Research Article

Finding the illuminance levels for walkers in a prominent public park in New Delhi during the post-twilight period for healthy visual comfort, security, and other related parameters.

Raja Singh[1,2]

1. Department of Architecture, School of Planning and Architecture, India; 2. ISAC Centre for Built Environment Policy, India

This paper measures the illuminance level during the post-twilight darkness on the walking path of a famous public park in New Delhi. The readings, 252 in number, were mapped on a map using Global Positioning System and were measured using a lux meter at regular intervals throughout the pathway. The required illuminance depends upon multiple factors, including visual comfort, safety, security, prevention of light pollution and energy-saving concerns. This paper has looked at the measured values and checked whether they fall within the limits of visual comfort derived from literature and security as taken from the Indian lighting standard. The readings show that about one-third of the points on the pathway have zero illuminance levels. Among the rest, 127 of the 252, about half the points were at the level of comfort of 1 to 2 lux. The remaining one-third of the total were over-illuminated from the visual comfort point of view but appropriate from the security approach, which requires readings above 5 lux. It is recommended that instead of the appropriate focus on lighting levels, uniformly distributed light at an equally distributed spacing throughout the pathway would be more appropriate. Bollard-based lighting focusing on the pathway will be more suitable than the existing high street lamps. This will not only provide lighting for security and comfort but will also prevent light pollution. Such studies must be repeated across parks and streets in India, and more factors like light temperature should be studied further.

Corresponding author: Raja Singh, dr.rajasingh@proton.me

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Introduction

In this study, we have looked at the walking path of a major public park in New Delhi, India, from the point of view of lighting during the post-twilight dark period. This was done to get information about the current lighting condition in this public park. The study of the illuminance levels for walkers in the evening is essential as it links to multiple factors. These include visual comfort for the walkers, safety & security of walkers, prevention of light pollution and the infrastructure capacity of the city in terms of energy usage in large parks.

The park chosen for the study is Lodhi Garden in New Delhi, one of Delhi's significant gardens or parks frequented by the public of Delhi. The entrance to the park is shown in Figure 2. This park is as much part of Delhi's popular culture as Hyde Park in London, Yoyogi Park in Tokyo or Central Park in New York City. This park is important because it is visited by the policymakers, parliamentarians, judges, bureaucrats and the everyday folks of Delhi [1]. It also forms the blueprint for garden development across the city and other parts of the country.

The study has been performed by taking the levels of illuminance in 'lux' on the walking paved paths which complete a complete round of the walking pathway of the garden.

The illuminance will get the value of the light that falls on a plane, and in our case, we can call it the brightness colloquially of a plane where the luminaire is used at night time. Multiple studies have been performed in public parks concerning visual comfort, but very few are believed to have been performed in India. The studies show that there is a particular liking based on the perception of people towards the lighting of public parks, and there are the following concerns revolving around this lighting:

1. Visual Comfort: As public parks are places people visit as leisure activities, they would want certain comfort to escape the otherwise high lighting levels of the city or their screens. This factor not only involves brightness but also includes the colour temperature of the white light [2]. In this current study, though, we will be limited to the illuminance or the brightness levels
2. Safety, legibility and Navigation: This is where proper lighting levels provide people with the primary prevention against getting hurt and not being able to navigate or getting hurt due to anything they may not be able to see and comprehend [3].
3. Security: The principle of Crime Prevention through Environmental Design involves a great deal of natural surveillance, which can only happen when proper visibility exists [4]. At night, this visibility

is possible only if appropriate lighting in the parks exists. Security has a significant component of actual security where you may see an offender. Still, there is a considerable component of perceived security where lighting may lead to the psychological feeling of security in a given space. This may be most relevant for women using the park at night time.

4. Light Pollution Concerns: Lighting in urban areas affects biodiversity, especially birds and smaller animals that are part of the park ecosystem [5][6][7].
5. Cost and Policy: The luminaire, the operational lighting cost, the available technology, and the government or industry push towards a particular type of lighting [8].

