Samarawickrama, Sumanthri, et al (eds), 2018, "Sustainability for people - *envisaging multi disciplinary solution": Proceedings of the 11th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, December 08, 2018 Galle* pp. 228–243. ©

THE IMPACT OF ARTIFICIAL LIGHTING ON VISUAL COMFORT AND VISUAL SATISFACTION OF PEOPLE

With special reference to outdoor public spaces in Colombo.

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Abstract
Besides having many benefits on ecological and environmental aspects, urban parks are found to have a predictable impact on human well-being. With the fast paced development, city dwellers have gradually become used to an active night life. In view of this, the use of artificial lighting in urban parks manifests a significance in catering to the psychophysiological requirements associated with night life. This research investigates the impact of outdoor artificial lighting installations on the visual comfort and visual satisfaction of users in popular urban parks in Colombo, Sri Lanka. It attempts in identifying the parameters of human visual satisfaction contributing towards more viable and aesthetically satisfying public outdoor environments. The study was carried out in five popular urban parks namely; Arcade Independence Square, Viharamahadevi Park, Urban Wetland Park, Diyatha Uyana and Galle Face Esplanade. Data collection was done adopting a mix method consisting of questionnaires, in-situ observations, measurements and photographic analyses. Convenience sampling, which is a non-probability sampling technique, was used when selecting the participants explicitly, 5 different samples (n= 12) with an equal number of males and females were tested in the selected 5 urban parks. Light level, brightness ratio, glare, colour rendering and colour temperature were measured to identify the participants' visual comfort. A subjective assessment was adopted to determine the users' visual satisfaction on the aesthetics, safety and security related to the parks. Artificial lighting was found to have a direct impact on human visual comfort and visual satisfaction. The overall visual satisfaction with reference to the user experience under outdoor artificial lighting was found to be correlated with the functionality of spaces. It can be concluded that implementing lighting installations to enhance the important design elements associated with visual comfort and visual satisfaction corresponding with the functionality of the outdoor urban spaces during the night time is *essential.*

Keywords: *Visual comfort, visual satisfaction, outdoor artificial lighting, urban parks*

1. Introduction

Artificial lighting has become an important requirement in the futuristic approach of the developing world. Due to the socio-economic development of Sri Lanka, towns have evolved to cities and the use of nighttime lighting has significantly increased with the construction of urban spaces (Bruederle & Hodler, 2018). Therefore, the application of artificial lighting becomes essential in the field of architecture. What humans create and construct are in favor of human comfort and satisfaction. The ultimate goal of the human being is the pursuit of comfort and satisfaction (Fincher & Boduch, 2009). Hence, visual comfort and visual satisfaction are important requirements for the use of artificial lighting (Farley & Veitch, 2001). Accordingly, this study will investigate the subjective impression of artificial lighting on the visual comfort and visual satisfaction of the users in urban outdoor spaces in Sri Lanka, by looking into different components of landscape architecture and human comfort needs.

1.1 BACKGROUND TO RESEARCH

With the development of a country, urban spaces start to expand and man-made constructions start to consume cities. Dark surfaces made of concrete and asphalt tends to cause temperatures to rise within the close compact of buildings. This makes urban areas warmer and a major factor in smog creation. Park spaces with trees can reduce this effect and also have a positive effect on air pollution and carbon sequestration. Therefore, urban parks can become a great place for social cohesion contributing to good human health and well-being. The city life is very fast paced and stressful and people can use urban parks to relax and participate in leisure activities. Parks amidst the urban topography can contribute to

the city's water management of run off regulation of rain and at the same time help preserve the natural ecosystems of the city (Konijnendijk et. al, 2013).

With the widespread development of public spaces, night time lighting has become a predominant essential in the consideration of safety and comfort for the human population. Hence, some of the basic functions of outdoor lighting in urban parks involve providing safety and security to the occupants that utilize the park. Visual comfort and visual satisfaction are phenomena that in fact have an important stance in the success of the human interaction with urban spaces (Hafiz, 2013). With reference to the current research topic, it becomes apparent that visual comfort and satisfaction which also has a contributory presence, constantly gets overlooked in the implementation process of an urban outdoor space. Only a minority of the designs have administered the installation of artificial lighting systems so as to enhance the effects that substantiate to visual comfort and satisfaction within the parks. Thus, it becomes evident that there are only a countable number of precedents where visual comfort and visual satisfaction is considered when artificially lighting an urban outdoor space.

1.2 SCOPE AND LIMITATIONS

The scope of this study is generalized around the basis of urban parks as a rapidly growing concept in the city of Colombo and how the artificial lighting systems of these urban parks are utilized in consideration of human visual comfort and satisfaction. It looks into the use of artificial lighting and its effects of a variety of popular urban parks in the geographical perimeter within Colombo, which include; Independence Arcade Square, Viharamahadevi Park, Nugegoda Urban Wetland Park, Diyatha Uyana and Galle Face Esplanade with view of the specific features of each park.

The limitations of this study border within the confinements of a time period of four months. These urban parks were selected after a critical evaluation of its specific features that correspond with the use of artificial lighting. The parameters used to measure the visual comfort effects of artificial lighting include light level, glare, brightness ratio, colour rendering and colour temperature. The parameters used to speculate visual satisfaction of the users of the urban parks include; safety, security and aesthetics.

1.3 OBJECTIVES

This research intends to provide empirical evidence by investigating the significance of artificial lighting and determining its contributions on visual comfort and visual satisfaction of the users of urban outdoor parks in Sri Lanka.

1.4 CONTRIBUTIONS

- Contributing to the development plans of the large scale constructions that are increasing throughout the country,
- Contributing to the maintenance and correcting errors of already existing constructs,
- Contributing to the improvement and development of the landscape architecture field in the country.

Ultimately, this study will be able to objectify the consideration of visual comfort and visual satisfaction parameters in future designing and planning of urban outdoor spaces in Sri Lanka to the same level that safety and energy sustainability methods in lighting systems are considered at present.

2. Theoretical Framework: Literature Review

2.1 VISUAL COMFORT AND VISUAL SATISFACTION PARAMETERS

Light facilitates our vision to perceive the physical universe. Therefore, light is the access through which the eye, and thus the human mind, interfaces with the world. Centered on this mechanism of light, the configuration of light in a space can evoke both psychological and physiological responses in humans. Human comfort is derived from human physiological components while human satisfaction is derived from psychological components. In the consideration of artificial lighting, the prominence of visual comfort and visual satisfaction which are measured by their specific parameters are important deliberations in designing outdoor urban spaces.

