2013 08:00am, we can create de silhouette of the building according to the target of sun position, in the example, summer and morning. (Figure 1 and 2)

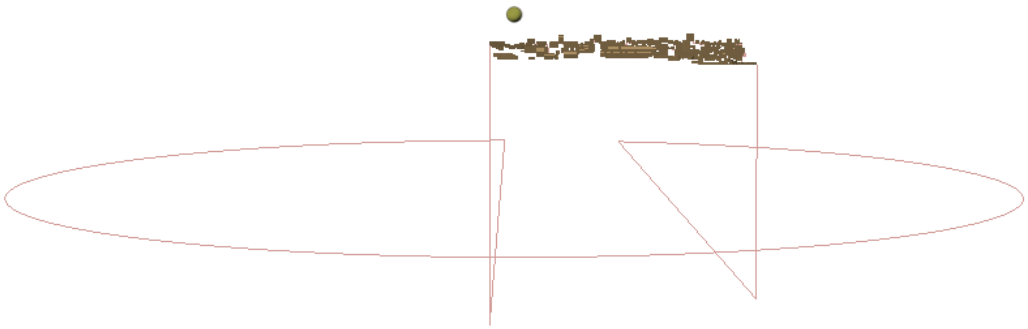

Figure 1. Position of the sun in relation to buildings

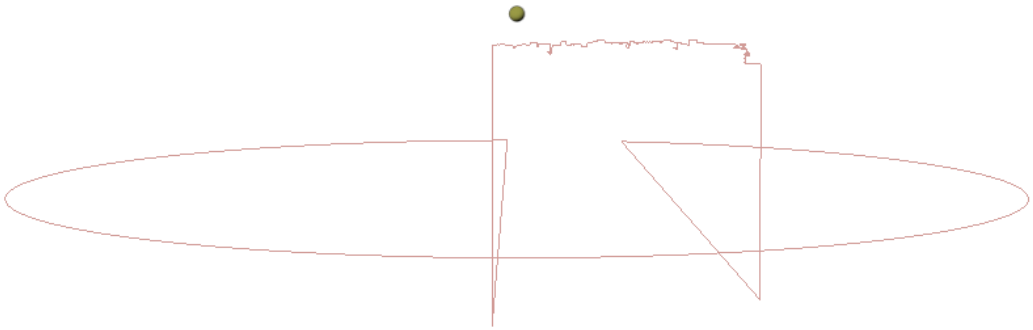

Figure 2. Silhouette of building in relation of the sun position

After drawing the silhouette of buildings for a specific position of the sun, it was created the shadow that these buildings will produce. The solar envelope generated by the application of high solar angles at the corners of the lot or currency area, determines the volume envelope by crossing diagonal angles on the ground (Figure 3)

