The use of spatial modeling techniques in Landscape Studies

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Abstract

Cities are living spaces in which private property and public property are mixed, both subject to variable change patterns in a process of very fast occurrence in Brazil. Considering the landscape in a way as a public good, in the other way a private good, we take into account the value of communication in relation to urban landscape planning.

Despite the current technological reach and diversity of media for communication available in the toolbox, several urban plans are also presented in textual simplified media– zoning dimensional maps, texts and tables with numerical values. This paper discusses an experiment that involves a possible approach related to the diagnosis, prognosis and especially the communication of urban planning for the community. Regarding the diagnosis / prognosis, the work compares experiences of modifying actions on the territory and over the intraurban landscape through the analysis of impacts of modifying actions on the landscape.

Besides getting established as a tool to evaluate the impact on the landscape, the paper concludes that the techniques discussed are examples of new forms of communication and management of facilities to be implemented through collaborative maps and other techniques, which directs the discussions and project processes on urban planning.

1. Introduction

The discussion of landscape and sustainability goes through an important moment in Brazil, given the intense process of urbanization widespread in the territory with forces acting similarly in a greater or lesser extent, not only in large urban centers but as in medium and small size cities. The use of models and geotechnologies grows in importance in its way as supporting tools for planning, insofar as this interferes on planning and defining the landscape that must be understood as a right from all the populations of the cities. In Brazil, changes in legislation process increased popular participation. Thus, the development of studies and investigation of the processes of intraurban change, we must emphasize the utility of geotechnologies and their analysis techniques, which are defined by three main purposes:

1. Acting to characterize the processes of change, enabling the recognition of potential, needs and standards, data storage and cross-spatial information;
2. Communicate processes and technology flowsallowing the reflection of interactions between the enterprise and this neighborhood´s landscape;
3. Promote integration of thoughts and values between the various stakes involved.

Among these concerns, we highlight the diffuse interest of the preservation and conservation of nature, expressed in federal environmental laws and another interest, specific, to discuss the results of long-term projects that will interfere with the landscape.

Characterization of projected visible urban Landscape

This paper discusses the action of city planning on the production of form and, consequently, of the visible urban landscape. This does not mean one is ignoring or belittling the spontaneous production and informally generated landscape, resulting from designed actions and not recognized as a not legalized urban landscape. It is just that this is not the focus of this work.

The main features of the projected visible urban landscape can be synthetically quoted as follows:

- The urban landscape is endowed with projected visible dynamism, and is a product of human action that produces a superimposed palimpsest (Harvey 1996, Calvino 1990, Santos 2006, Soja 2008);

- It is endowed with a historical dimension combined with a spatial dimension (Sauer 1998);
- The aspects of architecture and urbanism are inseparable in the urban landscape, since it is the result of the interplay of these aspects (Freitas 2007);
- Its interpretation depends on the observer's point of view, since it is the result of cognitive processes (Lynch 1988), and also who presents to the public, as this presentation may be imbued with some kind of strategy, for example, related to entrepreneurship (Harvey 1996, Souza 2006).

The entitlement to landscape

If utopia serves to guide our steps, why not also wish the city to be a beautiful landscape to be enjoyed by all? (Cavallazzi andD'Oliveira, 2002)

Once one has in mind a mode of production where landscape results from actions of entrepreneurship, it is approaching a point of significant importance in the production of cities: the transformation of the landscape generates losses and gains. This can result in changes to existing values producing a new landscape according to the interest of one group and not of the community, but may also result in gains of values that are not shared by the community's territory. Furthermore, the landscape can be seen and used as a commodity. In this case, the landscape becomes a very suitable often unevenly. It is now considered as attribute - environmental, natural and built. Thus, the landscape becomes a differentiator for investment property that can add value or not. (Cavallazzi and D'Oliveira, 2002). The landscape can be marketed in the same way that the "city-marketing", analyzed by Vainer (2000), to be transformed into a "thing" to be bought and sold.

