THE EFFECT OF LANDSCAPE ELEMENTS ON WALKABILITY IN EGYPTIAN GATED COMMUNITIES

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Abstract
Walking has always been one of the important modes of transport all over the world. During the second half of the twentieth century, motorized modes, especially private cars, emerged. A situation of overdependence on motorized transport evolved. Recently, the notion of reviving walking as one of the urban transport modes started to emerge, especially in developed countries. Both research work and professional practice now search for ways to rehabilitate urban areas in order to facilitate walking and cycling. The focus has mainly been on macro-scale factors such as land use distribution and street network planning. However, landscape elements, such as micro-scale measures, could play an important role in achieving that goal. This paper addresses the role of landscape elements in enhancing urban walkability. It mainly focuses on gated communities, which are widely emerging types of residential urban areas across the world and also in Egypt. Using statistical analysis, the paper identifies the most important landscape elements that could affect the walkability of gated communities in Egypt.

Keywords: Walkability; walking environment; landscape; hardscape; softscape; gated communities; accessibility; factor analysis; Egypt

INTRODUCTION
During the second half of the twentieth century, urban mobility became over dependent on motorized modes. Private vehicles (both cars and motorcycles) use is increasing from year to year. Even short-distance trips are made using cars and motorcycles. As a result, urban settlements are suffering from serious problems as their roads are frequently congested. The physical, temporal, and financial costs of urban mobility are increasing; this negatively affects the quality of life in urban areas. A notable emergence of reviving non-motorized modes of transport is currently taking place. Many cities and states are considering a tangible effort to get people back to walking and cycling. Many research studies therefore pay attention to the notion of walkability to express how urban areas encourage their users to walk and cycle. They mainly focus on urban planning measures, such as street network planning, land use distribution, and population density. Landscape elements have, however, been neglected, despite the fact that these elements are more relevant for walkers and cyclists and directly affect their transport behavior.

The main goal of this research is to recognize the landscape elements that could have an effect on the walkability of gated communities. The paper focuses on the gated communities in the Greater Cairo Region (GCR). The research adopted a quantitative approach to achieve this goal. By applying factor analysis to a set of case studies of gated communities in Egypt, the effects of a group of selected landscape elements are analyzed and evaluated.

This paper is composed of two main parts. The first part, the literature review, introduces walking as one of the urban transport modes. It presents the importance of reviving walking to solve some of the contemporary problems of urban settlements. In addition, it highlights how
Urban walkability is measured and how urban planning could play a vital role in encouraging people to walk instead of drive. The second part presents the research which statistically investigates the potential effects of landscape elements on enhancing the walkability of gated communities. A selected set of both hardscape and softscape elements is chosen from a group of gated communities in Egypt. Using factor analysis, these elements are classified and ordered, according to their effects.

LITERATURE REVIEW

As one of the most important non-motorized transport modes, walking has received an increasing interest from both the scientific community and local authorities. Walking is perceived as a solution to the great challenges of contemporary urban mobility. It is very clear that urban settlements are now facing continuous and serious traffic congestions during the day and night. Greater attention is being paid to making urban areas a suitable and encouraging environment for walking.