With respect to significant studies dealing with visual comfort, it has been found that in urban public parks, people are most comfortable with illuminance levels of 0.6 lux to 4.8 lux, with the mean value being 1.4 lux [2]. This result was particularly for lighting type of 3000K or the high-pressure Sodium Vapour Lamps, which have warmer temperatures of white light. Another study involving testing participants for visual comfort using virtual reality kept the low illuminance levels at 2 lux. But the same study found that high overall illuminance induces negative emotions, but the same study concluded that the sense of safety in low lighting conditions is less [9]. In another study dealing with streets in Korea, the minimum horizontal illuminance level in lux was considered 1 lux [4]. The Indian National Lighting Standard has no specific illuminance levels for parks and gardens, but they generally specify the warm temperature High Sodium vapour lamp, which has illuminance levels of 7 to 14 lux under the luminaire. But, for the sake of security, in a walking zone, the minimum suggested illuminance levels would be 5 lux at the minimum [10]. There was also another study dealing with public streets, which concluded that higher levels of illumination meant a higher perception of security, but the study also cautioned that lower illuminance levels over smartly distributed uniform lighting on streets were better than a large quantity of poorly distributed light which may have higher levels of illuminance [11]. In any case, no study highlights zero lighting as being of any virtue but is assumed that some lighting at nighttime will be there.

In this study, the above standards from the literature will be used to analyse the illuminance on the paved walking paths at Lodhi Garden, a prominent public park in New Delhi.

Figure 1. The garden pathway with a lighting patch falling on the path.

Source: Author.

Figure 2. The entrance of the Lodhi garden in New Delhi. Source: Author.

Materials and Methods

The main method followed is as follows:

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1. The values for outdoor lighting for security were derived from the standards of Outdoor Lighting of India from the National Lighting Code. Further values were derived on outdoor lighting, specifically of urban parks with respect to the following
    1. Safety and security at night and the role played by lighting.
    2. Visual comfort by lighting in outdoor settings, especially parks that are usually associated with a feeling of leisure.
    3. Outdoor Lighting pollution concerns
    4. Energy consumption concerns.
2. A prominent public park was identified in New Delhi and a data collection method was developed. This method has been mentioned in detail below.
3. The results from the data collection exercise were collected and analysed and compared against the standards collected as mentioned above.
4. Recommendations were charted out.

The data collection at the public park was done as follows:

1. The paved walking pathway in the public park was identified where there is use during the post-twilight and night time. See the area of the path near the entrance in Figure 1.
2. The timing was confirmed so that the readings were taken during the dark post-twilight timings. The artificial lighting in the public park was checked to be made sure was switched on.
3. The reading was taken in the horizontal plane, at 1m above the ground level [10]. At the first point, the Global Positioning System readings or the latitude/longitude readings were taken. The readings were taken using a smartphone-based GPS with a GPS test app. The readings were repeated at an equidistant 10 steps away and were repeated. The readings were taken at the centre of the path in front facing direction. The GPS readings were repeated at multiple points, esp. ones where there was a major change in direction.
4. The readings were noted down and mapped on the map of the park, as shown in figure 3. The summary of the readings is shown in Figure 4.
5. The readings were analysed against values that were derived from literature and standards, and the results were reported.

The Lux Meter used in the study was SIGMA Digital Lux Meter LX 1010B which has been calibrated. The instrument has the least count of 1 lux and has a maximum error of +/- 5%, which is 0.05 lux for 1 lux.

The device has a detached probe and is connected with a stretchable cable. This enables the sensor to be away from the reading display to collect data at the right horizontal plane.

The study involved no human subjects, no animals and no tissue. The study involved no human interaction or any questionnaire surveys. The data collection was non-obtrusive. In the above light, the study requires no ethical clearance as it is not within the same scope per the 2017 Indian Ethics clearance guidelines from the Indian Council of Medical Research, Government of India[12].