It is remarkable that these presented correlations keep a contradiction. As stressed by Cavalazzi and D'Oliveira (2002) a dichotomy and a conflict are set up between the "private-economic dimension" and "symbolic dimension / cultural / public" landscape. A conflict of interest blows up because often a form of ownership prevents or hinders another, as will be seen in the case study reported below.

City Statute

The Federal Constitution (Brazil, 1988) deals with themes and principles of planning the urban development, such as the notions of social func-

tion of property, the search for a balanced urban growth and the introduction of tools for state action to ensure social justice. This Constitution was the result of a multisectoral national movement who fought to include in instruments leading to the establishment of the social function of the city and ownership in the construction of the cities (Brazil, 2001). The inclusion of a specific chapter for urban policy (Articles 182 and 183) was the consequence of this action. The Constitution, however, lacks of specific legislation nationwide "that the principles and instruments listed in the Constitution could be implemented" (Brazil, 2001). Thus, further legislation was required for the regulation of instruments presented by the constitution, such as "the mandatory construction of master plans that incorporate constitutional principles in municipalities with over 20,000 inhabitants" (Brazil, 2001).

The regulation of these policies occurred with the enactment of the Federal Law. 10.257, of July 10, 2001, better known as the *City Statute*. This Law establishes general guidelines for urban policy and addresses issues of social interest related to the use of the property in defense of collective interests, environmental balance and promote the full development of the social functions of cities. Besides that it offers new tools for urban organization, besides regulating those already provided in the Federal Constitution. The *City Statute* also sought to provide state intervention mechanisms that regulate urban politics in large cities.

The City Statute seeks to increase popular participation in the processes involving collective decisions of great interest in the project implementation and to understand structural changes or major extension in the urban environment. Prestes (2003) summarizes the main guidelines expressed in the City Statute:

- The right of sustainable cities for the population to;
- Democratic management of urban space;
- Cooperation between the spheres of government, private sector and other sectors of society;
- Planning the development of cities;
- Appropriateness of instruments of economic policy, tax and financial and public spending in order to favor investments that generate well-being;
- Provision of urban and community equipment, transportation and adequate public services;
- Ordering and control of land use;
- Simplification of legislation installment and use and occupation of land;
- Fair distribution of benefits and burdens arising from the urbanization process;

- Land regularization and urbanization of areas occupied;
- Equality of conditions for public and private actors in promoting ventures.

Also according to Prestes (2003), "the breakthrough of the City Statute is to have society participation in public planning process, providing a series of instruments to induce the development, funding urban policy, democratization of urban management and land regularization". André et al. (2006) defines public participation as "the involvement of individuals and groups that are positively or negatively affected or who are interested in the proposed project, program, plan or policy, subject to a decision process".

The Statute establishes standards for municipalities in terms of "public order and social interest that regulate the use of urban property in favor of the collective good, safety and welfare of citizens and environmental balance" (Brazil, 2001). Its importance is, between other reasons, the fact that demonstrates effective means of presenting the standards to be developed by municipalities. It can be said that the Statute operates as a kind of "toolbox" for local urban politics (Brazil, 2001).

To Menegale (2002) the importance of the City Statute lies in the democratic character which requires the management of cities, through their premises. The document "provides not only the municipal government, but also to citizens, legal conditions to manage the formulation, implementation and monitoring of plans, programs and projects of urban development."

Cerqueira (2006) points out that the City Statute:

> [...] Took an important step in order to enhance the involvement of the community in urban planning to create legal demand participation and open up new mechanisms for their implementation. So, have today become more possibilities des citizens themselves articulate and able to exercise their rights.

The City Statute provides, innovatively preserve the right to landscape within the social function of the city. However, safeguarding the *heritage landscape* established by the City Statute restricts the application of the instrument Neighborhood Impact Study (NIS), which puts the requirement for analysis of effects in relation to the landscape.

According to Braga (2001), to set important foundations of policy urban, the Statute also became "an important tool for environmental management, given that urbanization has a set of the most impactful on the environment".

In the Statute, the concept of *neighborhood impact* goes beyond the conditions most commonly associated with the term "neighborhood", such as traffic and public peace. It covers "aspects such as changes in the urban

landscape and the natural and cultural heritage, although these go beyond the simple right neighborhood". (Braga, 2001).