The benefits of walking are diverse. Many research studies have highlighted the health benefits of walking for human health (Meiro-Lorenzo, Villafana, and Harrit, 2011; Spoon, 2005). The most important benefit is the reduction of obesity (Lopez and Hynes, 2006; US Department of Health and Human Services, 2001). This is because walking is considered to be one of the easiest and lowest-cost physical activities. As a result, it plays an important role in reducing the risks and the problems of many diseases such as diabetes, high blood pressure, heart attacks, anxiety, and depression (Atkinson and Weigand, 2008; Centers for Disease Control and Prevention, 2003). In addition, walking as a substitute for using motor-vehicles, especially for short trips, will help reduce both fuel consumption and harmful gas emissions, which in turn will result in improving the air quality in urban areas (U.S. Department of Transportation, 1999; Westminster City Council, 2004). Some urban benefits could be achieved by adopting walking as a mode of transport from short distances. The main benefits are alleviating both traffic congestion (Lo, 2011) and the increasing demand for car parking. This will indirectly lead to reducing the maintenance cost of street networks and traffic facilities (Litman, 2004). In addition, walkability has been found to be strongly correlated with raising the economic value of offices, retail businesses, and houses (Fisher and Pivo, 2001). Social life will also benefit from walking. As walking means the presence of more people in the streets and open spaces of the urban settlements, both social interaction and social security will be enhanced (Kamel, 2013). Besides, it is one of the important factors to enhance the sense of community in residential areas (Mahmoudi Farahani and Lozanovska, 2014). In sum, walkable urban areas are comfortable places to live in (Shamsuddin, Abu Hassan and Bilyamin, 2012) and are characterized by livability (Al-Hagla, 2010).

Walkability is a term that is widely being used all over the world to describe the urban suitability of an urban environment for walking. Despite the fact that the origin of the term ‘walkability’ is not clearly documented (Fitzsimons, 2013), many definitions already exist. Following are some of the definitions of walkability:

- “… the extent to which walking is readily available as a safe, connected, accessible and pleasant mode of transport” (Transport for London, 2004);
- “… a measure of the effectiveness of community design in promoting walking and bicycling as alternatives to driving cars to reach shopping, schools, and other common destinations” (Rattan, Campese, and Eden, 2012);
- “… the extent to which the built environment is walking friendly” (Abley, 2005);
- “The core meaning of the term relates to facilitating and encouraging walking trips by providing both attractive routes and destinations and functional paths and routes” (Fitzsimons, 2013).
Consequently, it can be concluded that the term walkability refers to the level that an urban setting encourages its residents to walk while traveling through it. Generally, achieving high levels of walkability will result in creating walkable urban areas and vice versa. These areas facilitate the conversion of automobile communities to walkable communities. Developing walkable environments that prioritize pedestrian transport is considered to be the aim of the new urbanism movement (Dogrusoy and Dalgakiran, 2011).

Searching for the requirements of creating walkable urban environments is one of the priorities of cities' local authorities, especially in developed nations. According to the Transport for London agency (TFL), creating a walkable environment requires achieving 5 Cs. These Cs describe an environment that is convenient, conspicuous, convivial, comfortable, and consistent (Transport for London, 2004). This set of requirements is also adopted by the public transport authority of Australia (Australian Public Transport Authority, 2012). Another study, which was financially supported by the European Union, determined two sets of requirements; the first set contains the same requirements as the 5 Cs and the second set includes permeability, legibility, human scale, functionality, and sense of place (Premier's Physical Activity Taskforce, 2007). Similarly, Portland city in the US identified a set of seven requirements that includes safety, accessibility, connectivity, usability, beauty of places, mixed uses, and economic feasibility (Vanderslice, 1998). The New Zealand transport agency adopted nine requirements of walkability. These requirements are connectivity, legibility, comfortability, convenient routes, pleasant environment, safe crossings, secure places, universal design, and accessibility (NZ Transport Agency, 2009). Table 1 summarizes the adoption of the walkability requirements by different authorities.

Table 1. Requirements of walkability (Source: based on NZ Transport Agency, 2009).

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conspicuous / Safety / Security</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>2</td>
<td>Convivial / User-friendly / Enjoyable</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>3</td>
<td>Comfortable / Suitability / Accessibility</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>4</td>
<td>Convenient / Connectivity / Permeability</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>5</td>
<td>Consistent / Sustainable</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>6</td>
<td>Legibility / Ease of use</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>7</td>
<td>Functionality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>8</td>
<td>Human scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>9</td>
<td>Diversity of activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>10</td>
<td>Economic Feasibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

