

Study of the Relationship between Building Arrangement and Visibility of Open Spaces Based on a Simplified Area Evaluation

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Abstract: This paper studies which building arrangement will provide the maximum visibility to an example of open space proposed in the Abu Dhabi 2030 Master Plan. The building forms, the distance between the buildings, the setback and the building heights would all affect visibility and were considered closely. Although this research methodology could be applied to any site in different situations, it remains simple and interesting. It can be applied in general, with a change of the variables (setback, distance between buildings, building height, building form), to any site by both professionals and students who can simply use any CAD program for producing drawing in both the architectural or urban designs phases, hence the importance of this research. Two different building arrangements were proposed and studied: a linear and an L-shaped arrangement. After applying the simulations, it appears that the L-shape offers more visibility to the open space. The outcomes of this study were combined with another research project that studies the same building arrangements to test the possible climatic comfort provided in outdoor spaces in order to encourage the use of open spaces and walkability in the studied area.

Key words: Visibility, open space, Abu Dhabi, 2030 Master Plan, building arrangement.

1. Introduction

The Abu Dhabi 2030 Master Plan is based on the vision and sustainable development principles of the Abu Dhabi government to make Abu Dhabi an international capital city. The plan [1] includes several districts with different characters: a business district, Capital District [2], Emirati residential district, etc., where landmarks, as important components, are generally located around plazas and open spaces. The buildings' arrangement was not proposed in the plan, and was left to the urban design phase for further orientation and more detailed design guidelines. This research is the second part of a wider research project [3-6], that analyses the design of the Capital District proposed in the Abu Dhabi 2030 Master Plan. The study includes the visibility and accessibility of facilities, open spaces, landmarks and public buildings,

as well as their integration to the overall urban system of the district. By using digitalized tools, such as ENVIRONMENT, DEPTHMAP and CAD programs such as AUTOCAD and SKETCHUP, simulations were carried out to study the relationship between building arrangements and the climatic comfort of indoor and outdoor spaces by testing different scenarios in order to figure out which building arrangements are the best to achieve the vision of Abu Dhabi as a modern capital and sustainable city with a local identity.

The author in their research is attempting to propose some methods or guidelines for design, and wishes to contribute to the development and improvement of the 2030 Master Plan at the smaller scale level of urban design.

2. Literature Review

2.1 Importance of Open Spaces

This research targets the study of the visibility of open space by considering two proposed building

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arrangements, and assesses which of them offers more visibility.

Open spaces are unbuilt lands that include green areas, parks and gardens, play areas and sports facilities, voids between buildings, walkways, promenades and green corridors. The term “open space” in this research, in particular in the study area, is associated within the context of local parks, gardens and green spaces.

The reader may question this interest in open spaces and their visibility, but beside their environmental role to provide fresh air and microclimates, and filter noise and the wind, open spaces represent a valuable opportunity for the community to socialize, entertain, gather or practice physical activities, such as sports or walking, and their aesthetic value has no limits and positively affects the psychology of people, even when viewed from a distance. Hidetoshi et al. [7] state that open views improve the urban environment and influence the residents’ satisfaction of an area. Also, as the area of any body of water increases, more beneficial psychological effects are found.

Hence the study of their visibility in an urban environment becomes interesting, not only to assess their social and environmental benefits, but also for economic reasons, since buildings having a view on open spaces will definitely increase their attractiveness and command a higher value in the real estate market as mentioned in Refs. [8, 9]. Ulrich et al. [10] and Ulrich [11] studied the effect of windows on inhabitants and found that windows provide more than just light and air, but also have a positive effect on such diverse factors as job and life satisfaction, general health and wellbeing. Ulrich et al. [10] and Ulrich [11] proved that windows and their views positively affected patient recovery time after surgery; the most important factor, even more important than the presence of a window, proved to be the nature of the view from the window.

Our study will be using a simple method that calculates for each building arrangement how much

area of the open space is visible from different buildings, and how much area of each building façade can see the open space. This leads to the question: are we studying the visibility linked to the building openness or the building exposure? In the next section, we will talk about the difference between them and the methods used to measure and assess the visibility of open spaces.