2. Methodology section

The analysis methodology consists of a case study in which the landscape is one of the striking elements. We used 3D modeling combined with digital image processing of Asteri.

We used 3D modeling combined with digital image processing of Aster. As quoted by NASA (2009), the Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) on the spacecraft Terra is capable of collecting in-track stereo using nadir- and after- looking near infrared cameras. Since 2001, these stereo pairs have been used to produce single-scene (60- x 60-kilometer (km)) digital elevation models (DEM) having vertical (root-mean-squared-error) accuracies generally between 10- and 25-meters (m). On 2009, NASA and the Ministry of Economy, Trade, and Industry (METI) of Japan released a Global Digital Elevation Model (GDEM) to users worldwide at no charge as a contribution to the Global Earth Observing System of Systems.

According to Sacks et al (2004), solid modeling allowed many of the original goals of 3D CAD to be realized: accurate representation of a three-dimensional shape; automatic derivation of any shape measurement, including volume and surface areas; cutting of sections, including automatic derivation of section properties; automatic drawing generation of parts or assemblies, with automatic dimensioning.

Aware of the fact that the city is a result of the application of parameters established in the legislation, that happen in individual operations but generate effects of irradiation once that constitute the whole of the landscape, we have chosen as a case study to discuss the questions previously placed the NIS - Neighborhood Impact Study. The case discusses the use of geotechnologies for the diagnosis and prognosis of movement of winds and sunshine in an informal consolidated settlement (aka "favela") which will give the installation of a general hospital. The paper presents the use of spatial modeling techniques in a Neighborhood Impact Study (NIS) for the diagnosis and evaluation of changes brought by the installation. The City Statute indicates as one of the EIV´s requirements the analysis of the transformations of the landscape by installing a new building. There are many possibilities to transformation caused by humans in the original landscape, hence the importance of evaluating the hypothesis in which a

new model to be defined for the human-space proposed by this modifying action keep this sustainability.

Preliminary investigation associated an enterprise of great impact, configured by a hospital, with the basic characteristics of the potentially affected environment, identified on the urban and environmental diagnostic. This diagnostic was based on a model for the region where the enterprise is going to be installed, which would evaluate present wind and insolation conditions. A model was defined by Haggett (1965) as "an ideal representation of reality in order to demonstrate certain of its properties", therefore aiming to reproduce local conditions of topography and building volume. As defined by the author, a 3D model is seen here as a simplification of positioning and spatial distribution complexities. Mathematical forms of representation are used in the creation of this model, in a way that, as a result, it is connected to realities' proprieties through analytical techniques. Finally, we briefly evaluated the enterprise's impact on the landscape in terms of positive and negative effects.

Studied area

There is a conflict between the conceptual landscape, defined here as an asset public use, and amendments taken in this public good by private modifications. These amendments are not easy to grasp, since its effects are diffuse and variable depending on the size of the building, the points of sight more affordable and the landscape itself to be changed. The case study deals with this conflict, which is more evident in an already degraded landscape.

The municipality of Betim is located within the metropolitan region of the Minas Gerais state capital, Belo Horizonte, and had circa 370,000 inhabitants in 2010. The Jardim Teresópolis district is an informal consolidated settlement, populated now for about 40 years, in a widespread manner. Today, the district's inhabitants reach the figure of 45,000 (Brazil, IBGE, 2010).

Fig. 1. Map showing the location of Betim - Belo Horizonte, Minas Gerais, Brazil

Air circulation in Jardim Teresópolis (which is an area of intense irregular and consolidated settlement, presenting 90% of built area) is difficult, due to the presence of two (or more) story buildings, in most cases, with no side setback space. It is also important to mention that building volumes did not respect any frontal setback from the public road, as seen on the Figure 2.

Fig. 2. Typical street

At the enterprise's landscape, wind action is fundamental in the dispersion of pollutants, evapotranspiration, and in moisture and heat advection. In that area, as in other intensely modified metropolitan areas, gases and solid particles are thrown into the atmosphere, where they remain. According to wind direction and intensity, these particles may be transported or confined in some areas, potentially influencing directly local conditions of quality of life.