To achieve these requirements, some urban factors should be addressed. To identify these factors that could affect walkability, some initiatives to numerically measure walkability are progressed. The walkability index that was created by the TFL agency determines a set of factors classified into three orders (Campos et al, 2003). Both ground floor activity and footway accessibility are considered to be the most important factors. This index identifies landscape factors as a second and a third order. WalkScore.com, which is an online measure of residential walkability, focuses on the existence of consumer destinations within a walking distance from a specific location (Duncan et al, 2013). The more destinations of amenities there are, the higher
the scores achieved. The Sydney walkability index adopts four main factors. These factors are residential dwelling density, intersection density, land use mix, and retail floor area ratio (Mayne et al, 2013). Similar to the previous indices, the transport walkability index, developed by the University of Melbourne, measures walkability using three main factors. These factors are residential density, street connectivity, and land use mix (Giles-Corti et al, 2014). Another research study conducted in San Francisco, USA determined five environmental attributes for neighborhood walkability. These attributes are residential density, street connectivity, public transit density, crime density, and land use mix (Pentella, 2009). Research conducted in Australia concluded that walkability is affected by four main factors, which are dwelling density, street connectivity, land use mix, and net retail area (Leslie et al, 2007). According to Carolina transportation program, eleven urban features are consistent with walkability. These features are classified into three main groups: consensus features, encouraging features, and complementary features. The most important features are mixed land uses, destination proximity, pedestrian facilities, and high connectivity (Shay, Spoon, and Khattak, 2003).

Building on this review of the literature, it would seem that the majority of research and practice has focused on macro-scale urban features as the main factors of walkability. Some general agreement exists regarding some factors such as street connectivity, land use mix, and residential density. However, micro-scale features, such as streetscape elements, appear to be frequently neglected. Despite the fact that macro-scale features have a fundamental effect on walkability, the micro-scale ones are easily perceived by users and have a direct impact on the pedestrian. A person walking can more easily recognize the sidewalk characteristics, the planting strips and other streetscape elements more than the mixing of land uses, the density level of dwelling and street network planning of his local urban community. These micro-scale features, therefore, have a role to play in enhancing the walkability of residential communities. Their role is determined in convincing residents that their local environment is walkable and that they can easily walk. In the next part of this paper, micro-scale features of walkability will be addressed and statistically analyzed.

RESEARCH METHODOLOGY
To find out the role of landscape elements in creating walkable paths, this research will apply statistical analysis to a set of landscape related variables that are selected on a theoretical basis. Factor analysis will be used to test these variables to investigate their correlation to walkability. The objective is to rank these variables according to their power.

Variables
A walking path is a strip on the right of way (ROW). It may be a sidewalk on a street or a pathway in a public space. Usually, it is defined by different levels, different floor finishings, or by plants and other furniture elements. A set of 15 landscape related variables that may have a potential role in walkability is identified. The selected variables could be classified into four main groups. These groups are path profile, route anatomy, hardscape features, and softscape elements. The first group of path profile variables describes the general profile of the path. It focuses on the width and the height parameters of the path and its boundaries. The second group of route anatomy represents the main characteristics of the walking route itself and its relation to both motorized transport routes and activities along it. The third group of hardscape features focuses on the hard elements such as flooring, seats, shades, and lighting units. Finally, the fourth group of softscape elements describes the existence of plants in the path, such as trees and ground covers. Table 2 presents the classification of the 15 variables.
Table 2. The selected landscape related variables (Source: Author).