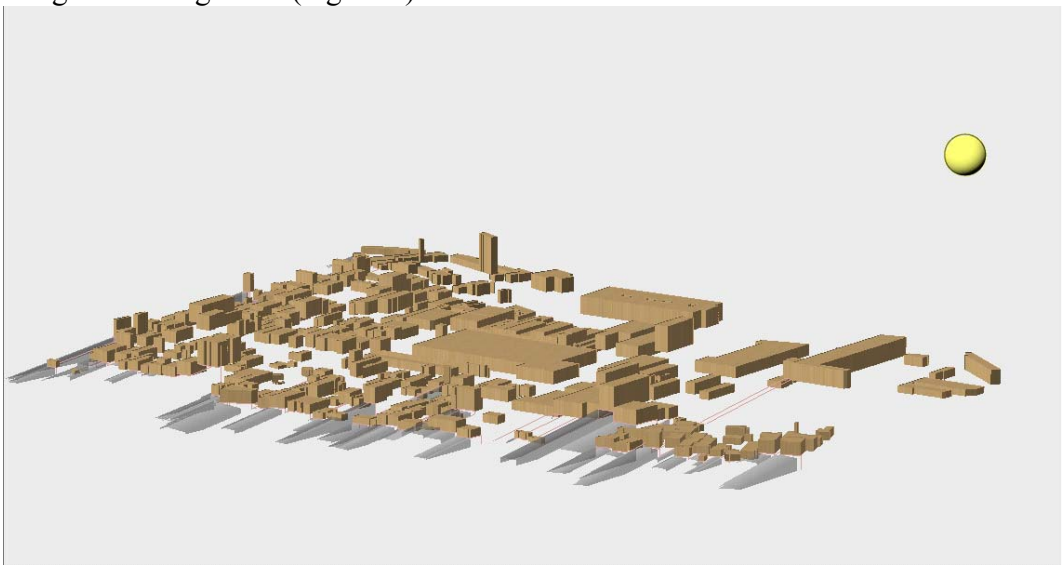

Figure 3. Shadow of the buildings for a specific time and date

3.RESULTS AND DISCUSSION

This paper attempts to improve the solar envelope calculation introducing a new technique for making calculations of solar envelopes over complex urban sites easier and more precise, with a city created in a GIM system.

By applying the techniques of shadow model proposed in this article within a GIM is possible to assess the impacts in relation to shadow that buildings are going to do in your surroundings. You can enter the sketch of a building that is still in the planning stages and do the projection of how is going to be this shadow of this building predicting the consequences before actually allow the construction of the building. (Figure 4)

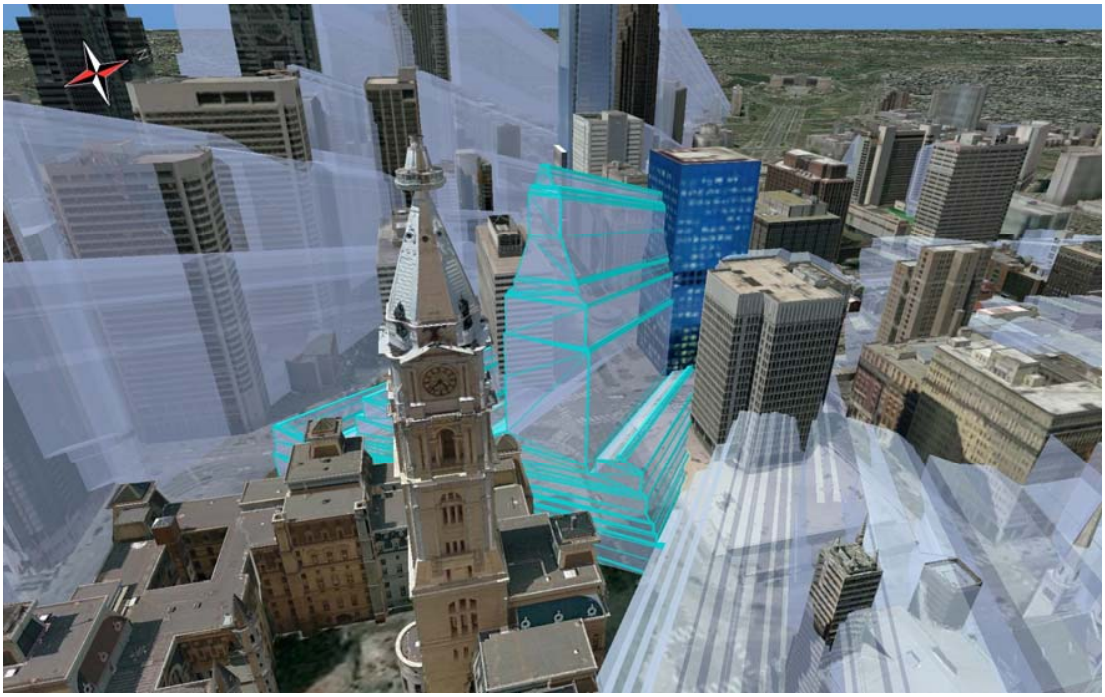

Figure 4. Shadow of the church that is in the project step.