Diagnostic of atmospheric circulation patterns

Air circulation analysis – with or without the enterprise's installation – is hindered by the absence of data regarding wind duration, intensity, direction and velocity, for the area to be modified. When data is not available, this paper is using data gathered for the entire Metropolitan Region of Belo Horizonte. Here we refer to the work undertaken by Prudente et al. (2008), which analyses local air circulation and the variables which interfere both direct and indirectly to its dynamics. It analyzes wind behavior by year, month and day, as well as studying wind variations occurring during specific periods of influence by meteorological systems (such as cold fronts, South Atlantic conversion zone and air masses on the region studied).

According to the authors previously mentioned, the Metropolitan Region of Minas Gerais is influenced by of a variety of atmospheric phenomena, typical of medium and tropical latitudes, making this an area of transitional tropical-extra tropical climate. The hilly and undulated relief presents peculiar characteristics to the region, which interfere in phenomena such as rain distribution, temperature variation, and wind velocity and direction. These authors point out that wind is generated by several factors, such as: horizontal pressure gradient, horizontal temperature differential, and atmospheric instability (Linacre, 1996), indicating differential heat as the main factor in generating wind. This is because differential heat generates atmospheric pressure gradients, in both local and global scales.

When data is not available for the enterprise's specific location, we used data gathered by the automatic station of *InstitutoNacional de Meteorologia*, Meteorology National Institute – *Inmet*, located inside *PUC Minas* university campus, in the municipality of Contagem (for velocity times, direction and wind gust, precipitation and temperature for 2004), as well as data gathered by the Meteorological Station of the state energy company, *Cemig*, located in the Barreiro region, in Belo Horizonte (regarding wind velocity and time). Prudente et al. (2008) analyzed data from the stations of Contagem and Barreiro, and reached the conclusion that wind velocity in both is similar, with the exception of both registered aver-

age values: in Contagem, annual average velocity is 2.7 m/s, while in Barreiro, is 5 m/s.

Wind direction varies in time and space, according to geographic location, surface irregularities associated to relief and vegetation, climate and time of the year (Vendramini, 1986). Due to existing high pressure above the Atlantic Ocean, winds reaching Minas Gerais are, in its most part, coming from E-NE.

Through wind direction data gathered from Contagem station, we verified that in the entire year wind traveled near 90°. This means that it is an east wind, with the only exception of October, when the predominant direction was southeast. The image below shows the arrangement of these directions for the enterprise's location.

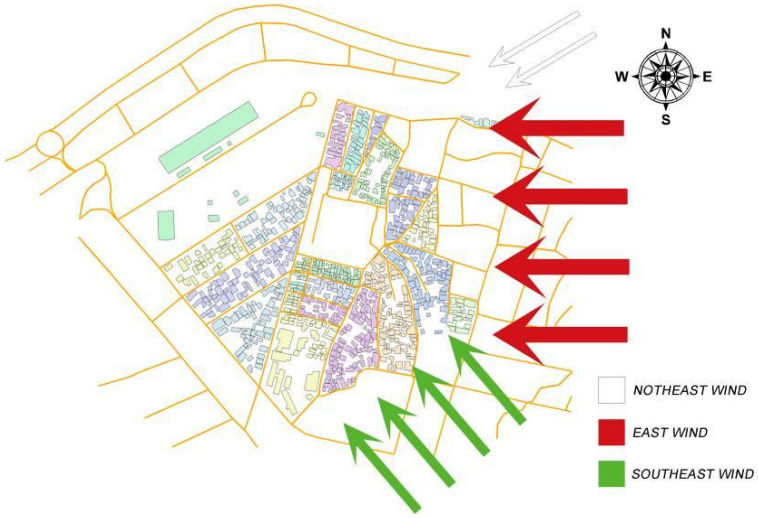

Fig. 3. Dominant Wind in the enterprise's location

Volumetry simulations

The *Diagnostic of atmospheric circulation patterns* was used for the region where the enterprise will be located, alongside with other information regarding the area's topography, obtained by digital elevation model – DEM of ASTER images, and from the architectural building project, in order to represent and simulate better the wind obstacles and volumes of the building and its surroundings. As seen in the volumetry simulations shown below, edification presents horizontal development, with a tower. The following images present volumetry in several angles.