<table>
<thead>
<tr>
<th>#</th>
<th>Group</th>
<th>Variable</th>
<th>Variable Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Path profile</td>
<td>1-1 ROW width.</td>
<td>V01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-2 ROW enclosure ratio.</td>
<td>V02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3 Path width.</td>
<td>V03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-4 Walking strip zone width.</td>
<td>V04</td>
</tr>
<tr>
<td>2</td>
<td>Route anatomy</td>
<td>2-1 Path-streets intersections.</td>
<td>V05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-2 Access points to residential activities.</td>
<td>V06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-3 Access points to non-residential activities.</td>
<td>V07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4 Barriers between path and ROW.</td>
<td>V08</td>
</tr>
<tr>
<td>3</td>
<td>Hardscape features</td>
<td>3-1 Path-floor height.</td>
<td>V09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-2 Anti-slipping level of flooring.</td>
<td>V10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-3 No. of seats along path.</td>
<td>V11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-4 Shaded area of walking zone.</td>
<td>V12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-5 Path illumination level.</td>
<td>V13</td>
</tr>
<tr>
<td>4</td>
<td>Softscape elements</td>
<td>4-1 No. of trees and palms.</td>
<td>V14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-2 Area of ground cover elements.</td>
<td>V15</td>
</tr>
</tbody>
</table>

In the following, a brief description of each variable is introduced. The description includes how to measure each variable and the measuring scale and unit.

- **ROW width (V01):** It is the total width of the public space where the path exists within it. The ROW is usually enclosed by buildings or fences on both sides. It allows the right to pass through urban components. Besides, it affects the quality of included paths. It will be measured in meters.

- **ROW enclosure ratio (V02):** This variable describes the section view of the ROW. It illustrates how the edges (buildings, fences, trees, etc.) create the boundaries of the ROW. It plays an important role in the spatial perception of the path. It is calculated by dividing the average height of edges by the width of the ROW.

- **Path width (V03):** It is the width of the path itself, which is only a part of the ROW. In case of streets, it would be the width of the sidewalk. It may include some street furniture such as seats, trees, or lighting poles. It is the zone that is prohibited to motorized mobility. The width will be measured in meters.

- **Walking strip zone width (V04):** It is the width of the zone that is dedicated to walking only. It is a part of the sidewalk that is free from all street furniture or elements. It will be measured in meters.

- **Path-streets intersections (V05):** It is the number of street intersections that exist along the path. These zones witness interferences between both motorized and non-motorized transport. Pedestrian have to cross the streets. Intersections are considered to be dangerous spots along paths. It is measured by counting.

- **Access points to residential activities (V06):** This variable counts the number of access points to residential buildings that exist along the path. The access points include gates at fences, doors at buildings, and terraces entrances. At these points, users may stop, waiting to enter the buildings or to meet someone or pick up...
something. This may interrupt the walking activity of other users. It is measured by counting.

- **Access points to non-residential activities (V07):** It is similar to the previous variable but deals with non-residential activities. Access points include civic center’s entrances, café seating areas, shops display windows, etc. At these points, users may stop, wait to enter, have a look, meet someone, or pick up something. This may interrupt the walking activity of other users. It also may distract pedestrian attention. It is measured by counting.

- **Barriers between path and ROW (V08):** As the path is only a part of the ROW, longitudinal barriers that separate the path and other parts of the ROW may exist. In streets, sometimes sidewalks are separated from the pavement by fences or shrubs. These barriers may restrict the movement of pedestrians as they reduce accessibility. Parked cars also create a barrier. This variable is measured by the percentage of barriers’ length in relation to the total length of the path.

- **Path-floor height (V09):** This variable measures the height of the path in relation to the level of the ROW floor. In streets, it is the height of the sidewalk at the curb line. It is measured in meters.

- **Anti-slipping level of flooring (V10):** Anti-slipping is one of the most important characteristics of good outdoor floors. A slippery floor is dangerous and not comfortable to walk on. This variable is measured by a scale of three grades. Zero grade is for smooth flooring, one grade for semi-rough flooring, and two grades for rough flooring.

- **No. of seats along path (V11):** Seating facilities are important street furniture. They are widely used in paths and sidewalks. It includes all types of furniture that could be used as a seat. It offers the opportunity to have a rest, wait for someone, or do other outdoor activities. It is calculated by dividing the number of existing seats by the total length on the path then multiplied by 100.