Results

After taking readings at 252 points on the paved walking path within the Lodhi Garden, it was found that the average value from the 252 points was 6.7 lux. What was most important to notice is that 79 points which are 29 per cent of the pathway, had zero lux as the reading, which means that one-third of the pathway was not lit. The other 179 points, or 71 per cent, were lit below 5 lux with only 3 per cent or 9 counts of points with 5 lux exactly. The readings have been mapped to the site plan shown in Figure 3. The total reading instances at various illuminance levels are charted in Figure 4.

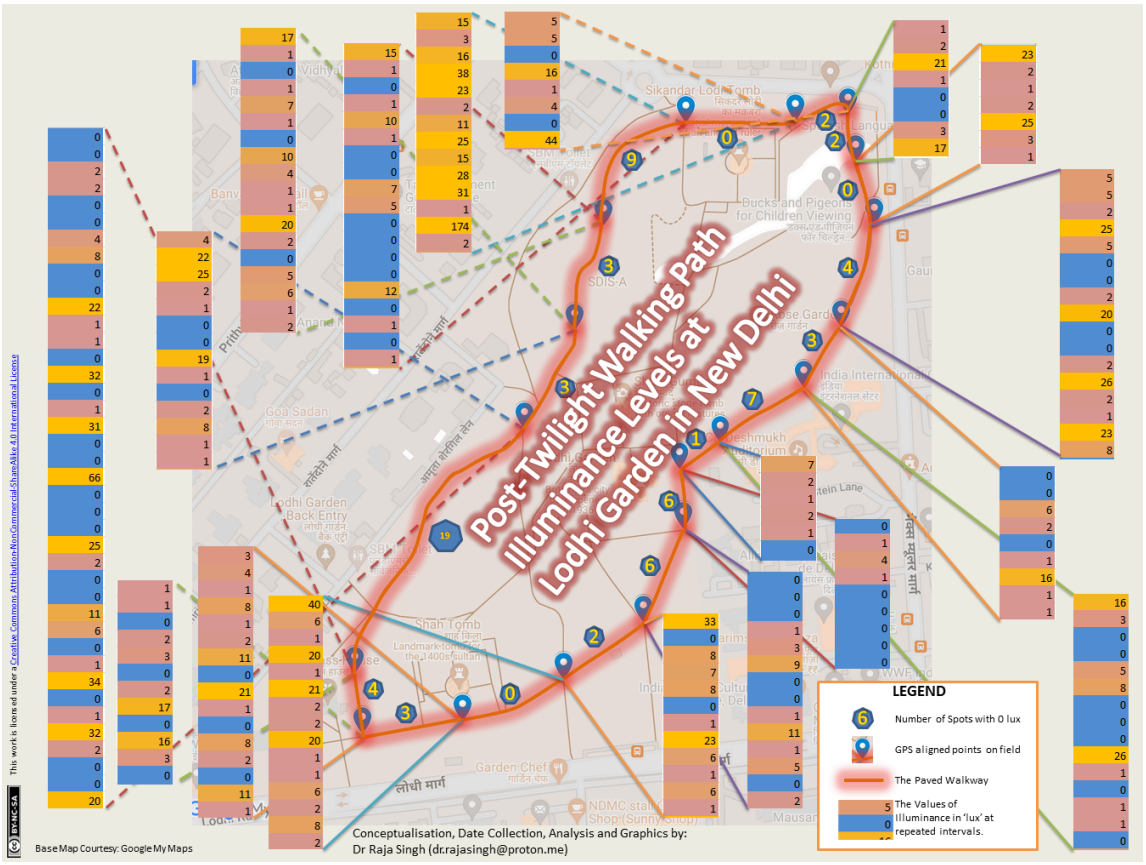

Figure 3. Post-Twilight Walking Path Illuminance Levels at Lodhi Garden in New Delhi. See legend for detail.

Source: Author.

The number of points lit at 1 lux, or 2 lux, was 50 per cent of the points, which is 127 points. See Figure 5.