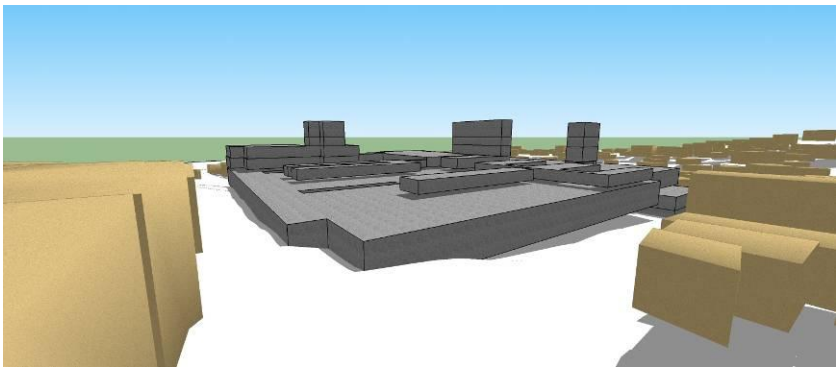

Fig. 4. Volumetry – Simulation from the side street A

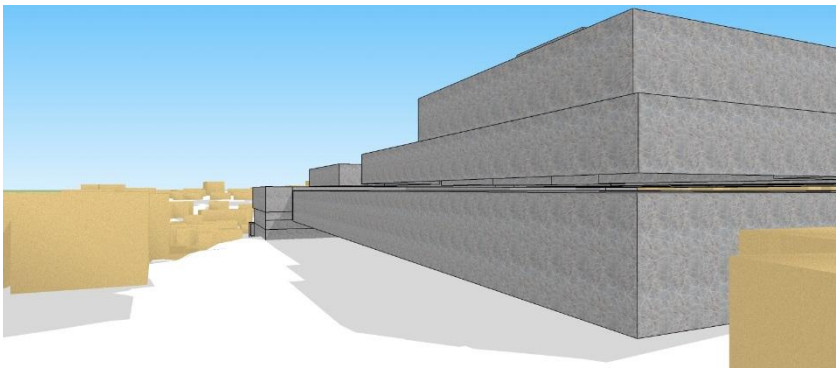

Fig. 5. Volumetry – Simulation from the side street B

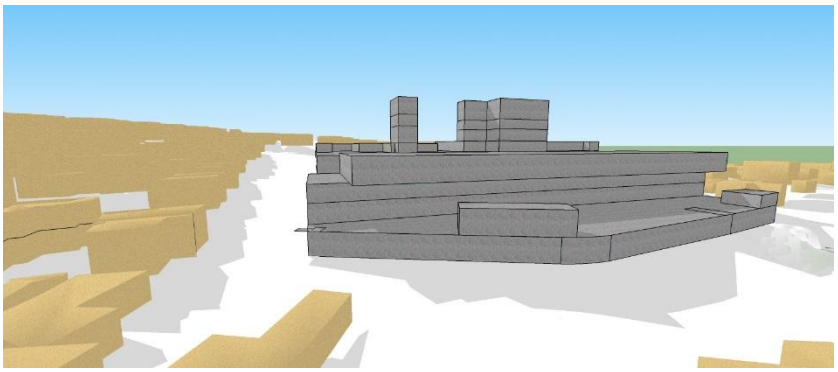

Fig. 6.Volumetry – Simulation from the Main Street Diagnostic of lightning and insolation

Urban comfort evaluation at the enterprise's landscape, takes into account lightning, insolation and thermal energy dissipation. As large areas are waterproofed, and buildings are closer together (since setbacks are absent), environmental damage is relevant, compromising the city's ventilation and lightning, altering micro-climate, insolation, wind paths, damaging health and comfort conditions inside buildings, and increasing energy consumption. According to Teza and Batista (2005), heat island phenomena results in the increase of average temperatures within central zones of urban clusters or metropolitan regions, comparatively to periphery zones or rural areas, caused mainly by anthropic influence.