- **Shaded area of walking zone (V12):** Shading is an important facility in a landscape. It offers shelter from direct sun rays, rainwater, and snow. It includes all types of both hardscape and softscape elements that create shading on the path. Pergolas, tents, cantilevers, and shading trees are all included. It is measured by the percentage of the path area that is shaded in relation to the total area of the path.

- **Path illumination level (V13):** Adequate levels of illumination are an important requirement of a walkable path. Good illumination offers a level of safety that encourages people to use the path at night. Due to measuring constraints, this variable will be estimated. Three degrees of illumination, low, moderate, and high, are determined and translated to degrees of zero, one, and two respectively.

- **No. of trees and palms (V14):** Generally, plants enhance the beauty, air quality, and the image of a path. This variable focuses on the tall plants such as trees and palms. It measures the density of these plants along the path. It is calculated by dividing the number of existing plants by the total length of the path then multiplied by 100.

- **Area of ground cover elements (V15):** This variable is similar to the previous one, but focuses on the ground cover plants. It measures the percentage of path-floor that is covered by ground cover plants. Actually, these areas could not be used for walking.

Figures 1 and 2 present schematic sketches that illustrate the 15 variables of landscape elements in the path.
Case Studies

This research focuses on the case of Egyptian gated communities. Forty-five pathways were selected in different closed residential compounds in the Greater Cairo Region (GCR). The selected communities are located in both halves of the region: the eastern extensions (New Cairo...
and Kattameya) and the western ones (6th October city and Sheikh Zayed city). The selection process was based on random multiple selections as the researcher asked a survey group consisting of 45 people to choose a pathway in a gated community. The selection criteria were the existence of residents (inhabited residential zone in a compound) and the existence of amenities and services center at one end of the path. Figure 3 shows samples of the selected pathways.

Figure 3. Aerial views of two samples of selected case studies (Source: Author).

FINDINGS
A first round of factor analysis was progressed on 15 variables for the 45 case studies. Only 6 components with initial eigenvalues greater than 1.0 were extracted. Two of them were strong components as they explained the 16.7% and 14.2% of variance respectively. Both of them were, therefore, used to filter the selected variables according to their loadings. The selected cut-off threshold was 0.5. It is worth mentioning that this threshold satisfies most of the cut-off criteria (Matsunaga, 2010; Yong and Pearce, 2013). As a result, 8 variables were excluded as their loadings did not exceed 0.5 in the first two components. Table 3 presents the classification of variables after the first round.
Table 3. Classification of variables after the first round of factor analysis (Source: Author).

<table>
<thead>
<tr>
<th>INCLUDED variables</th>
<th>EXCLUDED variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>Code</td>
</tr>
<tr>
<td>1</td>
<td>V01</td>
</tr>
<tr>
<td>2</td>
<td>V02</td>
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<tr>
<td>3</td>
<td>V04</td>
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<tr>
<td>4</td>
<td>V07</td>
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<tr>
<td>5</td>
<td>V09</td>
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<tr>
<td>6</td>
<td>V10</td>
</tr>
<tr>
<td>7</td>
<td>V14</td>
</tr>
<tr>
<td>8</td>
<td>V15</td>
</tr>
</tbody>
</table>

A second run was progressed after eliminating variables with weak loadings. Over the two runs, the power of the first two components had been increased from 31% to 58% respectively. After the second run, there were no weak variables. In addition, the results of both two tests of the analysis sample adequacy which are Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity (Field, 2005) achieved better scores compared to the previous round. Table 3 presents the evolution of the main results along the two rounds of factor analysis.

Table 4. The evolution of factor analysis results along the two rounds (Source: Author).