Once you have calculated these shadow volumes, you can use them in subsequent analyses. For example you can calculate which windows receive shadow at a particular time.

In the screenshot below (Figure 5), the colored points represent window locations. Using the Inside3D tool, we can analyze which windows will receive sun (yellow), which windows will receive shadows from existing structures (blue) and which windows will receive shadows from the new proposed structure (red)

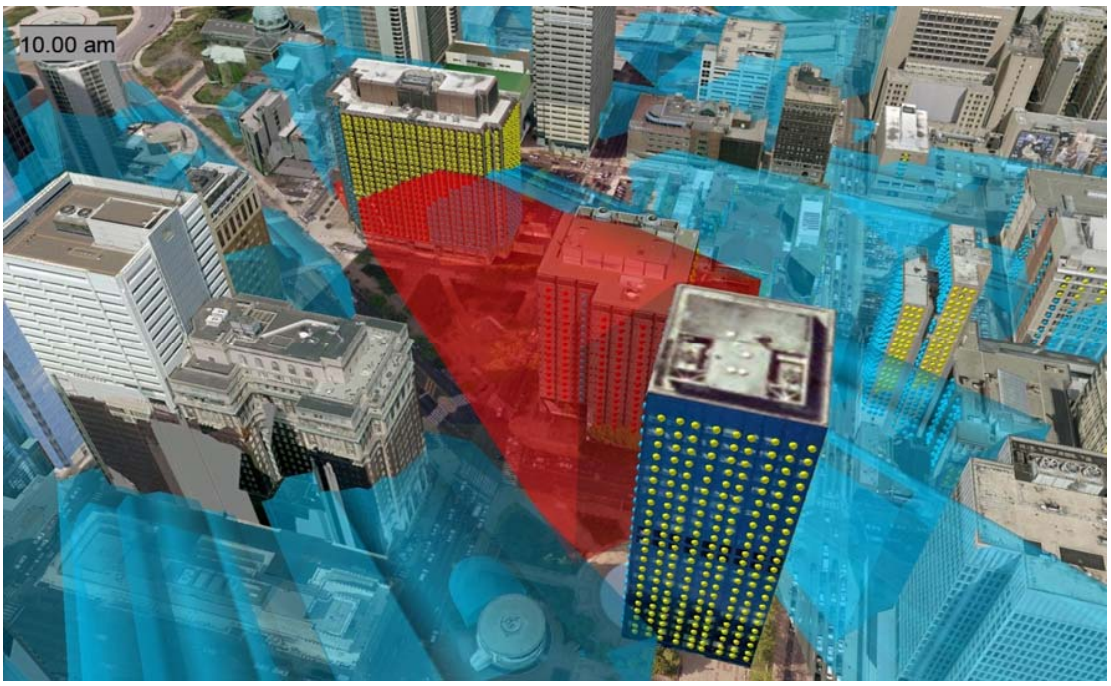

Figure 4. Colored points represent shadow

Along the same lines, we can calculate which facade areas will receive sun or shadow at any particular time. We can use Intersect3D to intersect the facade of a particular building of interest with the shadow volumes. This allows us to calculate the area affected by shadow of existing buildings, shadow of the proposed building or no shadow effect at all.