In the enterprise's landscape, the settlement pattern usually generated two story buildings, without façade's setbacks, and no side setback spaces. The diagnostic undergone also points out the predominant absence of finishing materials (with the exception of exposed masonry). This results in the formation of urban canyons, hindering not only wind circulation and dust dissipation, but also insolation of neighboring buildings.

Insolation Modeling

Aiming to simulate the enterprise's impacts on its surroundings regarding insolation, we created a three dimensional modeling of the building and its immediate setting. The modeling for insolation changes was divided into two stages. In the first stage, it has been performed a volumetry modeling of the hospital's building, using as a source, plants and sections of the architectural project. The extrusion occurred from the external masonry projection, considering the highest point in the ceiling. Volumes were created using SketchUp® software, and piled up, resulting in the building's total volume.

On the second stage, we created the modeling of the buildings' surroundings, as follows:

1. Gathering satellite images, made available by Google Earth®, followed by its storage as a KML file.
2. Conversion of KML files into SHP files, using Arc-ToolBox by ArcGis®.
3. Correction of the projection and ortorretification, also using the shape edition tool by ArcGis®.
4. Insertion of the fields *quantity of floors* and *height* in the shape's attribute table. To the attribute *height* was regarded a specific value, with a ceiling height of 3m multiplied by the number of floors identified for each building.

5. The shape file for the building's projection was then opened using ArcScene® software, and the volumes were extruded from the attribute *height*.
6. Building altimetric quota was allocated from the Digital Elevation Model generated from interpolation of the topographic contour lines shown in the ASTER images.
7. All 3D models generated by ArcScene@ were exported as a .WRL and converted into .SKP, using Blender open source software.
8. In SketchUp®, the 3D model of the hospital was manually placed between surrounding structures and over the modelled terrain (respecting each projection's scale).

Afterwards, a simulation was created depicting the solar traffic reaching the building and its surroundings, for summer (December 21st) and winter (June 21st) solstices. To analyze summer solstice, the analysis focused on hours between 06:00 and 18:00, since during summer it is customary to use Daylight Saving Time. In order to understand solar traffic, we also simulated a third position, corresponding to spring (June 21st) and autumn (March 21st) equinoxes. We then used the tool offered by SketchUp® application for generating shadows for the equinoxes and solstices mentioned, using three hours average intervals. As a result, we created superior orthographic views and perspectives faced views (frontal and right side of the hospital), as shown in the following images.