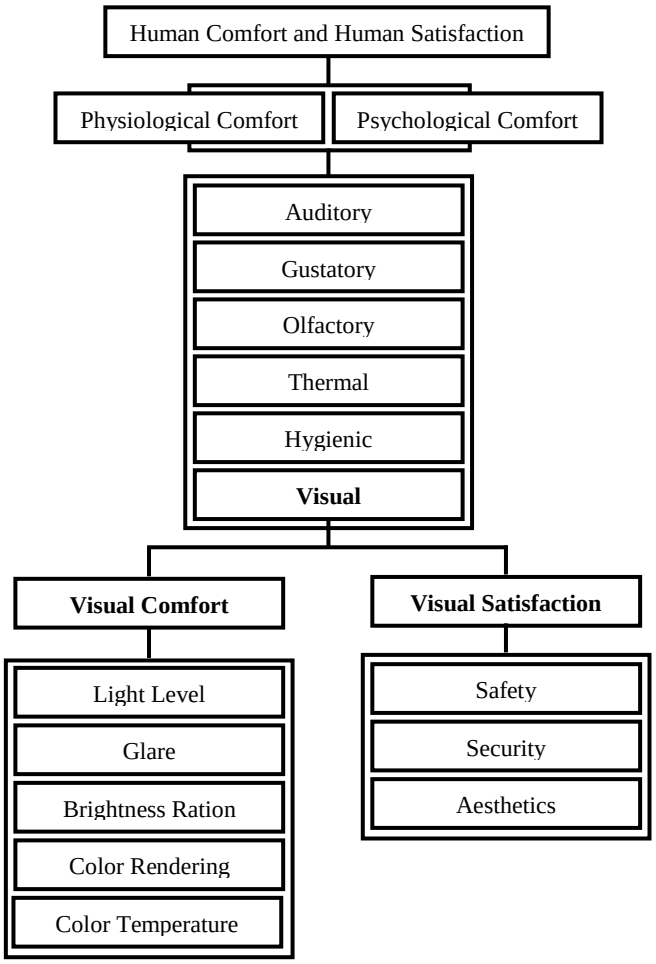


Figure 1, Human comfort and satisfaction

The visual comfort and visual satisfaction of a human is determined by that individual's ability and efficiency to carry out tasks comfortably in terms of their photo-sensory perception. The International Commission on Illumination (2005) documents that the standards on lighting environments specify the following parameters as relevant for visual comfort; glare, luminance levels, luminance ratios and uniformities, color rendering and color temperature (Iacomussi et. al, 2015). In simpler words, the focus of visual comfort includes the parameters of;

1. Light level - This is the quantity of visible light that is emitted from a light source and received by a surface. The level of light is evaluated with reference to the visual sensation experienced (Cuttle, 2008).
2. Glare - Glare occurs when there is excessive and uncontrolled brightness of light. It can cause discomfort and unsatisfying effects (Boyce, 2003).
3. Brightness ratio – Brightness ratio is the difference in luminance that can make an object's representation distinguishable. Human vision is more sensitive to the brightness ratio than luminance; therefore, brightness ratio of light is a major component in detecting visual comfort (Guerrero, 2014).
4. Colour rendering - this is the ability of a light source to display the true color when perceived by the human eye (Billmeyer, 1981).
5. Colour temperature - This is the temperature of a light source. The temperature that is emitted by a light source has important effects on the comfort and satisfaction of the human visual perception (Billmeyer, 1981).

These five parameters can be used to detect visual comfort with regard to the effects of artificial lighting in outdoor urban spaces
In measuring visual satisfaction, three main parameters that contribute to the application of artificial lighting were considered. These include;

1. Safety – Artificial lighting contributes to the visibility of the user, which in turn contributes to safety and feeling of safety. Being able to see where you are going and the obstacles in your pathway provokes a sense of assurance and visual satisfaction (Moyer, 1992).
2. Security – Lighting in the night time has a crucial impact on the reduction of crime rates. Users experience a visual satisfaction in terms of feeling safe and secure in a lighted area in the night time (Moyer, 1992).
3. Aesthetics – Light has the effects of creating elegance for the visual experience. Artificial lighting in the night time is a common tool in enhancing objects and places for the purpose of the users' visual satisfaction (Moyer, 1992).

2.4 STANDARDS OF OUTDOOR ARTIFICIAL LIGHTING

There are several important standards and recommendations that need to be followed in the implementation of artificial lighting. These standards countenance the integration of illumination requirements into the design principles of various artificial lighting plans in order to optimize necessary lighting practices (IESNA, 2015). In the regard of exterior lighting in public spaces, the Illuminating Engineering Society of North America has recommended certain standards and specifications to maintain the quality of artificial lighting practices.

Table 17 IESNA Lighting Ready Reference

(Source: The IESNA Lighting Handbook: Reference & Applications)

III. OUTDOOR Locations and tasks	Appearance of space and luminaires	Color appearance (and color	Direct glare	Light pollution/ trespass	Modeling of faces or objects	Peripheral detection	Point(s) of interest	Reflected glare	Shadows	Source task/ Eye geometry	Sparkle/ desirable reflected	Surface characteristics	**Horizontal Illuminence (lux)**
Hospitality – Exterior													
Restaurants and dining areas													**50**
Pool areas and terraces													**50**

Key: Very important | Important | Somewhat important | Not important

Sri Lanka follows the standard artificial lighting levels recommended by the Illuminating Engineering Society of North America guide for artificial lighting. Regarding outdoor recreational spaces in the urban context, a minimum horizontal luminance of 50 lux is the recommended lighting level according to the IESNA (IESNA, 2015). This illuminence level should be maintained on both ground and table level of an area.

3. Research Design

3.1 METHOD OF STUDY

This study employs both quantitative and qualitative research methods in obtaining the necessary and required data from the public that utilizes the chosen urban park venues. The urban parks which are located in the city limits of Sri Lanka have been selected so as to support the subject matter under this study. Convenience sampling, which is a non-probability sampling technique, was used. A questionnaire was prepared and distributed to the users of the selected urban parks during week days. The compiled questionnaire consisted of questions that measured the subjective response of visual comfort parameters; lighting level, brightness ratio, glare, colour rendering and colour temperature and the subjective response of visual satisfaction parameters; aesthetics, safety and security.

The subjects were selected according to the convenience of the vicinity to the most populated area focused around a lighting source of the park. A gender unbiased sample of 6 females and 6 males were used from each of the five case studies. Therefore, the whole study comprised of 30 male and 30 female participants (n=60). Lux levels of the focus areas of the parks were measured at approximately 8.30pm using a digital lux meter. This particular time was chosen because it is at this time that artificial lighting systems are in maximum usage and the participants who visited the park after the Colombo city rush hour were observed to be more relaxed and more responsive to answering a questionnaire by this time of the night than those who visited during the weekend. The participants' age range was considered under three categories namely; under 25, 26-50 years of age and over 50 years of age. Education, employment, preferred visiting time, and whether they enjoyed the park in the night time were all documented for the purpose of analyzing the user response with regard to the different lighting conditions of the selected spaces.

3.2 METHOD OF MEASURING AND ANALYSIS

As the most suitable medium of measure likert scales were used to measure the subjective response or opinions of the physical aspect of a stimulus of the participants on a linear continuum (Likert, 1932). The participants were offered a choice of five pre-coded responses. Each of the responses was pre-coded on a negative to positive continuum with the neutral response being negative as well.

- 'Very dissatisfied, Dissatisfied, Neutral, Satisfied, Very satisfied' spectrum scale with '-2, -1, 0, 1, 2', respectively.

Table 18 'Very dissatisfied to very satisfied' likert scale numeration

Answer	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Numeration	-2	-1	0	1	2
Likert numeration	-2	-1	-1	1	2
Assessment	Dissatisfied			Satisfied	

- Not very well, Neutral, Very well' spectrum scale with '-1, 0, -1' respectively,

Table 19 'Not very well to very well' likert scale numeration

Answer	Not very well	Neutral	Very well
Numeration	-1	0	1
Likert numeration	-1	-1	1
Assessment	Not very well		Very well

Lastly, a score scheme was formulated to determine each parameter's significance.

Table 20 Numerations formulated to visual comfort and visual satisfaction to numerically determine their consecutive parameters' significance

Visual Comfort				**Visual Satisfaction**	
Parameter			Numeration	Parameter	Numeration
Light level	Q1	10%	20%	Aesthetics	33.33%
	Q2	10%			
Glare			20%	Safety	33.33%
Brightness ratio			20%	Security	33.33%
Colour rendering			20%		
Colour temperature			20%		

4. Data Presentation

4.1 ARCADE INDEPENDENCE SQUARE – COLOMBO

The fish tank area that is located right at the entrance of the park with an area of 3750m² was the space which was chosen for observation. Since this area is surrounded by a combination of shops and restaurants, many visitors of the park were observed lingering in this area. It has a series of fountains and the tank is embedded to the ground with a fibre glass top above the water on which people can walk on. The steps and pathway leading up to the tank is installed with an array of pathlights and step lights and underwater lighting components.. Soft landscape features available in the location such as the trees has been enhanced with uplighting techniques using soft yellow coloured fixtures. Grazing lighting technique has been used to light up the building walls surrounding the focus area of study.

Figure 2, Arcade Independence Square tank area

4.1.1 Visual Comfort

(a) Light Level

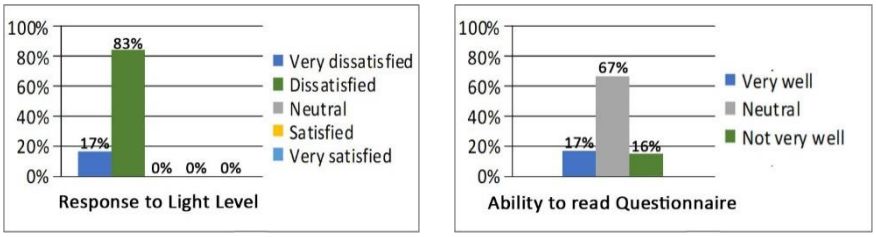


Figure 3, Arcade Independence Square participants' response to Light Levels

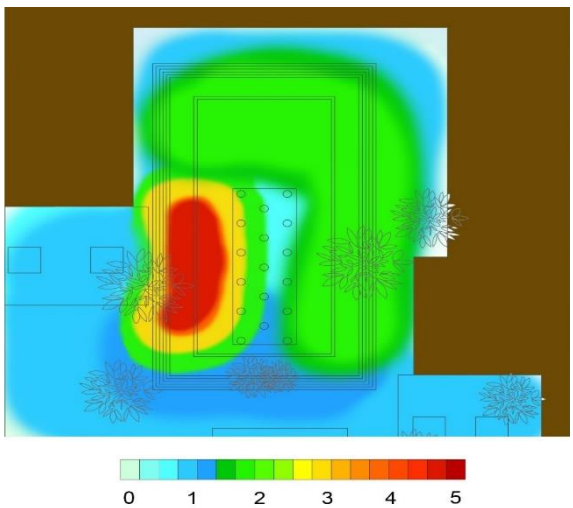


Figure 4, Illuminence levels of tank area as obtained by the digital lux meter and presented on a 0-5 lux range (Recommended standard minimum: 50 lux)

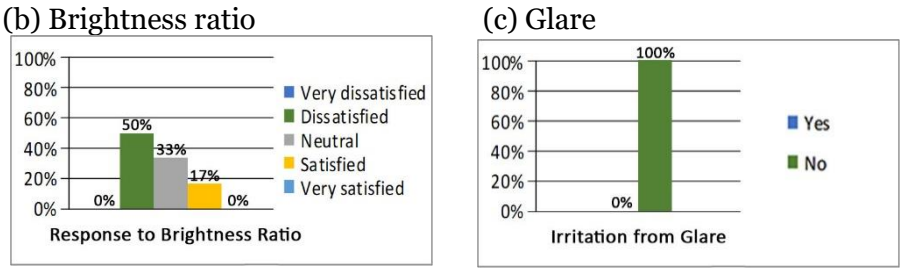


Figure 5, Arcade Independence Square participants' response to Brightness Ratio and Glare

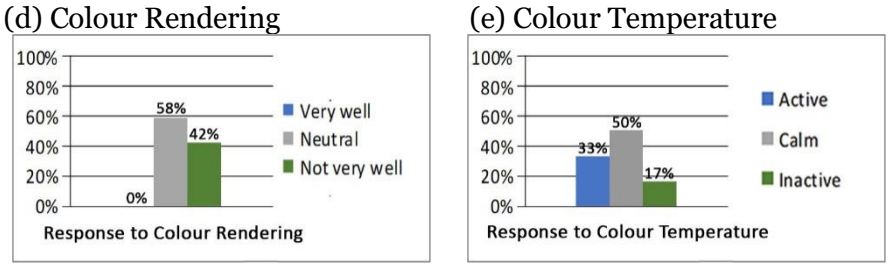


Figure 6, Arcade Independence Square participants' response to Colour Rendering and Colour Temperature

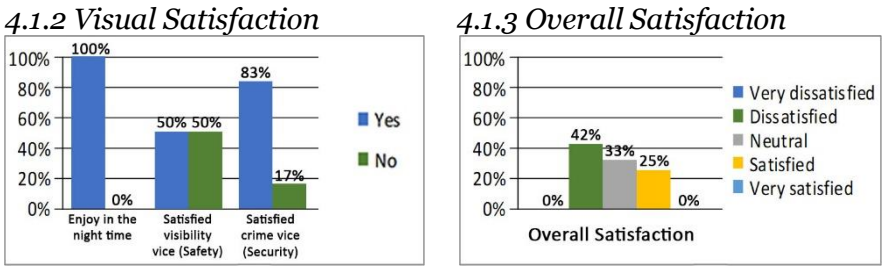


Figure 7, Arcade Independence Square participants' response to Visual Satisfaction and Overall Satisfaction

4.2 VIHARAMAHADEVI PARK – COLOMBO

The Buddha statue space which has an area of 7500m² was the focus region of the study. Relative to other areas of the park, most of the artificial lighting systems were installed in this particular area. The pond around the statue is illuminated by underwater lighting fixtures, and the pave way leading up to the statue is lit up by pathway lighting fixtures. From the results of the data obtained from the Viharamahadevi Park Buddha Statue area, it is evident that a majority of the participants were dissatisfied towards the lighting provided.

Figure 8, Viharamahadevi Park Brass Buddha Statue area

4.2.1 Visual Comfort

(a) Light Level

Figure 9, Viharamahadevi Park participants' response to Light Levels

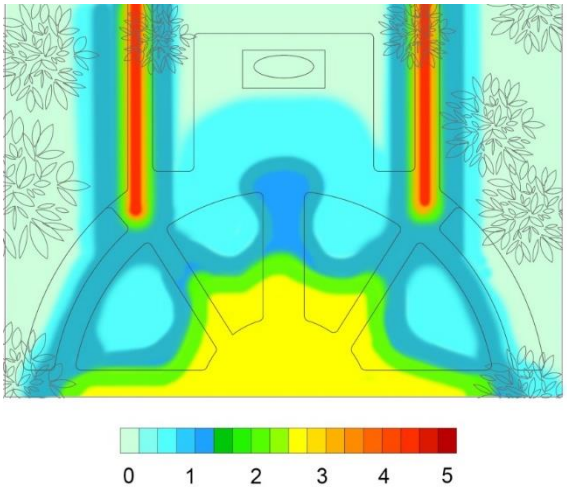


Figure 10, Illuminence levels of Viharamahadevi Park Buddha Statue area as obtained by the digital lux meter presented on a 0-5 lux range
(Recommended standard minimum: 50 lux)

(b) Brightness Ratio

(c) Glare

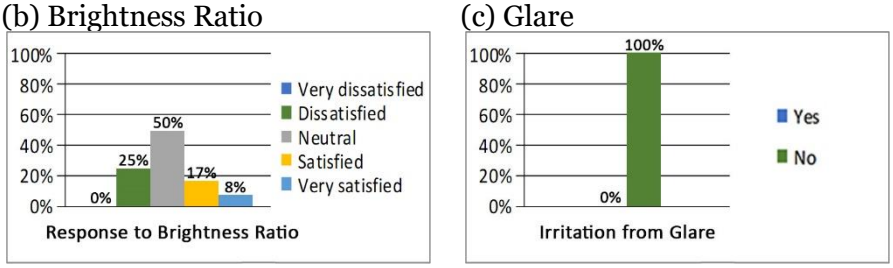


Figure 11, Viharamahadevi Park participants' response to Brightness Ratio and Glare

(d) Colour Rendering

(e) Colour Temperature

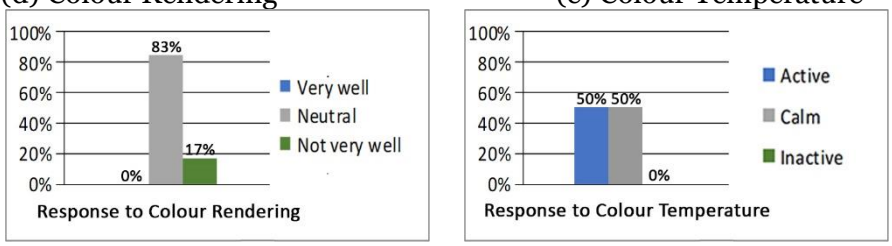
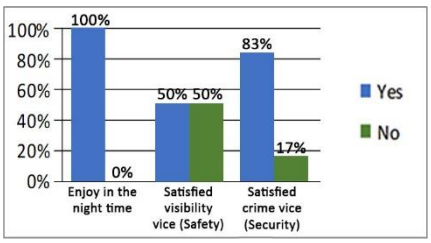


Figure 12, Viharamahadevi Park participants' response to Colour Temperature and Colour Rendering

4.2.2 Visual Satisfaction



4.2.3 Overall Satisfaction

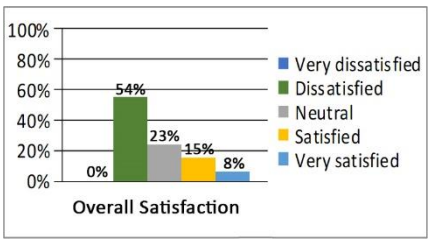


Figure 13, Viharamahadevi Park participants' response to Visual Satisfaction and Oveall Satisfaction

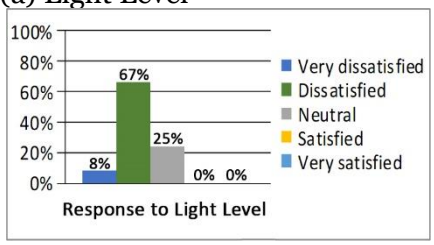
4.3 URBAN WETLAND PARK - NUGEGODA

The pond area of the Urban Wetland Park was chosen as the focus area of study in this case. A prominent crowd was observed in this area, and the lighting installations allowed the visitors to experience the park in a relaxed state. The 12,000m² area consists of a wide variety of lighting fixtures. The up-lighting component has been used to illuminate the greenery in the area and underwater lighting components have been used to illuminate the pond. The jogging and walking track start from the pond area therefore an arrangement of solar panel lighting posts has been used in the down lighting technique around the pond area and pathways while the steps have been lit by pathway lighting and step lighting techniques.

Figure 14, Urban Wetland Park pond area

4.3.1 Visual Comfort

(a) Light Level



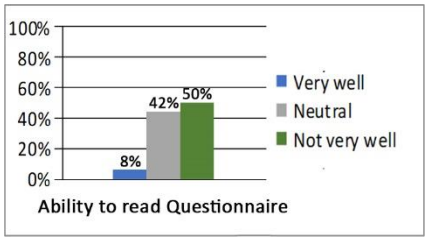


Figure 15, Urban Wetland Park participants' response to Light Levels

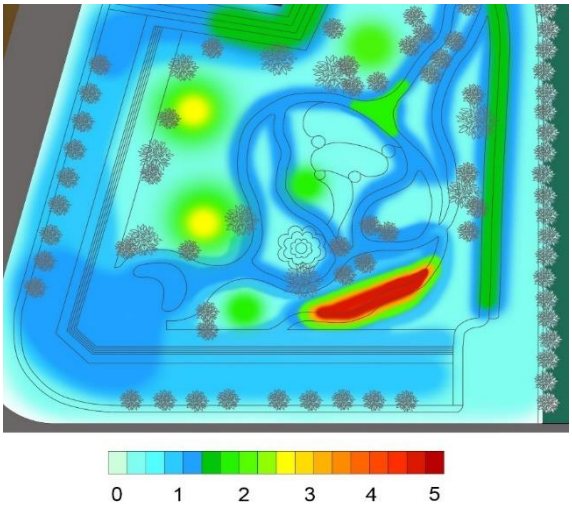


Figure 16, Illuminence levels of Wetland Park pond area as obtained by the digital lux meter presented on a 0-5 lux range (Recommended standard minimum: 50 lux)

Figure 17, Urban Wetland Park participants' response to Brightness Ratio and Glare

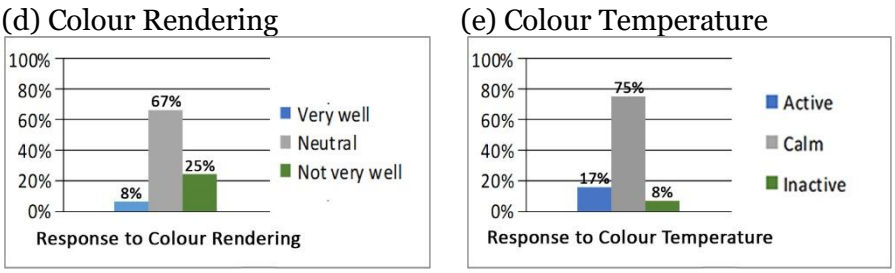


Figure 18, Urban Wetland Park participants' response to Colour Rendering and Colour Temperature

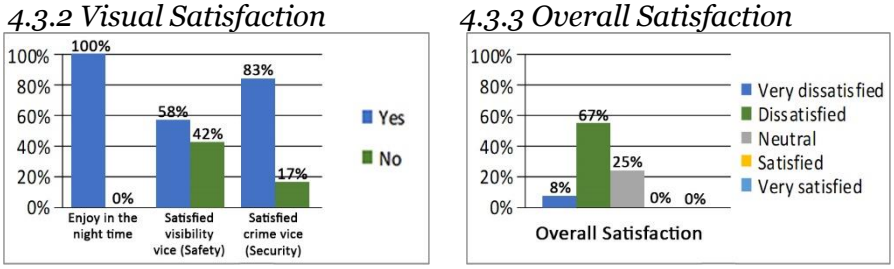


Figure 19, Urban Wetland Park participants' response to Visual Satisfaction and Oveall Satisfaction

4.4 DIYATHA UYANA – SRI JAYAWARDHANAPURA KOTTE

The Diyatha Uyana food court which is located in the proximity of the entrance of the park was area investigated. Most of the visitors were gathered in the outdoor, open sky dining region, which stretches over an area of 2500m². The wide variety of delicious cuisines that the Diyatha Uyana food court offers is one of the reasons that this park attracts this large amount of visitors every day. The technique of down lighting has been used to light up this area, with the use of solar powered LED lighting pole installations.

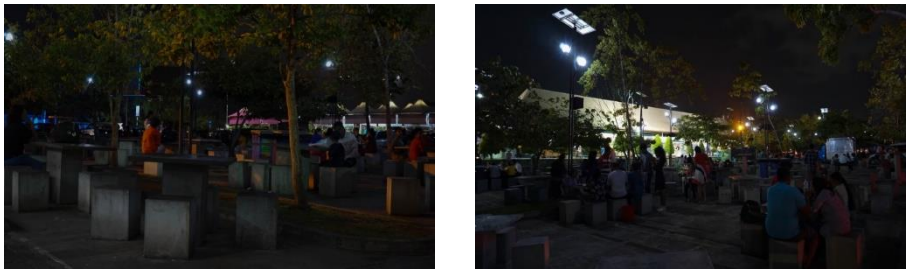


Figure 20, Diyatha Uyana food court dining area

3.1.1 *Visual Comfort*

(a) Light Level

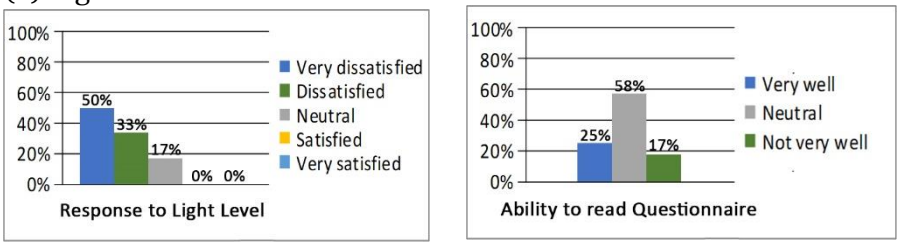


Figure 21, Diyatha Uyana participants' response to Light Levels

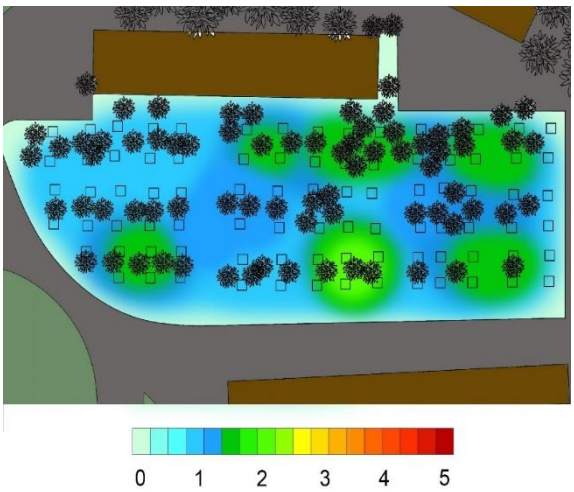


Figure 22, Illuminence levels of Diyatha Uyana food court dining area as obtained by the digital lux meter presented on a 0-5 lux range. (Recommended standard minimum: 50 lux)

(b) Brightness Ratio

(c) Glare

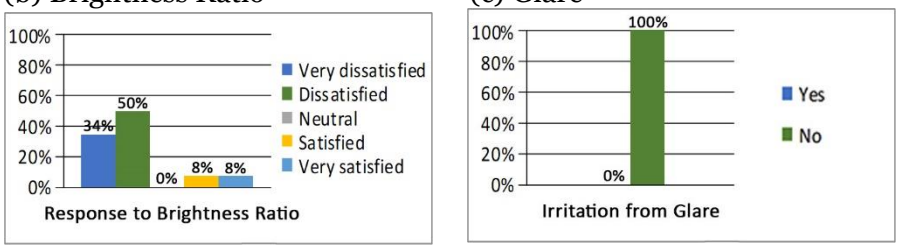
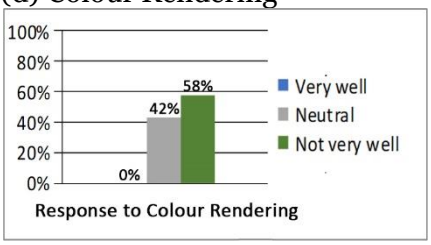


Figure 23, Diyatha Uyana participants' response to Brightness Ratio and Glare

(d) Colour Rendering



(e) Colour Temperature

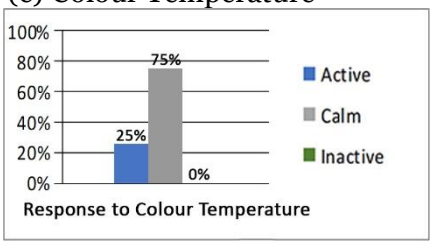
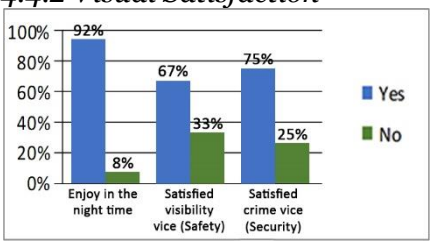


Figure 24, Diyatha Uyana participants' response to Colour Rendering and Colour Temperature

4.4.2 Visual Satisfaction



4.4.3 Overall Satisfaction

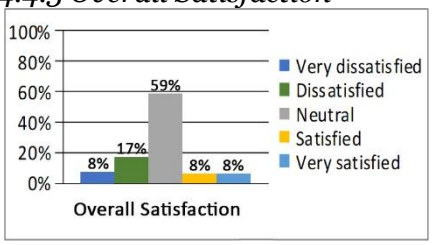


Figure 25, Diyatha Uyana participants' response to Visual Satisfaction and Oveall Satisfaction

4.5 GALLE FACE ESPLANADE – COLOMBO 02

In the night time, the whole park is bustling with people. Most of the visitors were found to linger around the street food vendors lining this 75,000m² area park. The lights from these shops also help illuminate this area and some flood light installations can also be observed in the same area of the vendor shops. Short sturdy vertical light posts also known as bollards are used to provide light to the pathway in the park along the Galle road. The questionnaires were distributed throughout the whole park on the 10th of July, 2018, Thursday.

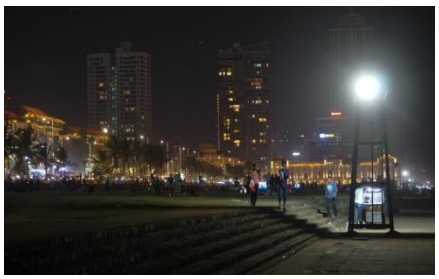
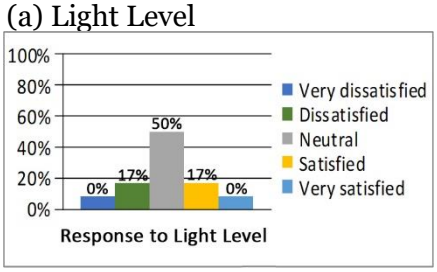


Figure 26, Galle Face Esplanade

4.5.1 Visual Comfort

(a) Light Level



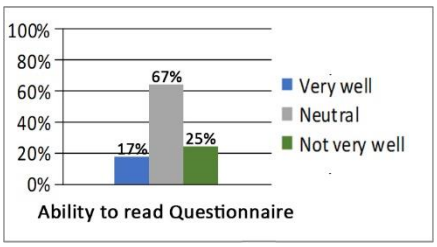


Figure 27, Galle Face Esplanade participants' response to Light Levels

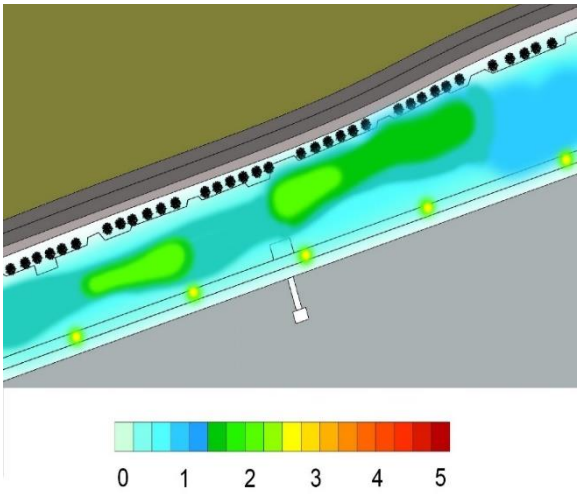


Figure 28, Illuminence levels of Galle Face Esplanade as obtained by the digital lux meter and presented on a 0-5 lux range. (Recommended standard minimum: 50 lux)

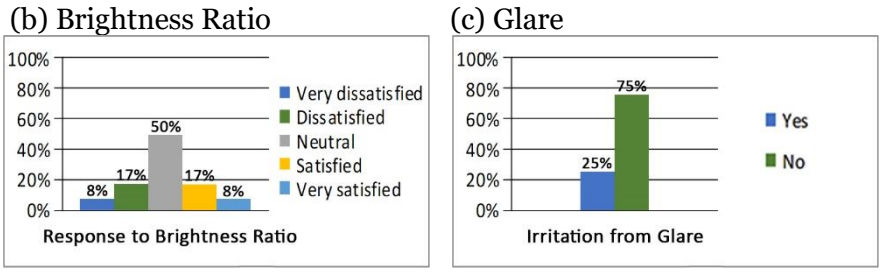


Figure 29, Galle Face Esplanade participants' response to Brightness Ratio and Glare

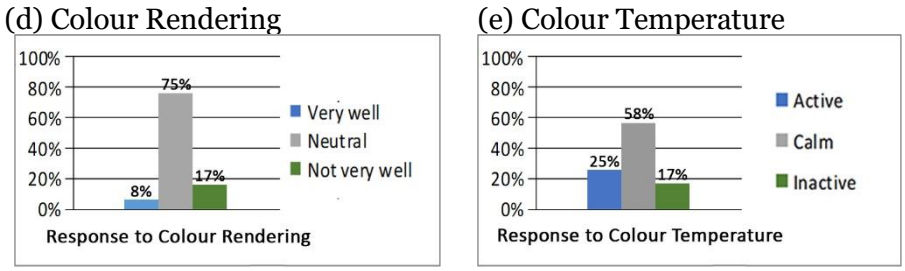


Figure 30, Galle Face Esplanade participants' response to Colour Rendering and Colour Temperature

Figure 31, Galle Face Esplanade participants' response to Visual Satisfaction and Oveall Satisfaction

5. Analysis

5.1 VISUAL COMFORT

The compilation of the constructive degrees of the parameters; light level, brightness ratio, glare, color rendering and color temperature that determine visual comfort together did not rise above 50% in all

of the parks. According to the standard lighting level that is recommended for outdoor public spaces, all the parks had a significant deficiency of lighting levels, therefore as a result the visual comfort was significantly low. Hence it is evident that light levels have an important association to the subjective impact of artificial lighting on visual comfort.

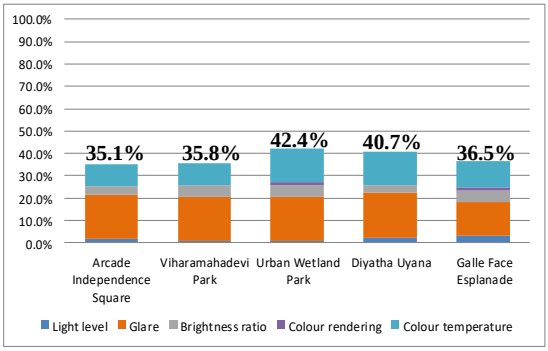


Figure 32, Visual Comfort %

5.2 VISUAL SATISFACTION

Visual satisfaction of the participants was determined by the three parameters; aesthetics, safety and security. The compilation of the determiners that construct visual satisfaction all indicated a considerably high magnitude comparatively to visual comfort. This indicates that other factors such as the social constitution of the users of the park and the topographical disposition of the park had an impact on the visual satisfaction.

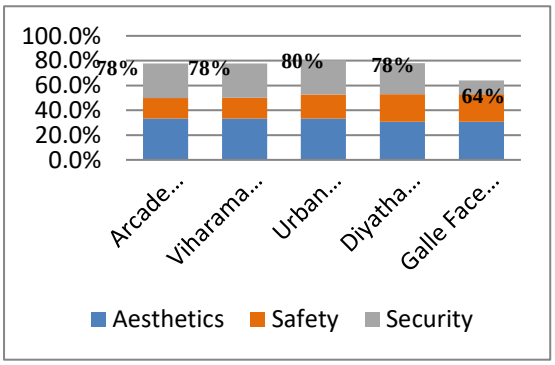


Figure 33, Visual Satisfaction %

Despite the indications towards the determiners of visual comfort being deficient with regard to the artificial lighting systems, the participants' subjective response towards the visual satisfaction determiners were considerably substantiating.

5.3 OVERALL SATISFACTION

The overall satisfaction indicated towards almost all the parks were significantly low. This demonstrates that both visual comfort and visual satisfaction has a correlation towards the overall satisfaction. The lighting intensity of artificial lighting systems has a great impact on the determiners of visual comfort and visual satisfaction. Furthermore, the consideration of the functionality of the space is also important. Meeting the lighting requirements of the reasons people come to a space in the night time, can also attribute to the overall satisfaction.

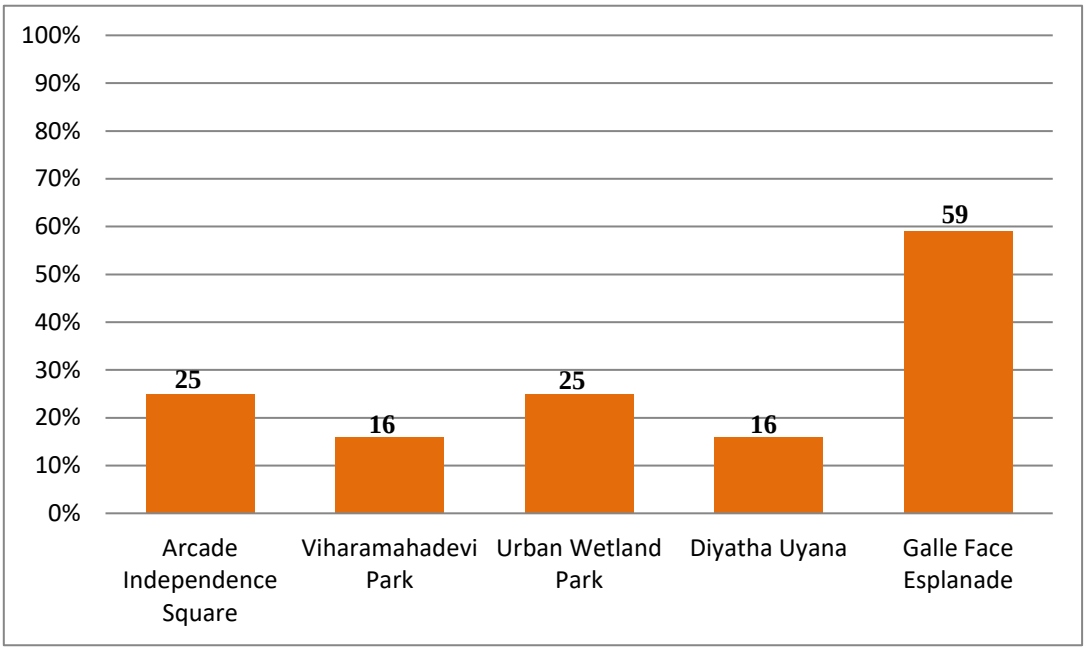


Figure 34 Overall satisfaction %
Source: Compiled by author

6. Conclusion and Recommendations

It was found that, even though the minimum requirements of visual satisfaction were fulfilled, important visual comfort factors such as lighting levels had a psychological influence on the overall visual satisfaction. Accordingly, although the participants indicated a considerable positive regard towards the determiners of visual satisfaction the negative responses towards the determiners of visual comfort resulted a negative indication to the overall visual satisfaction. According to the IESNA (2000), the standard minimum horizontal illuminence level for outdoor public spaces should be maintained at 50 lux. The maximum lux level recorded among all the parks did not exceed 5 lux. Consequently, none of the parks met the minimum standard lighting level requirement, therefore the brightness ratio of 10:3:1 optimum magnitude level was not available as well. Warm white color temperature of 3000K fixtures was used for the majority of the lamps throughout all the parks. This composition of the lighting fixtures with the low lighting levels affected the colour rendering index, causing the participants to misinterpret the true colors of the objects around them.

The constitution of each park and the participants' functional behavior within the parks showed evidence to be important attributes in the subjective response to visual satisfaction. More specifically, the safety aspect of a park with regard to the sufficiency of the horizontal illuminence of the area was also determined by the topographical and functional disposition of the area to the user. Different parks come with different features according to the different temperaments of the landscape and environment. Flat terrains evoke a safer sense within an individual with oppose to areas that have many obstacles such as steps and stairs. Implementing enough lighting levels with regard to the standard recommendations to areas that require precise task lighting would help maintain the subjective impact on visual satisfaction.

Accustomed by the socio-cultural connotations of local context, Sri Lankans are relatively less demanding when it comes to fulfilling the requirements pertaining to human satisfaction. Therefore, it can be observed in general terms that Sri Lankans demonstrate a greater level of adaptation to conditions which are not meeting the necessary comfort standards. Accordingly, the subjects were found to be satisfied even with low levels of lighting in urban parks, though such lighting levels were below the recommend comfort standards. Lack of knowledge in Architects, landscape Architects, Designers and Planners on the impact of different lighting levels in manipulating human psychological and behavioral aspects of night life could be one reason for the incorporation of such low levels of lighting in public places.

Although all the urban parks that were studied in this research had a lack or insufficiency of lighting levels according to the standard recommendations, due to reasons like; lighting fittings not being positioned in relation to the necessary areas properly, the insufficiency of lighting fixtures in the lighting system installations, low wattage levels of the used fixtures, wasted light to unwanted areas, and maintenance of the lighting system not being regulated, causing the overall visual comfort of the participants to be indicated at a low, glare irritation was significantly low to non-existent. Wastage of light was predominantly observed throughout all the parks, this was mainly due to the absence of the correct use of lighting techniques according to the landscape of the parks. If the appropriate techniques had been used the lighting levels would have been complimentary to the visual comfort and visual satisfaction of the users. The usage of some fixtures such as floodlights caused significant glare effects, hence using an abundant amount of small lighting fixtures instead, would give more control over the lighting system of the park and a positive remark on energy consumption.

In conclusion, it was evident from this study that lighting level had the most prominent impact on the subjective impression of both visual comfort and visual satisfaction. Maintaining lighting levels to cater to the necessary task requirements would eventually increase the positive regard on the other essential determining parameters of visual comfort and automatically increase the positive regard towards the overall visual satisfaction.

Thus, the deduction that artificial lighting has a direct impact on human visual comfort and visual satisfaction is evident through the results of this study. Therefore, it can be concluded that implementing lighting installations to provide to the important elements that detect visual comfort would administer beneficial outcomes when designing outdoor artificial lighting plans for urban spaces in the night time.

Low lighting levels may lead to reduced energy consumption and can be seen as a sustainable solution in lighting public spaces. However, sustainability in outdoor lighting encompasses not only a minimized energy consumption but also providing lighting for what is needed, when needed and at the intensity needed ensuring reduced adverse impacts on the user. Accordingly lighting levels in the selected cases have to be re-visited beyond addressing the aspect of low energy to suit the functionality of such spaces which are conducive for associated emotional and behavioral responses in users.

7. References

Billmeyer, F.(1981) Principles of color technology. 2nd ed. New York: Wiley & Sons

Boyce, P., Eklund, N., Hamilton, B. and Bruno, L. (2003) 'Perceptions of safety at night in different lighting conditions' *Lighting Research and Technology* 32(2) 79-91

Bruederle, A. and Hodler, R. (2018) 'Nighttime lights as a proxy for human development at the local level' *PLoS ONE* [online] 13(9), e0202231. available from < https://doi.org/10.1371/journal.pone.0202231>

Cuttle, C. (2008) Lighting by Design. 2nd edn. London: Macmillan

DilLaura, D., Houser, K., Mistrick, R., and Steffy, G. (2015) *The lighting handbook*. 10edn. Illuminating Engineering Society of North America. New York: IES

Farley, K. and Veitch, J. (2001) 'A Room With A View' *A Review of The Effects of Windows on Work and Well-being*

Fincher, W. and Boduch, M. (2009) Standards of Human Comfort: *Relative and Absolute* [online] (4-5). available from < https://soa.utexas.edu/sites/default/disk/preliminary/ preliminary/1-Boduch_Fincher-Standards_of_Human_Comfort.pdf>

Guerrero, O. (2014) 'Exploration of Asthenopia due to the ration of direct/indirect light in office environments' Master of Science, Eidenhoven University of Technology, Eidenhoven

Hafiz, D. (2013) A Dynamic Simulation Approach for Visual Comfort Evaluation under Daylighting Conditions 2 (1), 65-66

Iacamussi, P., Radis, M., Rossi, G., and Rossi, L. (2015) Visual Comfort with LED Lighting: Energy Procedia 729-734

Institute of Lighting Engineers. (2005) Outdoor Lighting Guide (1st edn.) Abingdon, Oxon: Taylor & Francis

Konijnendijk, C., Annerstedt, M., Nielsen, A., and Maruthaveeran, S. (2013) Benefits of Urban Parks: A Systematic Review. Copenhagen: IFPRA

Likert, R. (1932) 'A Technique for the Measurement of Attitudes' *Archives of Psychology* 140. 1-55.

Moyer, J. (1992) The Landscape Lighting Book. New York: John Wiley