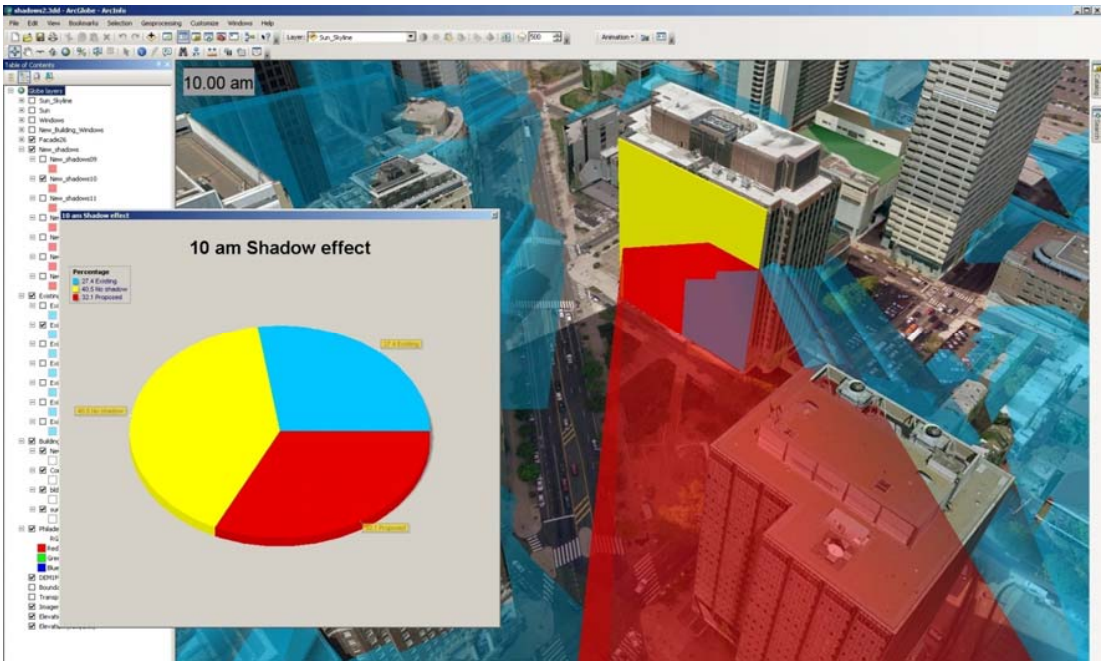

Figure 4. Area affected by shadow

4. CONCLUSIONS

The application of the shadow model in a system of three-dimensional representation of the town showed great interest in the context of regulation of access to sunlight. You can analyze forms to construct builds according to the parameters for urban and have the least possible impact on access to the sun's neighborhood.

This investigations into this issue indicate that the solar envelopes should be considered in the regulations constructive cities.

The solar envelope is proposed as a zoning device to achieve solar access by regulating development within limits derived from the sun's relative motion. Buildings within its boundaries will not shadow surrounding properties during critical periods of the day and year. Assured solar access thus offers the chance to replace unreliable energy sources and to enhance the quality of urban life. Assured sunlight also suggests rhythm as a novel design strategy, as a way to bring us closer to a sense of nature in our buildings and urban spaces.