<table>
<thead>
<tr>
<th>Item</th>
<th>1st Run</th>
<th>2nd Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Excluded variables</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>% of variance explained by first 2 components</td>
<td>31%</td>
<td>58%</td>
</tr>
<tr>
<td>KMO measure of sampling adequacy</td>
<td>0.39</td>
<td>0.48</td>
</tr>
<tr>
<td>Bartlett's Test of Sphericity</td>
<td>206.1</td>
<td>76.0</td>
</tr>
</tbody>
</table>

Finally, only 7 out of the 15 selected variables achieved high loadings in the first two components. These 7 variables could be considered the most influential variables that correlate to path walkability. They could be classified into two main groups; the first one includes three variables. These variables are path-floor height (V09), anti-slipping level of flooring (V10), and the number of trees and palms (V14). These three variables achieved high loadings in the first component only. The second group includes the remaining four variables: right of way width (V01), right of way enclosure ratio (V02), walking strip zone width (V04), and access points to non-residential activities (V07). These four variables achieved high loadings in the second component only. Table 5 presents the two groups of the variables sorted in descending order according to their loadings in the two components. Figure 4 presents a graphical illustration of the result.
Table 5. The extracted variables of walkability sorted in two main groups (Source: Author).

<table>
<thead>
<tr>
<th>Item</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of variables</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>% of variance explained</td>
<td>32%</td>
<td>27%</td>
</tr>
<tr>
<td>Variables (in descending order)</td>
<td>Anti-slipping level of flooring (0.85)</td>
<td>Walking strip zone width (0.74)</td>
</tr>
<tr>
<td></td>
<td>Path-floor height (0.65)</td>
<td>Right of way width (0.72)</td>
</tr>
<tr>
<td></td>
<td>No. of trees and palms (0.62)</td>
<td>Right of way enclosure ratio (0.55)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access points to non-residential activities (0.50)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The following part discusses the results of the factor analysis of the walkability variables of selected gated communities in Egypt. The discussion is composed of three main parts. The first part focuses on the variables that affect walkability. The second part compares the main four groups of variables: path profile, route anatomy, hardscape features, and softscape elements. The third part sets out the reasoning for excluding the statistically weak variables.
Walkability variables
According to the factor analysis, only 7 variables have a significant correlation to walkability in the selected gated communities. They could be considered as the most influential variables. These variables are:

- **Anti-slipping level of flooring (V10):** It is the most important variable that is positively correlated to walkability. It describes the characteristics of the walking floor. It mainly focuses on the quality of the finishing layer. According to standards, walking floor should be finished with a material that prevents slipping. Rough textured materials are recommended for outdoor walking floors. It is worth mentioning that this variable has the highest loading compared to the other walkability variables. Its loading scored 0.85 in the second component. This means that the more anti-slipping the walking floor is, the more walkable it will be.

- **Path-floor height (V09):** It is also positively correlated to walkability. Its loading in the first component scores 0.65. According to the factor analysis results, the higher the pedestrian path is from the surrounding ROW, the more walkable it will be. It is important to note the values of the path-floor height in the selected case studies range between 12 cm to 30 cm. In addition, 67% of the values are less than 17 cm (maximum acceptable height of stair riser). The higher path may help in enhancing the safety feeling for pedestrians. This may be perceived as more separated from motorized mobility. However, it should be noted that increasing the height should be within the human limits of vertically moving from one level to another.

- **Number of trees and palms (V14):** focuses on all plants characterized by high-rise such as trees and palms. Its loading in the first component scores 0.62. These plants have important environmental and aesthetic roles to play. They are considered as fresh air generators. At the same time, they enhance the image of the path. In addition, they may be used to create shaded areas along the path.

The three previously mentioned variables together combine to form a single group that affects walkability in a certain way. Statistically, they form the first and strongest component of walkability. The other four variables also strongly correlate to walkability and combine in another group that also affects walkability, but in a different way than the first group. They form the second component. These variables are:

- **Walking strip zone width (V04):** It determines the walking capacity of the path. The walking zone width is more important than other dimensions in the path, such as ROW width or the total width of the path. This is because it directly affects the flow of pedestrians. Sometimes, wide street sidewalks exist, but are full of street furniture and planting elements, so that pedestrians can hardly walk. As a result, it is important while designing a pedestrian path to make the walking zone as wide as possible and to make it clear without obstacles. Street furniture, plants and required areas for residential and non-residential activities should be clearly separated from the walking strip. Maybe some visual aids could be used such as different flooring, finishing materials, or colors. The loading of this variable in component two scores 0.74. It could be considered the second strongest variable affecting walkability.