With respect to over-illumination, there were 28 per cent points that were over-illuminated, i.e. having illumination of more than 5 lux. Figure 3 shows that these points were at the top side of the figure, which was adjacent to the tomb wall, and this is where the illumination values were 28 and the maximum peaking up to 174.

There was a stretch in the pathway where there was zero illumination for continuous 8 points at the maximum.

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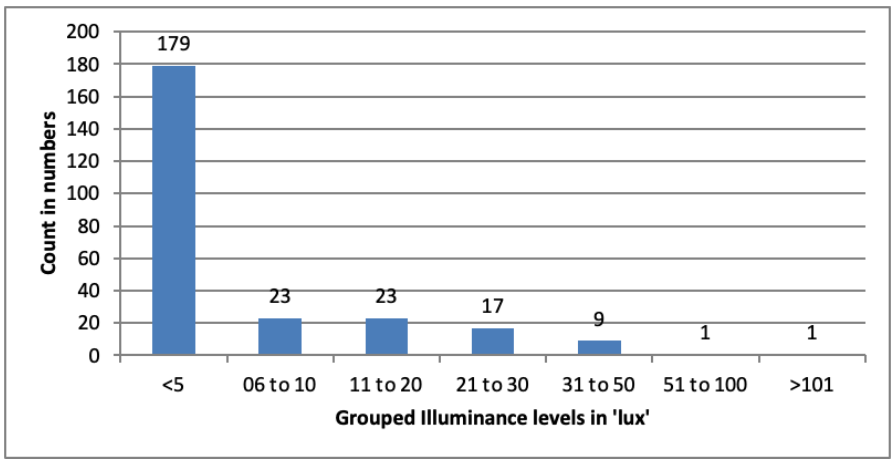

Figure 4. The graph showing grouped illuminance levels versus the count of the number of instances on the walkway of the park. Source: Author.

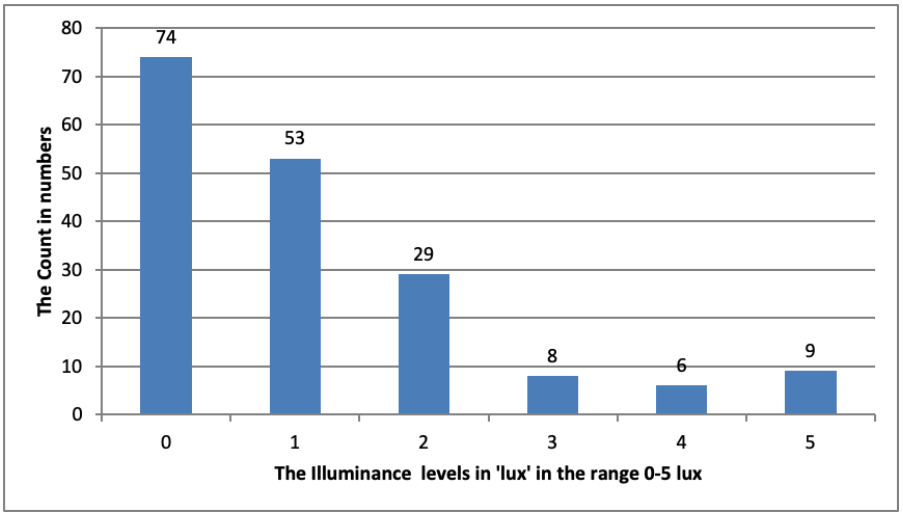

Figure 5. The chart showing the illuminance levels for the values below 5 lux with the number of reading instances for the same. Source: Author.

Discussion

The results provide a clear indication of the many factors with respect to the lighting at Lodhi garden in New Delhi. Firstly, the lighting is non-uniform with a zebra effect. This means that there are patches of required illuminance followed by no illuminance. On the other hand, low lighting, which is throughout the pathway uniformly, would have created a better effect regarding the sense of lighting for security.

This means that there are points where there is no illumination on the walking path. This is acute where there is no pathway illumination for a straight 8 points of recording. Dark spots with zero illumination mean an increased lack of vision, chances of perceived fear, and no visual comfort as one cannot make out the pathways or the objects around. The total portions where there are continuous two points or more with zero illuminance in the pathways are ten in number.