References

1. Brown, G.Z., Dekay, M. 2001. Sun, Wind & Light. New York: John Wiley &Sons. 89-98.
2. Campagna, Michele. (2012). Lecture Notes: Planning Support Systems: Models And Design Principles. Spatial Data Infrastructures And Volunteering Geographic Information: Advanced Development On Data Sources For Geodesign. Npgau – Núcleo De Pós-Graduação Em Arquitetura E Urbanismo, Ufmg, Arq 808.
3. Knowles, Ralph L. 1974. Energy And Form. Cambridge,Massachusetts:Mitpress.
4. Knowles, Ralph L. 1981. Sun Rhythm Form. Cambridge,Massachusetts:Mitpress.
5. Moura, Ana Clara M., Moura, Carlos Alberto, Santana, Sheyla Aguilar, Lanna, Lucas S., Azevedo, Úrsula Caroline, Lourenço, Paula M. (2010). Geoprocessamento Nos Diagnósticos E Prognósticos De Áreas De Interesse Especial Ao Na Área De Influência Das Linhas De Transmissão Da Cemig - Estudo De Caso Da Rmbh. Anais Do Xxiv Congresso Brasileiro De Cartografia , Aracaju-Se.
6. Moura, Ana Clara M. (2012). Learning Topics In Urban Planning At Ufmg: Geoprocessing To Support Analysis, Planning And Proposal Of The Urban Landscape At Neighborhood Scale. 5th International Seminar On Environmental Planning And Management - Urban Responses For Climate Change - Brasilia, Brazil - October 18 – 20, 2012. 15 P.
7. Niccola, C. (1991) Dialettica Di Modelli E Fattori D´Incertezza Nelo Studio Dele Aree Metropolitane. In.: Bolognafiere – Saie. Il Projeto Metropolitano: La Città Europea, Bologna: Fiere Di Bologna. P. 20.
8. O'brien, W.T., Kennedy. C.A., Athienitis, A.K., Kesik, T.J. 2010. The Relationship Between Net Energy Use And The Urban Density Of Solar Buildings. Environment And Planning B: Planning And Design. 37:1002-1021.
9. Rutten, D. 2010. Grasshopper: Generative Modeling For Rhino.(Version 0.7.0045) [Computer Software]. Robert Mcneel And Associates.Available From Http://Www.Grasshopper3d.Com
10. Van Der Berg, L. Van Der Meer, J. (1991). Politica E Gestione Urbana, Il Caso Rotterdam. In.: Bolognafiere – Saie. Il Projeto Metropolitano: La Città Europea, Bologna: Fiere Di Bologna. P. 41.

A bird-eye view to sustainable designs in changing cities: *Green roofs*

H. Aladağ[1*], H. Düzgün[2]
[1]Department of Civil Engineering, Yıldız Technical University, 34220, İstanbul, Turkey
[2]Department of Architecture, Yıldız Technical University, 34349, İstanbul, Turkey

*Corresponding author: E-mail: haladag@yildiz.edu.tr, handealadag@hotmail.com, Tel: +90 2123835258, Fax: +90 212 3835153

Abstract

After the recognition that the construction industry has the largest share on ecological damage with the energy use, fossil fuels and produced wastes during the life cycle; transition to "green" in sustainable architecture accelerates. Reduction of the green areas in changing cities has a negative impact on the ecosystem and the environment. Therefore, green roof surface as a solution-oriented application, which is offered by advanced technology, is becoming one of the most important opportunities.

In this paper, it is aimed to draw attention to the role of eco-design relationship and to evaluate the ecological parts of the city that are outstanding with various physical and social features in the changing cities. For this reason, many points in urban space will be re-discussed in terms of "sustainability" and the contribution of the relationship between sustainable design and energy efficient building design that provides sustainable architecture will be discussed by means of "green roofs".

In the context of nature-design relationship, it must be considered reasonably when it comes to creating natural environmental conditions with artificial spaces that have been designed. In this regard, positioning green roofs with their physical and social influences that is a part of sustainable architecture in the nature-design relationship constitutes this studies authentic value.

In this study, "green roofs" that are considered as a reflection of the physical aspect of sustainability concept over changing cities are emphasized. In this context, it is aimed to clarify the relationship between sustainable design and green roofs with the examples that will be discussed in the study. In order to determine the relationship between sustainable design and green roofs, a comprehensive literature survey will be conducted and then evaluations about examples chosen around the world will be carried out at the conclusion section.
Keywords: Sustainability, sustainable architecture, ecological design, green roofs, urban landscape

1. INTRODUCTION

To keep life and humanity continue to exist, environmental problems and solutions to these problems are always hot topic. We constantly question and discuss our design decisions and living conditions in order to deliver more quality and healthy environment for humanity and to constitute an environment that can address future generations' needs [1].

It should not be overlooked that built environment have impacts on individuals' and societies physical and psychological conditions as well as economic conditions [2]. Therefore under the title of sustainability, one of the prominent needs is the need for green areas for the cities that consists built environment. Recovery effort of natural areas that are destructed during building artificial environments considered that has contribution to the social, physical and economical aspects of