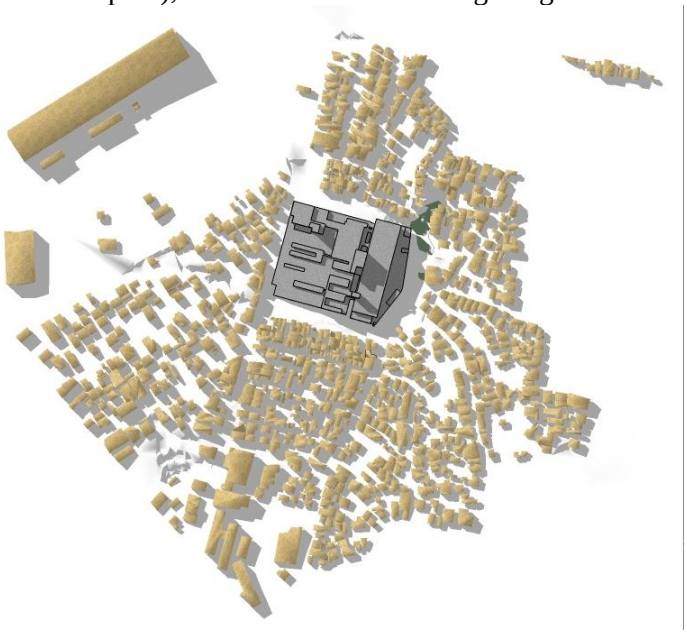

Fig. 7.3D Modeling – Winter solstice (June 21st) – 07:00

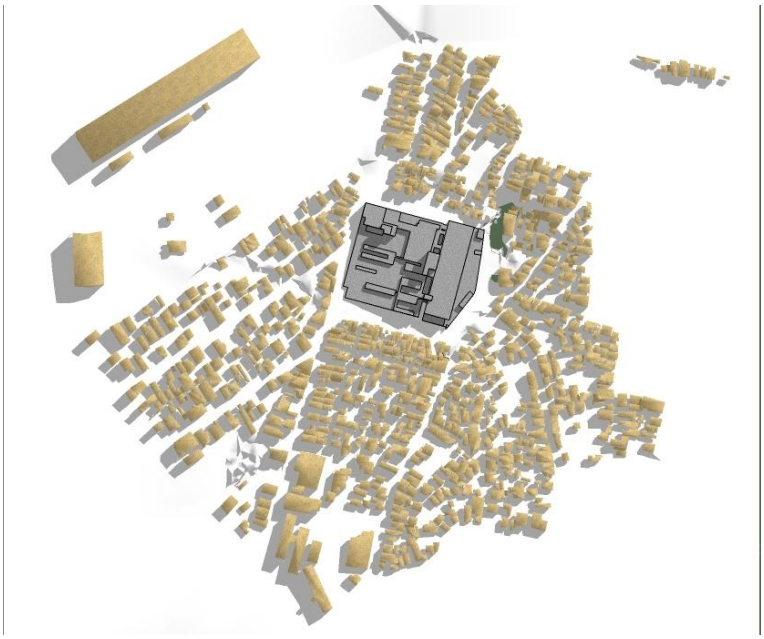

Fig. 8.3D Modeling – Winter solstice (June 21st) – 09:00

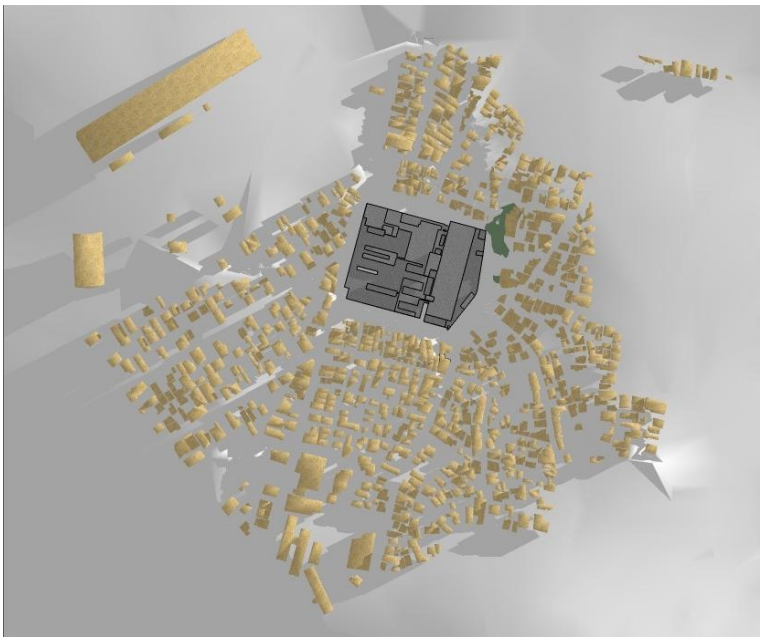

Fig. 9.3D Modeling – Winter solstice (June 21st) – 15:00

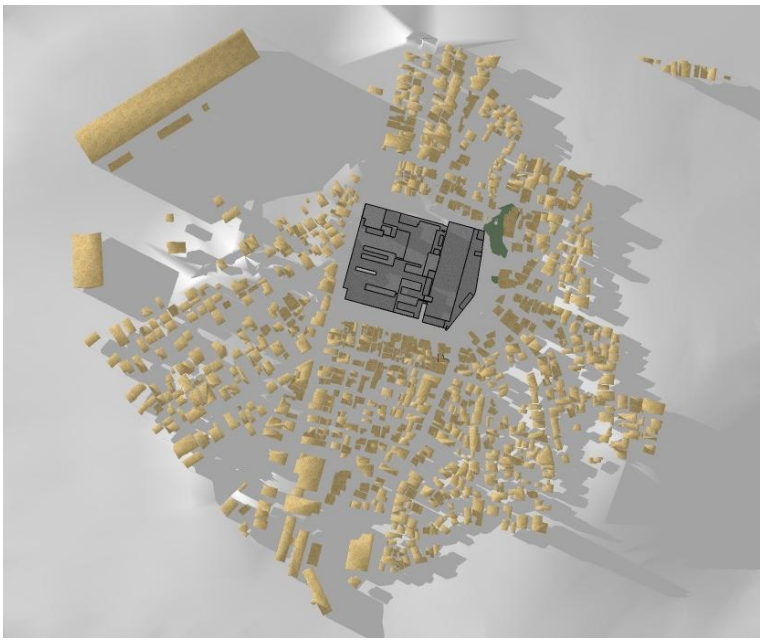

Fig. 10.3D Modeling – Winter solstice (June 21st) – 17:00

3. Results

The enterprise is analyzed according to the effects it generates on its landscape. These impacts are discussed as follows, bearing in mind urban planning parameters.

Effects on Wind circulation

Most radiation entering atmospheric environments in narrow roads (such as in the enterprise's surroundings) is absorbed due to multiple reflection, independently of its direction. Verticalization in itself does not constitute a problem. In fact, what makes this radiation a negative impact is mostly the lack of boundary setbacks, resulting in a poor air circulation. The diagnostic report does mention this problem in constructing the hospital. In the streets surrounding the building, heat is absorbed mainly by the building's walls. When following urban patterns for the area, the hospital's installation will mean an increase of non built volumes with no façade's setbacks, what will allow for greater air circulation in its immediate settings.

Effects on the area's insolation

Volumetric modeling and solar traffic simulation allowed for the identification of shading on public streets and façades. The main result of this analysis determines that the area, especially at the informal settlement, south of where the hospital will be built, do not receive morning sun before 10:00hs or after 15:00hs, meaning an obstructed horizon and resulting poor air circulation.

4. Conclusions and recommendations

Neighborhood Impact Studies (NIS) presents the characteristics and significance of an environmental study. However, they particularly focus on local impacts on anthropic and urban areas and are not limited to the study of insolation and ventilation, but they are much more complex and try to translate the effects of the installation of an enterprise on aspects of formal and conceptual relationships present in their neighborhood, seeking to maintain the balance and sustainability of such.