- **Right of way width (V01):** It is also strongly correlated to walkability. Its loading in the second component is 0.72. It describes the total width of the right of way that includes the path. It determines the geographic boundaries of the path. It affects pedestrian perception of the path surroundings. It includes other components than the path, such as pavement for motorized transport or open spaces and landscape activities.
• **Right of way enclosure ratio (V02):** It is positively correlated to walkability. It describes the enclosure degree of the ROW as the ratio between the boundaries (buildings elevations, fences, etc.) height and ROW width. High enclosure degrees help in defining the boundaries of the ROW and enhancing the visual perception of the path surroundings. The loading of this variable in component two scores 0.55.

• **Access points to non-residential activities (V07):** It is the last and least strong variable that affects the walkability. It describes the existing non-residential (commercial, entertainment, cultural, etc.) activities along the path. Usually such activities result in people gathering in small groups in front of the access points. These groups of people enhance both the livability and safety of the path. In addition, these activities create attraction points in the path.

**Groups of walkability variables**
The 7 walkability variables belong to the 4 groups of path profile, route anatomy, hardscape features, and softscape elements. Three variables were classified as path profile. They are the walking strip zone width (V04), right of way width (V01), and right of way enclosure ratio (V02). One variable belongs to the route anatomy group. It is an access point to non-residential activities (V07). It is important to remember that these four variables are already combined in a separate component, namely the second component. On the other hand, the 3 remaining variables belong to hardscape and softscape groups and also combined in one component. Figure 5 presents a tree diagram illustrating the classification of the 7 variables of walkability.

![Figure 5. Tree diagram classifying the extracted variables of walkability (Source: Author).](image)

The first and strongest extracted component includes variables that only belong to both hardscape and softscape elements. Then, the two groups of route anatomy and path profile come as their variables create the second component. Figure 6 presents a circular diagram that illustrates the cumulative power of each of the 7 walkability variables (at radial axis).
The excluded variables

According to the results of the first run of the factor analysis, 8 variables have been excluded, as their loadings did not exceed the cut-off threshold (0.5) in both components 1 and 2. Six of these variables had very low loadings in both components while each of the other two variables had loadings between 0.45 and 0.49 in one component only. The 8 variables are:

- **Path width (V03):** It describes the total width of the path. It had a weak correlation with walkability. It is worth mentioning that both ROW width and walking zone width were included in the list of walkability variables. This exclusion could be interpreted by the fact that the total path width includes all other hardscape and softscape elements and not restricted to walking activity. The width of the walking zone is more relevant and directly affects the walking flow.

- **Path-streets intersections (V05):** They represent the intersections between the motorized transport on the pavement and the walking activity on the pathway. This variable has the second least score in the loadings of the two components. This may be due to the special nature of case studies, as the motorized traffic in gated communities is more limited than in cities. So, its role could be neglected.

- **Access points to residential activities (V06):** This variable captures the existence of residential buildings along the path. It depends on the fact that some types of different activities may occur in front of the entrances of residential buildings. However, the variable did not achieve high loadings in the two components. Maybe this is also due to the nature of case studies as the population density and household activities are somehow limited in gated communities compared to mass housing and high-rise residences.

- **Number of seats along path (V11):** This variable captures the existence of one of the main types of street furniture. It counts the number of seats along the path. It had low loadings scores that range between 0.2 and 0.3. Maybe the reason of such weak correlation is due to the relatively short lengths of paths in gated communities and as a result pedestrians do not require a break while walking.

- **Path illumination level (V13):** It describes the level of illumination in the path at night. This variable has the least score in the loadings of the two components. It was
selected because good illumination helps in raising the safety of pedestrians. There is no clear explanation for excluding this variable; especially since the sample had a good variety of different levels of illumination.