The important point to note is the actual lighting threshold that may be required. We have a point with 1 lux and two lux as the majority are below 5 lux. This is a total of 32.5 per cent of the points of the total pathway. This would mean points that, as per literature, have the required visual comfort for a path in a public park. The other 20.6 per cent are above 2 lux but below or equal to 5 lux, which would mean that neither are these points have the required 5 lux and above for a security point of view, nor are they low enough for a visual comfort point of view. Visual comfort would prevent any form of overlighting that may be required.

It is important to note that the total above 50 lux instances in the pathway are only two. This means that there is no excess lighting as such in the pathway. The most lit part of the area was near the Lodhi Tomb, which abuts the road on the top side of figure 3. The number of dark points in this was zero. The average illumination in this stretch was 27.4 lux, which is way above the park's average at (6.7lux) and above the requirements for parks and much more than the requirement from the security point of view. This highlighting patch consisted of LED lights, and these were specifically to lighten the wall of the Lodhi Tomb so that the view could be taken from the road abutting the boundary very near the tomb. Of grave concern is that these levels may be harmful from the light pollution point of view. Light pollution may not only disturb the birds and other flora and fauna of the garden ecosystem but may also raise melatonin levels among walkers and disrupt the circadian rhythm. This high level of lighting in this stretch was, in contrast, to the rest of the walkway, which was lit majorly by High Power Sodium Lamps, which the Indian National Lighting Code has suggested to be suitable for parks at night and due to the warm colours are also suitable for visual comfort.

LED lights have seen rampant growth, and the newer lights in the park were also LED. But these lights have a very high brightness compared to Sodium vapour lamps. These lights give higher light output at lower power consumption. This fact must not become the key guiding principle, and visual comfort should be prioritised over what may be available. Most importantly, the LED luminaires must be pointed in the right direction and used as bollard-based lighting, which focuses n the pathway instead of the trees and directly into people’s eyes.

Regarding the luminaires, the lighting would spread all around instead of only aimed at the pathway itself. For light pollution prevention, bollard-based lighting should be used. This light points the light towards the pathway and is not very high, is just about 1 metre from the ground level and does not spill light upwards towards the trees, thus preventing light pollution. This type of lighting probably wouldn't have been used as these lights are more prone to vandalism and theft of the luminaire. But with bollard based available, these must be considered for parks so that the path is lit and light pollution is prevented. But with ground-based bollard lighting systems, people's faces may not be completely illuminated. A combination of pathway lights and higher-height street lamps may be used for this. But in any case, there is an absolute requirement for making a uniform spread of light, which may be lower in lux levels but is through the pathway. This will also create a more aesthetic experience for the walkers while giving them a proper sense of direction and legibility.

From the security point of view, incorporating principles of CPTED requires natural surveillance, which is possible at night only with appropriate visibility. Even at low lux levels, the presence of a person moving is possible. Very high lux levels with better colour rendering may be suitable but can be skipped as they may be aesthetically overlit and not ideal from the visual comfort point of view. But what is not suitable from the security point of view is points on the pathway that have zero illumination. This must be done away with in urban parks to give a sense of real and perceived security to people using these parks. The lux levels may be kept at around 2 lux to 5 lux.

Conclusion

This study set out to find the illumination levels in a famous public park in New Delhi, India. The study found that the pathway was not thoroughly and uniformly lit, with almost one-third of the path not lit. Another significant portion was underlit from the security point of view and overlit from the comfort point of view. If not a common suitable value, an average value must be kept so that both the parameters can be given some compensation. Security in urban areas is vital, as parks may be places of crime. Still, at the same time, the lighting should not flood the space and prevent any feeling of comfort for the people using it. This is also in sync with the prevention of light pollution.

Declarations

The author declares no competing interest. No specific funding was taken for this study. This study requires no ethical approval as it involves no human participants, tissue, or animals [12].

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