2.2 Literature Review on Visual Exposure

Gewirtzman and Wagner [12] relate the visual exposure and the visual openness of any space to the viewing distance and measured them in all directions and from every façade opening. Gewirtzman and Wagner [12] link the visual exposure to short viewing distances, however visual openness is linked to long viewing distances.

Let us note that the previous researches have studied visibility from street level; however we are interested in studying the visibility from buildings facing the open spaces.

Pinsly et al. [13] aimed to analyze visual exposure in two dimensions at every building level, as well as in three dimensions between building levels. In this reference, the author carried out an interesting literature review of both visual exposure and visual openness.

In Ref. [14], the author proposed to quantify the visual exposure through the factors affecting it, for example: window location, height of façade openings in relation to the height of adjacent buildings, building orientation, construction layout, position of entrance doors, and functional distribution.

Although, the literature presents the distance between buildings as the major effect on visual exposure, no methodological approach was found that explains the relationship between the distances between buildings and viewing distances.

However, privacy is strongly related to the distance between buildings and windows facing each other.

Newell [15] stated that visual exposure is related as

part of the visual privacy definition; the nature of privacy is such an interesting and complex issue that no commonly agreed description of privacy has been established.

2.3 Literature Review on Visual Openness

The following methods and tools were used to carry out the study of visibility of open spaces.

The visibility graph produced by Depthmap software [16, 17], which applies space syntax theory by UCL (University College London) [18] has been used earlier by the author to study visibility, accessibility and integration of outdoor spaces [5, 6, 19]. The visibility graph can be used to analyze the visibility level to an indoor or outdoor space related to its accessibility via Isovist, but does not calculate the visible area seen from a specific building. The visibility graph can be used to analyze the visibility level to an indoor or outdoor space related to its accessibility via Isovist, but does not calculate the visible area seen from a specific building. Furthermore, space syntax was applied to study how visual fields effect the design and the structure of an open public space and integrate it with the basic urban grid [20]. Rana [21] associated Isovist Analyst done by ArcView software with GIS (geographic information system) in order to plan natural and artificial surveillance of indoor and outdoor open spaces. This was made possible by studying the visibility of open spaces via the visual coverage by using an automated technique, namely ROPE (rank and overlap elimination) [22]. In order to assess natural surveillance, the reference proposes measurements to characterize the shape of open spaces. In Refs. [23, 24], the authors used the spatial openness index, which is a computerized tool to measure the quantity of the open space viewed from buildings surrounding it, specifically from the center of every building, where the viewer stands. The building's height was considered and included in the angle of view which is assumed to be better in the higher floors. Furthermore, different spatial configurations were studied then

compared to decide the best one.

In this paper, we are concerned more with visual openness and our methodology is based on measuring the visible area of the open space from each building that looks out upon it. In contrast to most of the previous researches, the viewer's location is not located in the center of the building, but in the center of each window in the building floor. Further explanation is presented in the methodology section.

3. Measuring the Visibility of Open Spaces

3.1 Site Selection and Building Arrangement

The site is located in the South Spine, one of the six precincts of the Capital District proposed in the Abu Dhabi 2030 Master Plan (Fig. 1).

The author selected a site which is unbuilt so as to be able to propose a building arrangement, and then test them through a simulation, so that the result would provide practical help in making or improving design guidelines for the selected site. The site is interesting because it is surrounded by different land uses and building heights (Fig. 2), so that any proposed building arrangement will test more than one criterion at each simulation time.

The open space has a rectangular shape and is surrounded by plots in all directions.

It is important here to note that the author conducted another study on the same site for the purpose of comparing the outcomes of the two studies. In the other research, the author proposed a few building arrangements and ran climatic simulations to calculate the best building arrangement for offering climatic comfort in the outdoor area, in particular to provide more shadow [3].