• **Area of ground cover elements (V15):** Compared to the other softscape variable (number of trees and palms), this variable has a poor correlation to walkability in both selected components. Its scores did not exceed 0.35 in the components loadings. It was selected because green ground cover has a role in enhancing the aesthetics of urban spaces.

• **Barriers between path and ROW (V08):** This variable represents a type of path accessibility from the surrounding ROW. It is worth mentioning that it achieved a score in component 1 loading that is a little bit below the cut-off threshold. It achieved -0.43 which is only 0.07 less than the cut-off. In addition, the weak correlation is negative. This means that the less the barriers, the better the walkability will be.

• **Shaded area of walking zone (V12):** This variable is similar to the previous one. It also has a loading score of -0.48 which is only 0.02 less than the cut-off threshold, but in component 2. The negative correlation is somehow unexpected. It means that the smaller the shaded area in the path, the more walkable it will be. Maybe this result somehow depends on the local environment and the climate. It may also be because Egypt, in general, and GCR, in particular, have a climate that is warm in the winter and moderate in the summer without heavy rains and even no snow. Therefore, while walking, people prefer sky exposure and usually do not need shelter.

**CONCLUSION**

Walkability is one of the important characteristics of pedestrian pathways. It is a notion that emphasizes the importance of creating paths that encourage people to walk. This type of non-motorized transport is very important to sustainable communities. Previous research focused mainly on macro-scale factors that affect walkability. These factors, such as land use distribution and street network planning, belong to the field of urban planning. On the other hand, micro-scale factors, such as path profile and anatomy and landscape elements, are more realized by pedestrian and directly affect them. This research highlights the importance of micro-scale factors in gated communities in Egypt. It applied factor analysis on a set of 15 variables for the 45 selected paths. According to the statistical results, 7 variables are strongly correlated to walkability. These variables are classified into two main groups. Group 1 is the landscape qualities and group 2 is the path characteristics. Despite the fact that the two groups are strongly correlated to walkability, each one has its own impact. Group 1’s effect is relatively more powerful than group two. Three variables are included in group 1: the quality of floor finishing, the path rise from the surroundings, and the density of trees and palms. Four variables are included in group 2: walking strip width, ROW width, ROW enclosure ratio, and access points to non-residential activities. Other factors turned out to not have an effect on walkability in Egyptian gated communities, such as intersections with motorized transport, barriers between path and ROW, and access point to residential activities. This may be due to the nature of gated communities which are generally characterized by limited motorized traffic and the dominance of residential activities. In addition, other landscape factors such as shading intensity turned out to be insignificant. This is a result of the moderate climate in Egypt. It is important to note that this result may be changed in other case studies in different climate zones.

Architects and urban designers are advised to pay special attention to qualities of walkway flooring, vertical separation from ROW, and number of trees and plants. These factors can achieve direct enhancement of path walkability.

Three main areas of research could be identified for the future. The first one is verifying the landscape factors that affect walkability in gated communities. This research executed an
exploratory factor analysis aiming at finding these factors through selected case studies. For further accuracy, another research that adopts confirmatory factor analysis is imperative. In this research, the sample size should be larger and cover various types of gated communities. The second area is numerical measurement of walkability. As previously mentioned in the literature review, there are a number of initiatives to measure walkability, but most are focused on urban factors rather than landscape factors. Setting a numerical index of walkability that measures the level of walkability in gated communities based on a comprehensive set of both macro and micro-scale factors will help in evaluating these communities and could then be used for ranking it periodically. Such an index could be utilized in the real estate market in Egypt as an evaluation tool. The third area is analyzing the pedestrian perception of walkability in gated communities. It is important to spot the light on the gated community resident who will use the paths and walk. Identifying how people experience the walking path and how they create their mental image of the gated community landscape is a corner stone in developing the design of its urban components.

REFERENCES


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