Through NIS, we verify in this case study that the impact caused by the hospital on the local wind circulation patterns will be minimal. Also, we point out that the demolition of buildings at the hospital's immediate surroundings will reduce the volume cluster and side setbacks, promoting frontal setbacks following the new structure and wider roads, and, therefore, resulting in lowering the probability of heat islands, as discussed by Ribeiro et al. (2008).

Also, regarding heat islands, the analysis of volumetric alteration confirms Oke's affirmation (2006), for who is not possible to establish a standard climate behavior within an urban canyon. This is due to several factors influential in a micro-climate: street direction (which changes solar angle), constructive materials, and street dimensions (height x width), which define the difficulty in solar energy penetration.

The results of applying this system to support planning is part of a new way of rethinking the urban and the varying degrees of popular participation necessary for the effective construction of a collegiate space

- Considering the landscape in a way as a public asset to be maintained,
- Considering the same landscape in another way as a private asset subject to changes,
- Taking into account the value of communication in relation to urban landscape planning.

Concerning the tools tested to improve the means of communication requested by Neighborhood Impact Study (NIS) results shown an expansion on data communication pointing out a possible way to improve on building diagnosis / prognosis.

The results of applying this system to support planning is part of a new way of rethinking the urban and the varying degrees of popular participation necessary for the effective construction of a collegiate space.

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[i]ASTER GDEM is a product of METI and NASA.