The building arrangements tested in the previous research were: the linear (the horizontal, vertical and oblique) arrangement, the L-shape arrangement, and the U-shape arrangement. In this study which represents the second part of a research project to conduct visibility simulation, the author has kept the

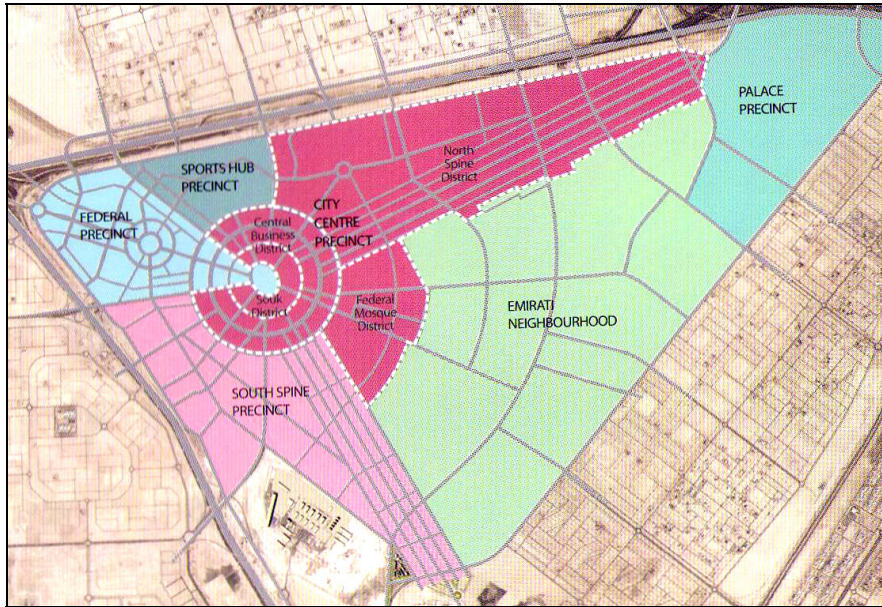


Fig. 1 The six precincts that compose the business district, Abu Dhabi 2030 Master Plan.

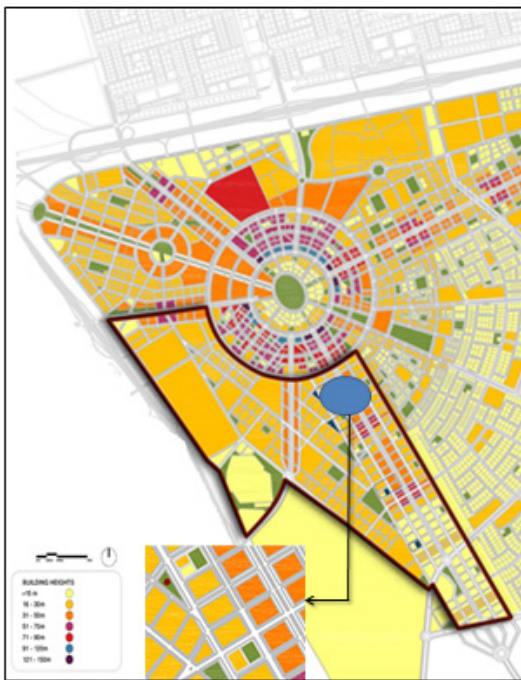


Fig. 2 The site location and the heights of the surrounding buildings.

same site and the same building arrangement Fig. 3 represents the Building Arrangement 1, mainly the horizontal one, which increases the walkability around the buildings and to the open spaces.

Fig. 4 represents the Building Arrangement 2, mainly the L-shape one that increases the open spaces between buildings (residential use).

The objective after comparing the results of both simulations is to decide the best building arrangement that simultaneously provides visibility to open space and climatic comfort. The target here is to improve the quality of life of residents, visitors and pedestrians using that area, and not simply focus on one aspect.

