

URBAN PUBLIC SPACE ILLUMINATION PRACTICE AND CITY BEAUTIFICATION IN THE INNER-CITY CORRIDOR OF ADDIS ABABA: SPATIAL, ARCHITECTURAL, AND ENERGY IMPLICATIONS

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THIS THESIS IS SUBMITTED TO THE ADDISABABA UNIVERSITY COLLEGE OF TECHNOLOGY AND BUILT ENVIRONMENT SCHOOL OF BUILT ENVIRONMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN URBAN AND REGIONAL PLANNING STUDIES WITH A SPECIALIZATION OF URBAN DESIGN AND DEVELOPMENT.

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Declaration

I declare that this thesis was prepared for the partial fulfilment of the requirements for the degree of master of Urban Design and Development entitled “Urban Illumination Practice and Its Impact on the Inner-City Corridors of Addis Ababa.” This original research work was prepared by my own effort with the close advice and guidance of my advisor. I also declare that this thesis has not been presented in any university, and all sources I have quoted have been indicated and acknowledged by means of complete reference.

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List of Acronyms

AACRA	Addis Ababa City Roads Authority
AASHTO	American Association of State Highway and Transportation Officials
ALAN	Artificial Light At Night
CCT	Correlated Colour Temperature
CIE	Commission Internationale de l'Éclairage (International Commission on Illumination)
ESAA	Addis Ababa City Administration Electric Service Administration Authority (also referred to as EAAS)
GIS	Geographic Information System
IEC	International Electrotechnical Commission
IES	Illuminating Engineering Society
IESNA	Illuminating Engineering Society of North America
kWh	Kilowatt-hour
LED	Light Emitting Diode
NOAA	National Oceanic and Atmospheric Administration
DALI	Digital Addressable Lighting Interface
DOB	Driver-on –Board
VIIRS	Visible Infrared Imaging Radiometer Suite (referenced via remote sensing time-series data)
PAS	Primary Arterial Street
SAS	Secondary Arterial Street
NTL	Nighttime Light

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Abstract

Urban illumination has become an important component of contemporary urban development and city beautification, influencing the spatial quality, architectural expression, nighttime experience, and energy performance of urban environments. In Addis Ababa, recent corridor development and beautification initiatives have introduced extensive decorative street and façade lighting along major inner-city corridors. However, the extent to which these practices respond to existing spatial structures, architectural character, public-space needs, and energy sustainability remains insufficiently understood. This study investigates urban illumination practices and their spatial, aesthetic, perceptual, and energy impacts in the inner-city corridors of Addis Ababa. A mixed-methods case study approach was employed, combining field observation, photographic documentation, GIS-based spatial analysis, technical lighting assessment, questionnaire surveys, institutional inquiry, and nighttime illumination analysis. A total of 280 questionnaires were used to examine perceptions of visual comfort, glare, spatial integration, architectural quality, and energy utilisation. Technical assessment considered lighting specifications, installed wattage, fixture quantities, operating duration, spatial distribution, and relevant illumination requirements, while GIS and nighttime satellite imagery were used to examine the spatial distribution and broader patterns of urban illumination. The analysis was organized around four domains: formal and regulatory consistency, spatial and visual integration, illumination as a medium of architectural and urban perception, and sustainability and operational management.

The findings indicate that illumination has improved nighttime visibility and contributed to corridor beautification and visual presence, but its integration with the existing urban environment remains inconsistent. Decorative street lighting was frequently found to have weak relationships with building setbacks, street proportions, pedestrian spaces, and architectural scale. Excessive brightness, glare, light trespass, exposed infrastructure, and repetitive lighting arrangements affected visual comfort and reduced architectural distinctiveness. Façade lighting also showed irregular fixture placement, excessive brightness, and insufficient coordination with architectural elements. The technical assessment further identified significant energy-use concerns associated with high-wattage decorative lighting and extended

operating periods. Although institutional mechanisms for monitoring and maintenance are emerging, stronger coordination between lighting design, spatial planning, architectural control, and energy management is required. The study concludes that the main challenge is not the provision of urban illumination itself, but its limited integration with urban spatial structure, architectural character, public-space quality, and energy sustainability. It recommends a corridor-based lighting master plan, stronger control of pole height and setback, context-responsive façade lighting, improved shielding and glare control, energy-efficient and adaptive lighting systems, and coordinated institutional management to support a more integrated, spatially responsive, architecturally sensitive, and energy-sustainable urban lighting strategy in Addis Ababa.

Keywords: *Urban illumination; City beautification; Spatial quality; Architectural expression; Façade lighting; Street lighting; Energy sustainability; Addis Ababa*

Chapter One

1. Introduction

1.1 Background of the Study

Urban illumination has become an important component of contemporary urban design, influencing how cities function and appear at night. Artificial lighting improves visibility, movement, safety, and nighttime activity, while also shaping the visual identity and spatial image of urban environments. As a medium through which the city is perceived, experienced, and used, illumination is increasingly recognized — alongside its functional role — as a legitimate instrument of beautification, tourism promotion, and the enhancement of urban character (Lynch, 1960). The four sub-sections below situate this study within four bodies of literature in turn: urban development as a process, city beautification as a specific strand of that process, inner-city corridor development as the spatial unit through which beautification is delivered in Addis Ababa, and the emergence of urban illumination as an increasingly central instrument within all three.

1.1.1 Urban Development

Urban development is understood in the literature not simply as physical construction but as the ongoing process of making better places for people than would otherwise be produced. Carmona and Tiesdell (2007) frame this process as being for and about people, as centred on the value of 'place', as operating within real-world economic and regulatory constraints, and as fundamentally a design process rather than a single design outcome. Understood this way, urban development encompasses the arrangement of streets and plots, the massing of buildings, and the shaping of the public space between them — the same physical substrate that decorative and facade illumination is later applied to. This framing is significant for the present study because it treats illumination not as a technical add-on to a finished city, but as one further act of urban development, subject to the same evaluative standards of place-making as any other.

1.1.2 City Beautification

Urban beautification as an organized planning practice traces to the City Beautiful movement, which gained ground in the United States following the 1893 World's Columbian Exposition in Chicago. Under the direction of architect Daniel Burnham, the Exposition's temporary 'White City' combined Beaux-Arts civic buildings with parks, lagoons, and grand boulevards to demonstrate that a city could be simultaneously ordered, functional, and aesthetically elevated (Wilson, 1989; Britannica, 2024). The movement's central instruments — civic centres, parks, and grand boulevards — were intended to enhance both the visual appearance of the city and the practical flow of pedestrian and vehicle traffic through it, and its influence subsequently extended to Washington, D.C., Cleveland, and San Francisco, among other cities (Britannica, 2024).

Contemporary city beautification has broadened well beyond the monumentalism of the original movement to include streetscape enhancement, facade treatment, planting, and — increasingly — decorative and architectural lighting as everyday instruments of civic identity and nighttime economic vitality. Addis Ababa's recent corridor redevelopment projects sit within this broadened tradition: they extend the same underlying logic — that a well-composed public realm strengthens both civic pride and urban function — to the specific medium of nighttime illumination, which is the focus of this study.

1.1.3 Inner-City Corridor Development

Corridor-scale redevelopment concentrates new residential, commercial, and mobility investment along a city's principal axes, using the corridor as the spatial unit through which surrounding districts are regenerated and connected to the wider transport network. Urban design practice associates such corridor concentration with the aim of reducing resource and transport consumption while strengthening city centres as meeting places for commercial and social life, an approach illustrated in Nordic urban-renewal projects that align new development with public transit corridors and nodes (Barnett, 2003). Inner-city regeneration of this kind is typically pursued as a series of interrelated actions combining infrastructure, streetscape, and economic objectives rather than a single physical intervention.

In Addis Ababa, this pattern is visible in the corridor-based pedestrian- and cyclist-promotion projects that have extended outward from the inner city historically the

seat of the country's diplomatic and decision-making institutions into other districts of the capital since the early 2020s (African Cities Research Consortium, 2021). Decorative street lighting and facade illumination form part of this same corridor-development package, applied alongside pedestrian infrastructure and streetscape upgrades as one further layer of the inner city's redevelopment.

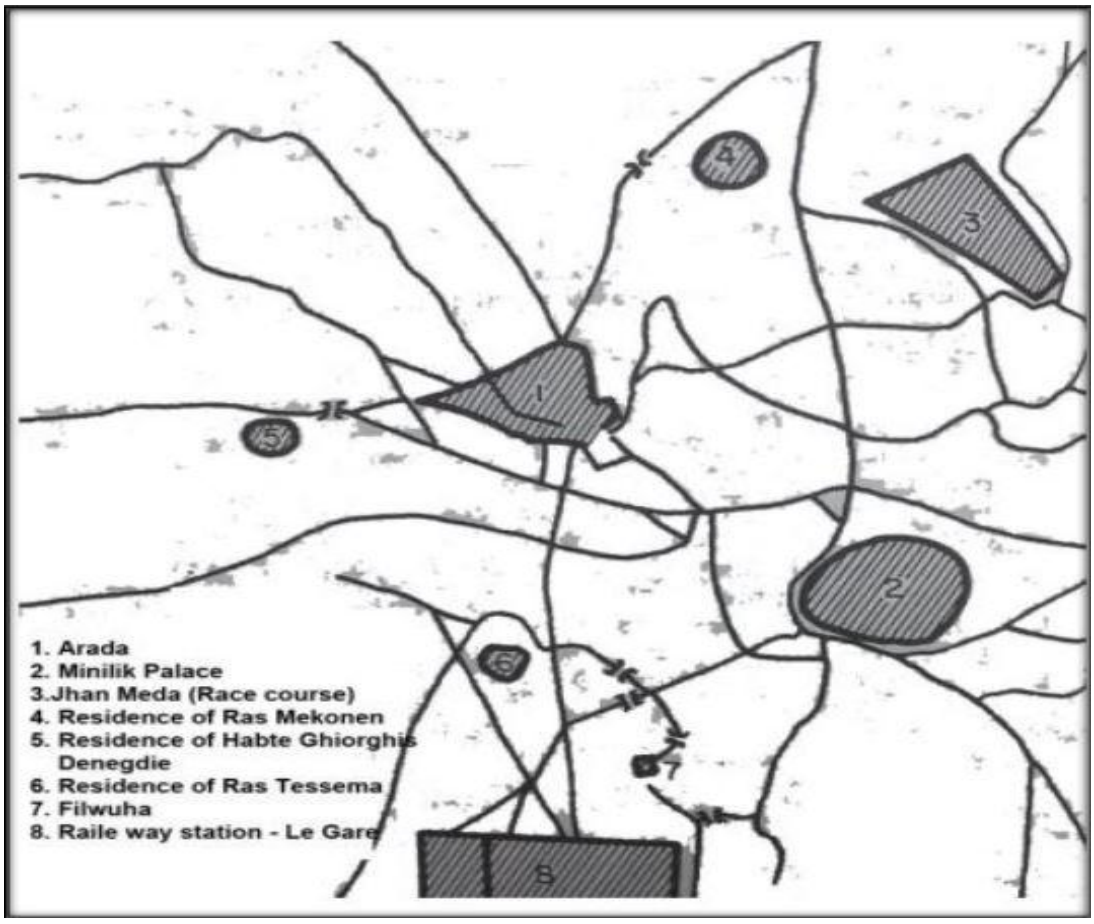


Figure 1. The early inner-city map of Addis Ababa, whose corridors remain the starting point for the redevelopment projects discussed throughout this study.

Source: Journal of Ethiopian Studies, 1974.

1.1.4 Emergence of Urban Illumination

Artificial illumination emerged as an essential component of urban infrastructure through a series of technological transitions that progressively extended the hours and areas available for economic, social, and civic activities. Pre-industrial cities depended mainly on torches, oil lamps, and candles, which provided localized and relatively low-intensity illumination. The introduction of municipal gas networks in

nineteenth-century Europe and North America marked an important shift toward organized public lighting infrastructure. This was followed by electric arc and incandescent lighting in the early twentieth century, high-intensity discharge technologies such as high-pressure sodium lamps during the mid-twentieth century, and, more recently, Light Emitting Diode (LED) systems (Schivelbusch, 1988; Nye, 1990; Energy Cities, 2023; van Bommel, 2015).

Addis Ababa's lighting history developed through a comparable progression. Emperor Menelik II introduced the city's first artificial lighting through a diesel-powered generator at the Imperial Palace in the 1890s. The commissioning of the Aba Samuel Hydroelectric Plant in 1932 subsequently supported the development of centralized electricity distribution, while the establishment of the Ethiopian Electric Light and Power Authority in 1955 contributed to the wider provision and standardization of electric lighting as the city expanded. The 2003 AACRA Street Lighting Manual further established technical guidance for street lighting that continues to inform practice. Since around 2010, rapid corridor redevelopment has increasingly incorporated high-wattage LED systems and decorative façade lighting alongside conventional street lighting. This development represents a transition from illumination primarily as basic urban infrastructure toward its growing use as a tool for urban beautification, identity, and nighttime visual enhancement, providing the broader historical context for evaluating contemporary urban illumination practices in Addis Ababa

1.2 Statement of the Problem

Urban illumination has rapidly expanded across the inner-city corridors of Addis Ababa through decorative street and façade lighting introduced as part of urban beautification and redevelopment. Although these interventions have strengthened the nighttime image and visual identity of the city, their increasing application raises concerns about how well lighting systems respond to the existing spatial structure, architectural character, street hierarchy, and energy requirements of the corridors.

In some locations, the intensity, repetition, and positioning of lighting fixtures create glare, visual imbalance, and uncomfortable contrasts, while poorly integrated façade lighting can obscure rather than reveal architectural form. During the daytime,

exposed fixtures, wiring, and other lighting components may also contribute to visual clutter within the streetscape. At the same time, the widespread use of high-intensity systems across corridors with different functions and spatial conditions raises concerns about unnecessary energy consumption and maintenance demand.

The underlying problem is therefore not the provision of illumination itself, but the limited integration of current illumination practices with the spatial, architectural, and energy characteristics of the urban environment. There remains insufficient integrated assessment of these relationships within Addis Ababa's inner-city corridors. This study addresses this gap by examining how street and façade lighting are positioned, distributed, and operated, and how these practices affect spatial quality, architectural expression, and energy performance.

1.3 General Objective

To investigate the extent to which urban public space illumination and city beautification practices in the inner-city corridors of Addis Ababa are consistent with established principles of urban development, urban design, public space quality, illumination, and energy sustainability, with particular emphasis on their spatial, functional, aesthetic, perceptual, and energy dimensions.

1.4 Specific Objectives

1. To identify the key spatial, functional, aesthetic, perceptual, management, and energy-related principles of urban development, beautification, public space, and illumination that provide a basis for evaluating urban illumination practices.
2. To examine how street and façade illumination practices in the inner-city corridors of Addis Ababa respond to the spatial structure, functional characteristics, architectural expression, public space quality, and energy requirements of the urban environment.
3. To assess the extent to which current illumination practices contribute to the perception, experience, visual quality, and nighttime identity of the inner-city corridors, while identifying issues related to glare, visual imbalance, architectural integration, and energy use.

4. To comparatively evaluate public-sector and privately managed illumination practices in selected inner-city corridors of Addis Ababa against the established analytical framework and relevant international practices.
5. To identify the major spatial, architectural, perceptual, management, and energy-related challenges in current illumination practice and propose context-responsive strategies for improving the quality, integration, and energy sustainability of urban illumination in Addis Ababa.

1.5 Research Questions

1. What spatial, functional, aesthetic, perceptual, management, and energy-related principles can be established from the literature as a basis for evaluating urban illumination and city beautification practices?
2. To what extent do existing street and façade illumination practices in the inner-city corridors of Addis Ababa respond to the spatial structure, functional characteristics, architectural expression, public space quality, and energy requirements of the urban environment?
3. To what extent does current illumination practice enhance the perception, experience, visual quality, and nighttime identity of the inner-city corridors, and what perceptual, architectural, and energy-related challenges emerge from its application?
4. How do public-sector and privately managed illumination practices differ in their spatial, architectural, perceptual, management, and energy performance when evaluated against a common analytical framework?
5. What strategies can strengthen urban illumination practice in Addis Ababa to achieve better spatial and architectural integration, visual quality, effective management, and energy sustainability while supporting the functional and social use of the city at night?

1.6 Scope of the Study

The study focuses on urban public space illumination and city beautification practices within selected inner-city corridors of Addis Ababa. It examines decorative street lighting and architectural façade lighting introduced through recent corridor redevelopment and beautification initiatives. The study specifically considers their spatial integration, functional performance, architectural expression, visual and

perceptual effects, management practices, and energy use. The assessment is limited to the selected study corridors and evaluates existing illumination practices against established principles of urban development, urban design, public space quality, illumination, and energy sustainability.

Thematic Scope: The study focuses on the relationship between urban illumination and urban development and city beautification. It examines spatial and functional qualities of public space, architectural expression, perception and nighttime experience, energy use and efficiency, lighting infrastructure, technical characteristics, and the historical development of urban illumination. These themes provide the basis for evaluating contemporary illumination practices, without extending to detailed electrical system design or luminaire manufacturing specifications.

Spatial Scope: The study is geographically confined to selected inner-city corridors of Addis Ababa where substantial redevelopment, beautification, and illumination interventions have been implemented. The study areas include the Bole Airport–Meskel Square axis, Filwuha–National Palace corridor, and selected central corridors of Piassa, Churchill Avenue, and Mexico. These corridors provide representative urban settings for assessing the relationship between illumination, spatial structure, architectural character, public space, and nighttime experience.

Temporal Scope: The study primarily examines urban illumination practices implemented between 2022 and 2026, corresponding to the period of major recent corridor redevelopment and beautification interventions. This period provides the principal basis for evaluating contemporary street and façade lighting practices and their spatial, architectural, and energy-related implications

1.7 Significance of the Study

The study contributes to a clearer understanding of how urban illumination and city beautification practices in Addis Ababa can be strengthened through better integration of spatial, architectural, perceptual, management, and energy considerations. By identifying gaps between existing illumination practices and established principles of urban design and public space quality, the study provides an evidence-based basis for improving the planning, design, and management of illuminated urban corridors.

For urban designers and architects, the study provides practical considerations for evaluating the spatial and architectural integration of street and façade lighting before and during implementation. For planners and city administrators, it identifies key areas requiring improvement in illumination planning, design review, management, and energy use. For the ongoing city beautification programme, the study provides strategies to reinforce illumination's positive contribution to nighttime identity and visual quality while improving spatial coherence, architectural expression, and energy sustainability. More broadly, the study contributes to the development of context-responsive urban illumination practices suited to the physical and functional characteristics of Addis Ababa's inner-city environment.

1.8 Limitations of the Study

The study encountered several limitations during data collection and field investigation. Nighttime observation and photographic documentation required extended evening fieldwork, presenting challenges related to accessibility, mobility, and personal safety. In some corridor segments, security conditions restricted documentation of lighting installations and building façades, limiting the completeness of visual records.

A further limitation concerned the availability and coordination of institutional data on lighting specifications, operating conditions, and energy consumption. Incomplete or inconsistent access to such information constrained the precision of the energy-performance assessment, while time and fieldwork constraints limited the number of corridors examined in comparable depth. Consequently, the selected corridors represent purposive cases of contemporary illumination practice rather than an exhaustive assessment of all illuminated inner-city corridors of Addis Ababa. These limitations were considered in interpreting the findings and determining their appropriate level of generalization.

1.9 Thesis Organization

Chapter One: Introduction establishes the context and rationale of the study by presenting the background of urban development, city beautification, inner-city corridor development, and the emergence of urban illumination in Addis Ababa. It further defines the statement of the problem, general and specific objectives, research questions, scope, significance, and limitations of the study.

Chapter Two: Literature Review and Theoretical Framework reviews relevant literature on urban development, city beautification, public space quality, urban illumination, spatial and architectural considerations, perception and nighttime experience, energy use, lighting infrastructure, technical practices, and the historical development of illumination. The review establishes the conceptual and analytical framework used to assess existing illumination practices.

Chapter Three: Research Methodology presents the research approach, study area and case-selection criteria, data sources, data collection methods, and analytical procedures employed to examine urban illumination practices within the selected corridors.

Chapter Four: Results and Analysis presents and analyzes the empirical findings on street and façade illumination practices in the selected corridors. The analysis examines their spatial, functional, architectural, perceptual, management, and energy-related characteristics using the established analytical framework.

Chapter Five: Discussion interprets the findings in relation to the relevant theoretical perspectives, literature, and research objectives, highlighting the major patterns, relationships, gaps, and implications identified through the analysis.

Chapter Six: Conclusions and Recommendations synthesizes the principal findings, draws conclusions in relation to the research objectives, and proposes context-responsive strategies for improving the spatial integration, architectural quality, management, and energy sustainability of urban illumination and city beautification practices in Addis Ababa.

Chapter Two

2. Literature Review

2.1 Introduction

This chapter builds the literature-based framework against which urban public space illumination and city beautification practice in Addis Ababa's inner-city corridors is evaluated in later chapters. Rather than reviewing lighting technique in isolation, it follows the logic of the formal urban development process itself: it establishes what that process is and the elements of the urban public realm and public-space quality it acts on from the section on Formal Urban Development and City Beautification as Production-Plus-Correction through to the section on Public-Space Quality as the Outcome Against Which Illumination is Judged positions urban illumination within that process as a medium of perception delivered through physical infrastructure and a specific technological history from the section on Urban Illumination as a Medium of Perception rather than an end in itself through to the section on historical development of urban lighting from Scarce localized illumination to Abundant Controllable Light reviews four domains in which that medium is practically applied street and corridor lighting, landscape and water-feature lighting, building and façade lighting, and lighting's role in marketing, branding, and city image which are covered in the sections from Street and Corridor Lighting Governed by Dimensional and Spatial Proportions through to Marketing, Branding, and City Image as Communication Through Illumination and evaluates the sustainability performance and international precedent against which local practice can be measured, as set out in the sections on Sustainable Urban Illumination Organized Around Five Recurring Design Principles and International Examples Showing the Range of Outcomes Associated with Managing the Night.

2.2 Urban Development and City Beautification

City beautification is treated here as an instance of the formal urban development process: development that is professionally designed and produced, and whose failures are managed, corrected, or regulated by a relevant public authority through mechanisms such as urban planning, urban design guidance, building regulation, manuals, and standards. Carmona and Tiesdell (2007) describe this as comprising a development process through which places are actually produced and a parallel control process, through which design quality is safeguarded via development management and design review. Read together, these two processes frame city beautification as production plus correction, rather than as a single design act.

The beautification strand of this process traces to the City Beautiful movement, which gained ground following the 1893 World's Columbian Exposition in Chicago, where Daniel Burnham's 'White City' combined Beaux-Arts civic buildings with parks and grand boulevards to demonstrate that a city could be simultaneously ordered, functional, and aesthetically elevated (Wilson, 1989; Britannica, 2024). Its central instruments civic centers, parks, and grand boulevards were intended to enhance both visual appearance and the practical flow of pedestrian and vehicle traffic (Britannica, 2024). Contemporary beautification has broadened this tradition to include streetscape enhancement, facade treatment, and as reviewed in the section on **Urban Illumination** as a Medium of Perception Rather Than an End in Itself and following sections decorative and architectural illumination, applied through the same production-plus-correction logic and, in Addis Ababa, through the corridor redevelopment projects described in Chapter One.

The control-process half of this definition matters as much as the design-process half. Carmona and Tiesdell's (2007) account of development management and design review treats correction not as a bureaucratic afterthought but as the mechanism by which the gap between a design intention and its built outcome is caught and remedied the same distinction the examiner's comments apply directly to illumination practice in Addis Ababa, where a design that performs poorly and a design-review system that fails to catch that underperformance are, in this framework, two separable findings rather than one. Barnett's (2003) related observation that the goals of urban development are structural and functional soundness together with

giving pleasure to those who see it gives a second, complementary standard: a beautification intervention succeeds only when all three goals are met together, not when visual appeal is achieved at the expense of structural or functional performance.

2.3 The Physical, Social, and Functional Elements of the Urban Public Realm

The literature identifies the physical elements of the urban public realm acted upon by beautification and illumination as the street and plot pattern, building form, and public space network — Carmona and Tiesdell's (2007) morphological dimension — together with the aesthetic and perceptual quality of that substrate, including planting, water features, and streetscape furnishings, captured in their visual dimension. Beyond these physical elements, the urban public realm is also social, economic, and environmental: it must support safety and community life (the social dimension), accommodate everyday activity and economic exchange (the functional dimension), and remain within ecological limits, including the effects of artificial light at night on vegetation and wildlife (Gaston et al., 2015).

Within the streetscape specifically, this physical substrate is further defined by street hierarchy and volumetric enclosure the ratio between street width and the height of flanking buildings, which governs how much a given scale of infrastructure can be absorbed without visual conflict and by the functional zoning and technical clearances that separate pedestrian, vehicular, and utility space. These proportions recur directly in the section on Street and Corridor Lighting Governed by Dimensional and Spatial Proportions, where mismatches between fixture scale and corridor width are identified as a primary literature-based risk.

Carmona and Tiesdell (2007) organize these physical, social, and functional elements into six interacting dimensions of urban design: morphological (the layout of blocks, plots, and buildings), perceptual (how the resulting environment is experienced and given meaning), social (the public life and interaction the space supports), visual (its aesthetic and compositional quality), functional (how it accommodates movement and activity), and temporal (how its use and appearance change across the day and

seasons). Urban illumination intersects every one of these dimensions simultaneously it alters morphological legibility by revealing or obscuring building form, reshapes the perceptual dimension by defining a corridor's night identity, and is itself the primary mechanism of the temporal dimension after dark which is why the literature review in this chapter treats illumination as inseparable from, rather than additional to, the elements of the urban public realm defined here.

2.4 Public-Space Quality as the Basis for Evaluating Urban Illumination

Public-space quality provides a broader basis for evaluating the effectiveness of urban illumination. Successful public spaces should respond to multiple dimensions of urban life, including social use, economic activity, environmental performance, and the quality of the physical environment (Carmona & Tiesdell, 2007). From this perspective, illumination should not be evaluated solely according to illuminance levels or visual intensity, but according to how effectively it contributes to the overall performance and experience of public space. A well-lit corridor is therefore not necessarily a high-quality corridor if the lighting produces glare, visual discomfort, excessive energy consumption, or visual conflict with the surrounding built environment.

Social dimension: Concerns the extent to which illumination supports safe, comfortable, accessible, and meaningful use of public space after dark. Appropriate lighting can improve visibility, assist pedestrian orientation, reinforce perceptions of safety, and encourage continued use of streets and public spaces during nighttime hours. These functions can be related to Lynch's (1960) concept of legibility**,** through which environmental elements help people understand, navigate, and orient themselves within the urban environment. Applied to nighttime conditions, illumination can strengthen the visibility of paths, edges, landmarks, entrances, and other spatial elements. However, increasing the amount of light does not automatically improve these qualities. Excessive brightness, glare, strong contrasts, or poorly positioned luminaires may instead reduce visual comfort and negatively affect the pedestrian experience.

Economic dimension: Concerns the capacity of illumination to support appropriate nighttime urban activity. In commercial and central-city corridors, lighting can contribute to the visibility and attractiveness of shops, restaurants, hospitality facilities, cultural destinations, and other evening activities. It can also contribute to the communication of place identity and city image by emphasizing architectural features and establishing a recognizable nighttime character. Carmona and Tiesdell (2007) emphasize the importance of considering the broader social and economic functions of urban spaces rather than treating physical interventions as isolated design objects. Accordingly, the effectiveness of illumination should be considered in relation to whether it supports the intended use and activity of the corridor after dark, rather than being judged only by its decorative or visual appeal.

Environmental dimension: Establishes an important constraint on these social, spatial, and economic objectives. Public-space quality cannot be considered independently of the resources required to produce and maintain the nighttime lighting environment. Excessive energy consumption, unnecessarily long operating periods, inefficient luminaires, and uncontrolled light distribution can impose environmental and economic costs that may outweigh the benefits of the lighting intervention. Sustainable public-space design therefore requires an appropriate balance between environmental performance and the social and economic functions of the space (Carmona & Tiesdell, 2007).

In this context, energy efficiency should not be considered merely as a technical property of individual luminaires, but as an integral component of the overall quality, performance, and long-term sustainability of the nighttime public realm. The environmental performance of illumination is consequently influenced not only by the efficiency of lighting equipment, but also by the quantity of lighting provided, its spatial distribution, operating duration, control mechanisms, and relationship to actual nighttime use.

A further dimension of public-space quality concerns the visual and spatial relationship between illumination infrastructure and the surrounding built environment. Urban spaces are experienced through the relationship between their physical elements, and the scale, form, and arrangement of these elements contribute to the character and legibility of a place (Lynch, 1960). Street-lighting poles, brackets,

luminaires, cables, and associated equipment therefore become part of the physical streetscape rather than functioning solely as technical infrastructure. Their height, scale, profile, location, and material expression should be considered in relation to street width, building height, façade composition, setbacks, pedestrian movement, landscape elements, and architectural character. When lighting infrastructure is appropriately integrated with these elements, it can reinforce spatial coherence, support visual orientation, and contribute to the identity and character of the corridor. Conversely, oversized fixtures, inappropriate pole proportions, exposed services, poorly coordinated installations, and inadequate spatial clearances can introduce visual clutter and weaken the relationship between the lighting system and the surrounding urban form.

Architectural dimension of illumination: It is similarly important because nighttime lighting influences how buildings and streets are perceived after dark. