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ABSTRACT

Environmental quality is an important concern affecting quality of life and plays a critical role in every urban milieu. Aspects of environmental quality, such as safety, security, privacy, sense of place, and visibility are considered to be qualitative and are generally studied using qualitative methods, tools and techniques in order to describe and explain their role in the urban space, but lack the designer's perspective and tools for analysing the results in urban geometric terms

This paper proposes an approach and a methodology framework that transforms qualitative aspects of environmental quality into quantitative geometrical terms that provide support to the work of architects and urban designers by allowing them to reference these aspects objectively. The new approach is demonstrated on one qualitative aspect, the visual privacy, and introduces a model that measures it in the urban environment, developed based on the proposed methodology. This includes the three parts of the methodology framework: (1) transformation - identifying qualitative aspects of privacy for transforming them to objective terms; (2) development of measurement methods – for evaluating and measuring privacy in the urban environment; (3) development of a scenario for the use of the methods during the urban design process. The model to measure the visual privacy emphasizes the potential for future development, where the designer will have the opportunity to evaluate one quality type of the environment, the visual privacy level, and be able to improve the design for benefitting better privacy levels. Hence, this morphological approach can be used by urban designers and architects during the design and development process and can contribute to the development of sustainable urban environments.

Keywords: environment quality, visual privacy, urban design, quality of life.

1. Introduction: the advantage of measuring aspects of environmental quality

Currently, most quantitative measurements relating to urban design principally analyze building components. The measurement of qualitative environmental characteristics of an asset – what is in-between the buildings but has great effect on the environment quality of the tenants inside the buildings (either in the private or public domain) – can result in an upgrading of the quality of the urban environment. The quantification and measurement of qualitative aspects of environmental quality in the urban environment is an interdisciplinary area that has not been researched sufficiently and yet has the potential of significantly influencing the future of urban design and planning as a whole.

The proposed analysis can also assist potential residents in making their own decisions while examining a property. How they perceive levels of environmental quality (whether high or low) of a desired urban fabric has consequences for how they may value their potential residence in a more particular way. In this context, changes in parameters of environmental quality, such as levels of safety and the perception of safety, levels of security, privacy, visibility, sense of place and more, are captured by the real estate market through property prices. The ability to predict the levels of a diverse range of aspects of environmental quality has the potential to upgrade the quality of the life of tenants in their urban environment with consequences for urban design as a whole.

Researchers from many diverse disciplines have pointed out and defined many qualitative aspects affecting the urban environment and quality of life in buildings, such as privacy (Jacobs, 1961; Archea, 1977), sense of place (Whyte, 1980, Shamai, 1991), security (Jacobs, 1961, Guel, 1971, 2010, Coaffee and Bosher, 2008) and more. Others expressed these definitions with images and demonstrated diverse situations that present such qualitative aspects in the urban environment (for example: Cooper Marcus & Sarkissian, 1986, Guel, 2010 and Berghauser Pont, et al, 2010) but not many have developed models by which the designers can evaluate the urban environment for a better development of urban design.

One of the greatest challenges facing urban designers is the development of secure and safe environments while maintaining privacy and visibility, and while still creating a sense of place. People place value on urban design when they are aware that qualitative aspects of the environment have been taken into account. Urban designers will benefit from doing something important without compromising convenience. The ability to predict the levels of a diverse range of aspects of environmental quality has the potential to upgrade the quality of the life of tenants in their urban environment with consequences for urban design as a whole.

The main assumption of the current work is that there is a possibility to evaluate and measure qualitative aspects of environment quality in objective terms. However, the question is: How can we evaluate and measure these diverse aspects so as to benefit the designers' work. Therefore, the main problem at the basis of this research is the lack of a methodology that can serve architects and urban designers in their work.

1.1 Identifying aspects of environmental quality for purposes of quantitative measurement

Therefore, first we must evaluate and define those aspects of environmental quality which can be transformed into quantifiable terms, and identify their primary components for evaluation and measurement that can serve the designer's work. Figure 1 demonstrates several qualitative aspects that have the potential for transforming their qualitative characteristics into geometrical terms (later we will demonstrate the ability of identifying primary components of a single qualitative characteristic such as 'privacy' and transforming those primary components into geometric terms):

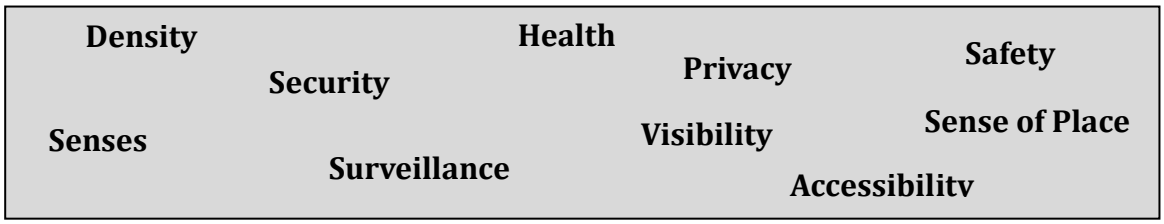

Figure 1: *Aspects of environmental quality that can be transformed into quantifiable terms*

The following describes several such aspects of environmental quality:

Security – in the sense of public safety, is one of the main objectives in the sustainable development of urban areas and can be described as the degree of protection against danger or criminal activity. A separation is needed between benefits and threats (Newman, 1995, Coaffee, 2010, Bosher, et. al, 2011, Mang, & Reed, 2012).

Security relates to visibility and territories (Gehl, 2010). The possibility of transforming and measuring security can be performed by: lines of visibility, number of obstacles or viewpoint position, distances.

Safety – is the state of being safe, of being protected from various conditions such as physical or social damage or from any consequences or events. The feeling of safety can contribute to an individual's feeling of control of his personal space (Cai, et al, 2006; Raco, 2007; Lu, & Chen, 2007; Coaffee and Bosher, 2008). For example, the possibility of transforming and measuring safety can be performed by: the number of obstacles, distance, visible area, and viewpoint position.

Sense of place – the term sense of place has been defined and used in many different ways by many different people. It is a feeling or perception held by people (Whyte, 1980) often used in relation to characteristics that make a place special and unique, to which people are authentically attached and to which they have a sense of belonging (Shamai, 1991; Shamai et. al, 2005, Mendoza, 2013). Some relate to sense of place as something not inherently "positive," such as fear (Yi-Fu, 1977). The possibility of measuring sense of place can be performed by: number of components in the area, connection between different viewpoints and other components.

Visual privacy – is defined as the extent of visual penetration into one's private space as a result of being viewed from the external spaces of other building façades or public spaces at street level. Protecting the visual privacy of tenants in the urban environment can improve their personal confidence, contribute to their feeling of control of their personal space and prevent penetration by undesirable disturbances (Archea, 1977; Newell, 1995). Visual privacy can be quantified by: number of components in the area, surrounding space, building orientation, function arrangements and by distances between buildings or façade openings as is demonstrated in Shach-Pinsly (2010), and later in this paper.

Note: there are additional ***qualities*** that can also be measured, such as those related to the senses (noise – hearing, sound, smell, and touch), surveillance (Coleman, 2005), walkability (Lin, & Moudon, 2010), and others, however are not in the scope of this current paper.

In addition to identifying environmental qualities to be measured, there are several other aspects affecting them which can support efforts at quantification. These aspects relate to ***Distance*** and perception (short distances – strong impressions, long distances – many impressions, spatial distances); ***Scale*** (single building, compounds of buildings, neighborhoods, dimensions of city space, tall buildings beside short buildings, high-rise building areas versus low level building areas); Density (good city space at street level and at upper levels); and ***cultural*** differences (different places in the world). We see for example, that the meter of ***safety and security*** is highly influenced by distance between entrances or from a main road, and is applied differently by referring to the scale aspect (López and Van Nes, 2007). In addition, by relating to senses, distance has a strong influence. For example, as Hall (1966) identified, for short distances, each distance represents a different social aspect, and with regard to the visual aspect between windows of building compounds, different measurements of distances affect the level of ***visual privacy*** for a location (Shach-Pinsly, 2010; Shach-Pinsly et al., 2011).

1.2 Methodology framework

Based on the above, a ***methodology framework*** for transforming qualitative aspects of environmental quality into quantitative terms for the benefit of the designers' work has been developed with three main objectives:

(1) ***Transformation*** – identification of qualitative aspects of environmental quality that can be transformed into measurable terms in order to be evaluated objectively. The transformation is a core issue for establishing a foundation that is capable of stimulating a dialogue among a variety of practitioners and decision-makers, as described by Svec, et. al, (2012).

(1) ***Development of measurements method, criteria and guidelines*** – there is a need for establishment of a basic methodology framework for developing diverse methods, based on geometrical terms, for evaluating and measuring qualitative aspects, followed by developing criteria and guidelines for urban development. Note: there is not one approach or one model for all qualities. For each quality different approaches and different models must be developed, based on their primary components, defined for transforming the quality into objective terms.

(2) ***Development of a scenario for the use of the methods during the urban design process*** –by architects and urban designers for the purpose of measuring the quality of the urban environment during the design development process. Hence there would be different models for measuring different qualities, and there is a need to develop a scenario for use of the models by designers in relation to the quality being evaluated.

Demonstrating the visual privacy measurement model as an example

The proposed methodology framework is demonstrated on one qualitative aspect of the environment, the visual privacy, through three suggested steps: 1) transformation - as privacy was defined in the literature, broken into its primary components and transformed into geometrical terms 2) a model for measuring visual privacy, and 3) a scenario framework for the use of the model during the urban design development process.

2.1. *Transformation*

As the first step, we have searched how privacy is defined in the literature and explored elements that describe conditions of privacy in geometrical terms. Following is a short summary. Perspectives on privacy vary, are occasionally in conflict, and are generally difficult to evaluate in a coherent fashion. There is no agreement about what privacy is (Newell, 1995). The definition of what is private varies among individuals and cultures, although it shares basic common themes. Altman (1975) distinguished among three cases of desired and achieved privacy: 1. If the achieved privacy is equal to the desired privacy, an optimum state of privacy exists. 2. If the achieved privacy is less than the desired privacy, a sense of privacy invasion exists. 3. If the achieved privacy is more than the desired privacy, a sense of loneliness exists. Archea (1977) argued that the organization of the physical elements surrounding people affects their social behavior in the environment and on the information they receive from their surroundings. Archea (1977) introduced two concepts related to visual privacy: the first being visual access – the ability to monitor one's immediate spatial surroundings by sight – and the second being visual exposure – the probability that one's behavior can be monitored by sight from one's immediate physical surroundings. He concluded by arguing that both definitions can be measured objectively in geometrical terms. Therefore, the degree to which private information is exposed depends on how the public will receive this information, which differs from place to place and over time. In addition, the literature offers several definitions that characterize elements affecting visual privacy in the urban environment that can be transformed into urban elements, such as: green spaces between buildings, height of adjacent buildings, window locations, and more. **However, the most affecting aspect found was the distance between buildings, or the distance between facade openings**. Therefore, with regard to evaluation and measurement visual privacy, the distance was the element that was defined in order to measure visual privacy in the urban environment in addition to viewpoint position (the façade openings), and view lines between different viewpoints.

1.3 Development of a measurement method

The model for measuring visual privacy in the urban environment was developed based on the literature survey and definition of distances between buildings. This model was employed on several case studies that enabled the development of derived primary findings and conclusions, for future establishment as criteria and guidelines (Shach-Pinsly, 2010). Following is a short description of the developed model.

Several main definitions lay at the basis of the model for measuring 'visual privacy':

Viewpoint location: The viewpoints in the model have been determined consistently at a height of 160 cm in every façade opening (such as: windows, doors) at the inner part of the facade walls. In order to simplify the method, only view lines between viewpoint locations were measured; in addition viewpoints are defined and numbered without regard to window area and proportions.

Measuring view distances: View distances, termed 'sightlines', and their lengths were measured between all horizontal viewpoints in every story level and between various story levels.

Ranking sightlines by distance: Sightlines were categorized by visual distances regarding low levels of visual privacy (in a positive sense relating to privacy) and high levels of visual privacy (in a negative sense, relating to the lack of privacy), according to the literature survey. These measurements were collected and arranged into six sightline categories, were the lengths of the various distances were coded by colors:

- Sightline - X<10m - high level of visual exposure (darker gray)
- Sightline - 10m<X<20m – high-medium level of visual exposure (dark gray)
- Sightline - 20m<X<30m - medium level of visual exposure (dark/lighter gray).
- Sightline - 30m<X<40m – relatively medium level of visual exposure (lighter/dark gray).
- Sightline - 40m<X<50m – medium-low level of visual exposure (light gray).

- Sightline - 50m<X - low level of visual exposure (very light gray).

The measured data: The sightlines are measured as two parameters and represented graphically:

1. Number of viewpoints (n) – according to their category
2. Number of sightlines (sl) – according to their length category

In this paper the model is applied on three phases of a developed urban construction, demonstrating the model abilities. The visual privacy is being measured in each of the three phases, demonstrating the visual privacy differences in each phase, and the differences of the privacy levels in diverse sections of the development (figure 2).

2.3. Development of a scenario for the use of the model during the urban design process

A scenario framework for the use of this model during the design was created, demonstrated on three different phases of a design (figure 2). The model was applied during the design process. The distances between façade openings were measured, analyzed and sorted by length. This analysis revealed different levels of visual privacy for each phase of the design, resulting in the possibility of creating comparative evaluations between design phases regarding their visual privacy levels situation (figure 2).

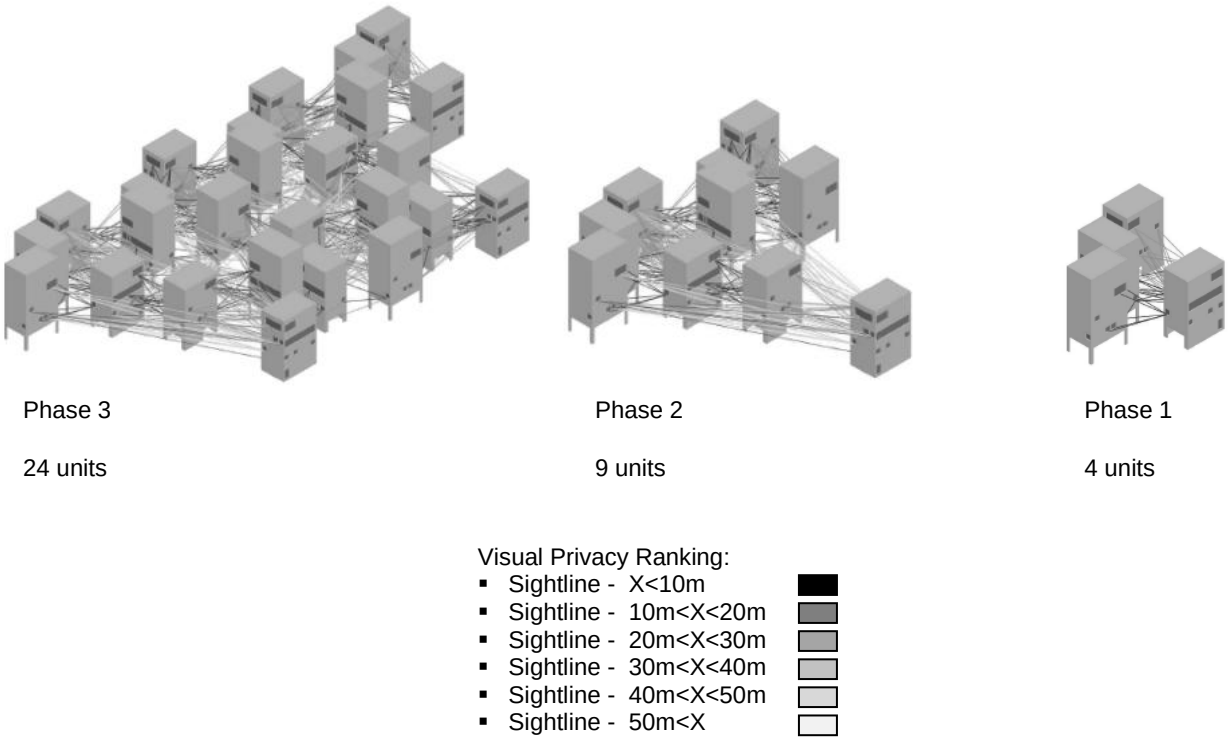

Figure 2*: Visual privacy model applied on three different design phases, revealing different levels of visual privacy. The distance between façade openings was measured, analyzed and sorted by length. The lengths of the diverse distances were coded by colors: red for high levels of visual privacy (not positive from privacy point of view), moving towards green (positive from privacy point of view).*

The design drawings demonstrate the visual privacy results in a visualized manner. This design has relatively ordered construction which results with a high level of low distance sightlines that can be seen only by observing the three phases. In addition, it can be noted that most of the high level sightlines are located at the side of the project.

2.3.1. The analysis results:

In this paper the numeric results will relate to the number of sightlines counted in all phases. The amount of sightlines is expressed graphically and numerically, distributed by categories. The numeric results of the analysis are presented in Table 1 and Graph 1:

Table 1: measurement results of three phases of the design

Sightlines Meters	Phase 1	Phase 2	Phase 3
X<10m	411 (sl)	134 (sl)	39 (sl)
10m<X<20m	665 (sl)	175 (sl)	30 (sl)
20m<X<30m	26 (sl)	10 (sl)	0
30m<X<40m	111 (sl)	43 (sl)	0
40m<X<50m	4 (sl)	4 (sl)	0
50m<X	0	0	0

Graph 1: measurement results of three phases of the design

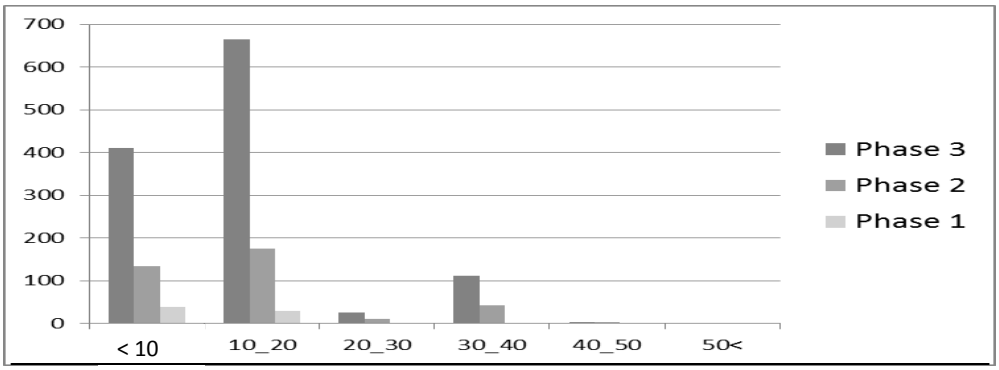

Table no. 1 and graph no.1 emphasize the visual results of the three design phases in numerical manner. It should be noted that the dominant sightlines category is X<10, which points out the high level of privacy in all three phases. In addition there is a relatively low number of sightlines of low level categories, such as 30 < X > 40. In addition, most of the high level sightlines are mainly located at the edge of the project, in all three phases, leaving wider distances in the core of the whole design. This can be seen by observing the analysis. Hence, if such an analysis could be employed during the design process a better understanding of the issue of visual privacy could be

captured by the designer. In the future, this process may have significant effect on the continuous design, which will proceed with better design solutions, and changes in the design could be made before the actual construction.

To conclude, the model to measure the visual privacy emphasizes the potential for future development, were the designer will have the opportunity to understand the situation of one quality of the environment, the visual privacy level. Therefore, as additional models for measuring diverse aspects of the environment quality will be available for the designer's benefit, it will improve the level of the environment quality of the design and will benefit the residents.

3. Conclusions and discussion

Several conclusions have been reached regarding the presented methodology and the model demonstrated: (1) it is possible to identify qualitative aspects of the environment and transform them into objective terms. In this paper we have demonstrated how the visual privacy characteristic can be transformed into geometric terms and measured objectively. (2) based on the objective terms, the method presented in this paper demonstrates the ability to develop a model that measures a qualitative aspect, in this demonstration the visual privacy. In addition, the model shows that there is a possibility to point out problematic locations of visual privacy in building compounds with possible individual improvements. (3) and above all, the approach demonstrated in this paper emphasizes the ability to use such a model during the design process for the benefit of the designers work, and to develop better urban environments aspiring high environment quality, in the demonstrated model, high levels of privacy. To conclude, the quantitative analysis performed in this paper enables the site architect to measure the current levels of visual privacy of the site, identify problematic dwelling units within the urban configurations and develop improved alternative configurations. In the future, the ability to support the designers with new models to measure additional qualitative aspects will result in better urban environments as a whole.

To the extent that architects and other urban design professionals will be provided with a greater variety of practical models to assist them in the planning process, this may result in improvement in urban environmental quality and a greater number of people benefitting from those high levels of environmental quality as a whole. In conclusion, this methodology may have a significant potential for influencing the development of future urban environments that seek to attain high levels of deployment of a diverse range of the components comprising environment quality. In the future, this can lead to the development of models and tools to measure separately the qualitative aspects of environmental quality which could be of a great benefit for understanding problems in urban morphology, identifying them, and potentially solving them during the design process.

This paper seeks to emphasize the point of view of urban designers and architects. The development of quantitative evaluation and control methods and tools to be used by urban designers and architects is greatly needed, both to evaluate and control urban development during the design process and to analyze existing urban fabrics, contributing greatly to the future of urban development.

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