3.2. Methodology

The author chose a quite simple, but effective method to study visibility and which can generally be used without using complicated software or advanced computer programs. The method is useful also to students

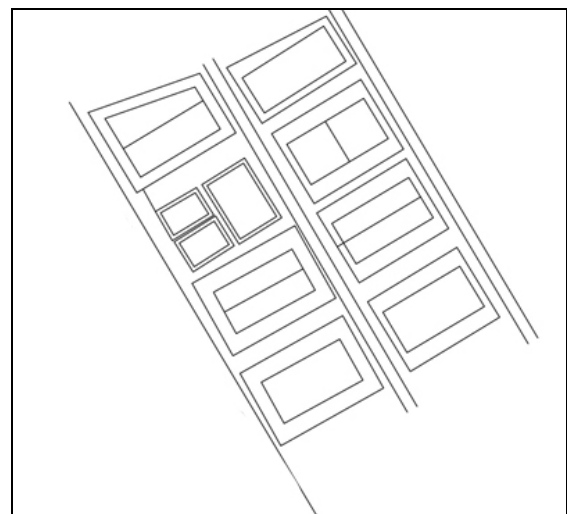


Fig. 3 Proposal 1 for the buildings arrangement.

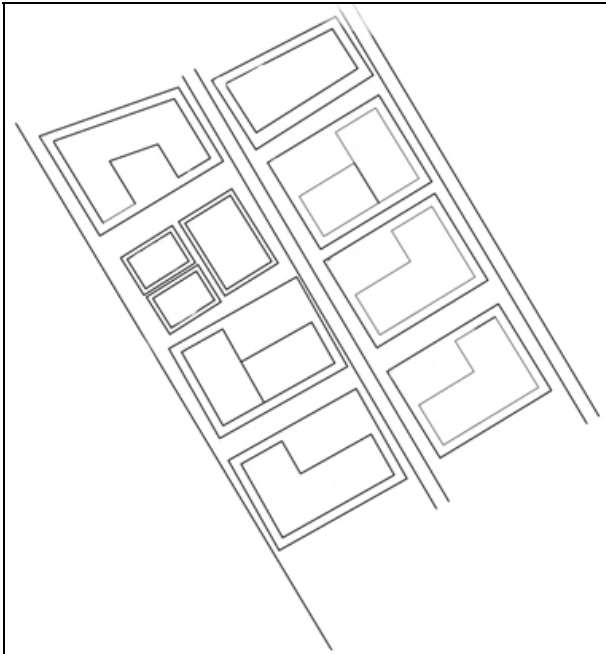


Fig. 4 Proposal 2 for the buildings arrangement.

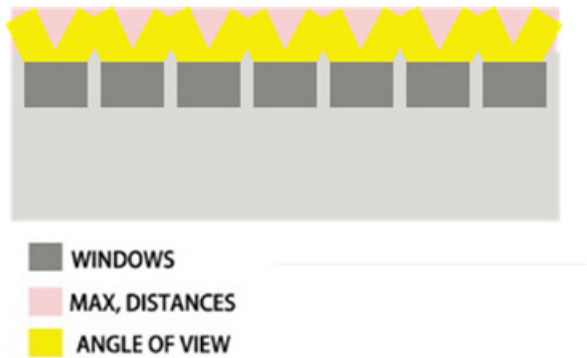


Fig. 5 A schematic design representing the horizontal distance and angle of view from the center point of each window.

and can be applied in their architecture design, particularly in the phase of location and distribution of windows, or in the urban design process while proposing the building arrangements and forms.

The target in this paper is not to study the building openness, but the visibility of the open space from the façades of the surrounding buildings. This will be carried out using two scenarios, in which building arrangement, as well as the building height will differ. Such measurement is carried out assuming that all the floors have a good view to the open spaces, and the viewer’s location is the center of each window located

on the building floor.

The visibility here is studied according to the distance of the viewer and assumes the following: they are standing in the middle of a window, and that the façade of the building has 1.2 m length of windows located 3 m to 5 m from the center point of each window, and this represents the first layer. The second layer applied to the visibility study of the open space represents the angle of view which is limited by the edges of the window. Fig. 5 shows a schematic design of the two layers applied to a building façade.

The user can change the location of the windows

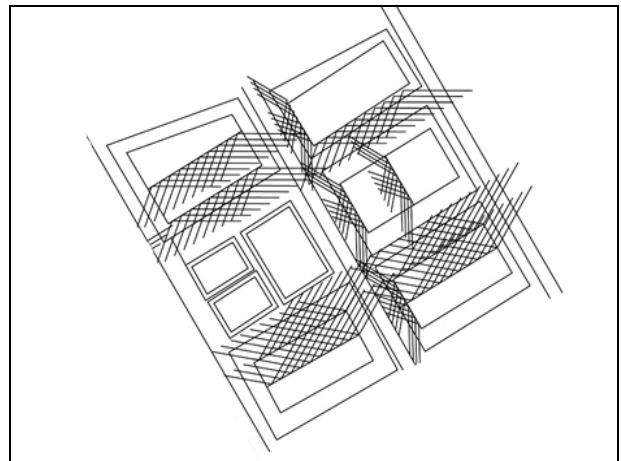


Fig. 6 Simulation of Scenario 1.

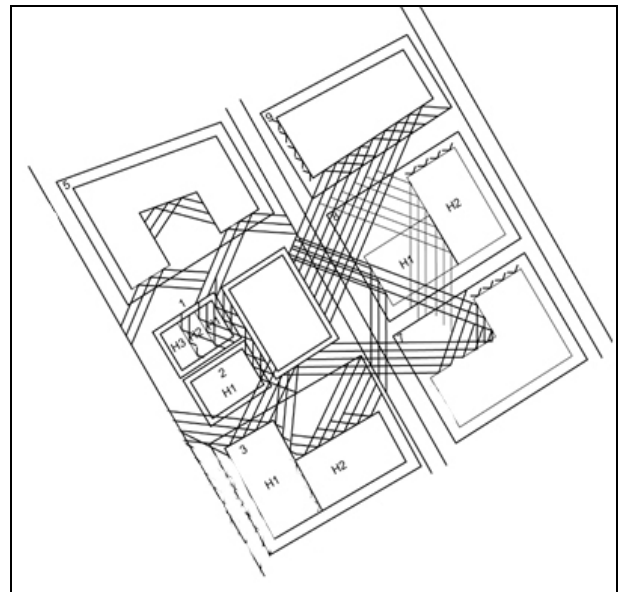





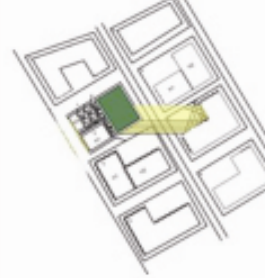
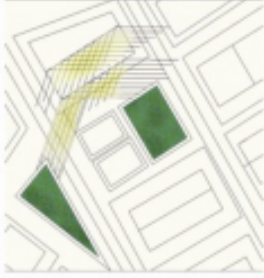

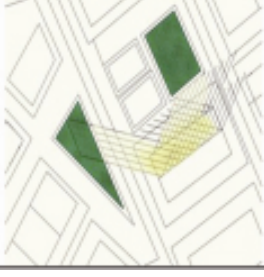



Fig. 7 Simulation of Scenario 2.

Table 1 Simulation results of Scenarios 1 and 2.

Scenario 1—Building arrangement 1	Scenario 2—Building arrangement 2
 <div data-bbox="639 405 793 633" style="border: 1px solid black; padding: 5px;"> <p>Simulation 1 Visible open space in % = 53. % of building that can see the open space = 55.5</p> </div>	 <div data-bbox="1144 405 1297 633" style="border: 1px solid black; padding: 5px;"> <p>Simulation 1 Visible open space in % = 20. % of building that can see the open space = 60</p> </div>
 <div data-bbox="639 707 793 936" style="border: 1px solid black; padding: 5px;"> <p>Simulation 2 Visible open space in % = 100. % of building that can see the open space = 66.6</p> </div>	 <div data-bbox="1144 707 1297 936" style="border: 1px solid black; padding: 5px;"> <p>Simulation 2 Visible open space in % = 40. % of building that can see the open space = 70</p> </div>
 <div data-bbox="639 1010 793 1238" style="border: 1px solid black; padding: 5px;"> <p>Simulation 3 Visible open space in % = 12.5. % of building that can see the open space = 74.2</p> </div>	 <div data-bbox="1144 1010 1297 1238" style="border: 1px solid black; padding: 5px;"> <p>Simulation 3 Visible open space in % = 40. % of building that can see the open space = 60</p> </div>
 <div data-bbox="639 1312 793 1541" style="border: 1px solid black; padding: 5px;"> <p>Simulation 4 Visible open space in % = 100. % of building that can see the open space = 66.6</p> </div>	 <div data-bbox="1144 1312 1297 1541" style="border: 1px solid black; padding: 5px;"> <p>Simulation 4 Visible open space in % = 40. % of building that can see the open space = 70</p> </div>
 <div data-bbox="639 1615 793 1843" style="border: 1px solid black; padding: 5px;"> <p>Simulation 5 Visible open space in % = 100. % of building that can see the open space = 66.6</p> </div>	 <div data-bbox="1144 1615 1297 1843" style="border: 1px solid black; padding: 5px;"> <p>Simulation 5 Visible open space in % = 90. % of building that can see the open space = 80</p> </div>

and their sizes according to their case study; hence the viewer's position will change.

Lines representing the horizontal distance of view and defining the angle of view are drawn from each

viewer's position (in the middle of each window) toward the open space. They are then applied each time on the plan, in order to study the visibility from each building surrounding the open space from the front, back, right and left sides.

After applying the two layers to each building façade facing the open space in Scenario 1 (Fig. 6) and Scenario 2 (Fig. 7), an estimated percentage was produced to assess how much area of the open space is visible from each building façade facing the open space, as well as how much the viewer can see the open space from each building façade surrounding it (Table 1).

Please note that in order to maximize the visibility within the permitted height range mentioned in the design guidelines of the Abu Dhabi 2030 Master Plan, whenever possible during the simulation, different building heights were considered in the same building bar.

3.3. Results and Analysis

After comparing the results shown in Figs. 6 and 7, it appeared that the second scenario with the L-shape arrangement provides more visibility to the open space. Beside this, this type of arrangement produces more open spaces and voids between buildings that can be used for social or physical activities such as playground areas or meeting and sitting areas. This type of arrangement is more suitable to the residential use of the land.

4. Conclusions

This paper represents the second part of a research project that tests two building arrangements around an ordinary open space located in the South Spine of the Capital District in the Abu Dhabi 2030 Master Plan. Simulations were carried out by simple computer programs related to: (1) climatic comfort, in particular for providing more shadow in the outdoor areas in the first part of the project; and (2) assess the visibility of open space by measuring the amount of visible area

from each building surrounding the open space in the second part of the research project, which is presented in this paper. Results were compared and combined in order to come up with the best building arrangement that simultaneously provides more shadow to the outdoor spaces and visibility of open space. The objective in this paper is to propose design guidelines that raise and improve the quality of life in compliance with the vision of a sustainable and modern city proposed in the Abu Dhabi 2030 Master Plan.

The digital tools and computer programs used in both parts of the research project are accessible and simple to use by students in their phase of architecture or urban design proposals, as well as by professionals, hence the importance of this research.

In this paper, the author measured the visibility of an open space surrounded by buildings arranged in a linear manner in one scenario, and as an L-shape in the other scenario. The methodology applied such criteria as: the building height, setback, and distance between buildings, number of windows, their size and the distance between them. For the sake of this research, some assumptions were made, for example, the window's length is 1.2 m and the distance between the center points of each window is 3 m to 5 m. The angle of view and the maximum distance of view were considered in the measurement done for the center point of each window of all the surrounding buildings.

The simulation shows that the L-shape arrangement provides more visibility of the open space, which increases its economic value, in addition to the environmental values demonstrated in a previous paper [3]. The L-shape arrangement is very suitable for residential use and provides extra outdoor areas that can be used for socialization, physical activities, entertainment, etc.

Finally, the author is willing to gather all the research results and present them to the Urban Planning Council of the city, especially as this research targets several aspects which affect the

comfort of the residents, visitors and pedestrians to this area of the city.

Further research is planned to create a user-friendly computer program that assesses the quality of life of any building arrangement by testing its efficiency in providing more visibility to open spaces. This computer program would have different variables appropriate to the context of a site, be more flexible and adaptable to different situations, and would save simulation time, provide more accurate results and present a clear comparison between different scenarios and building arrangements. We believe that such a digital tool will be very useful to both students and professionals.

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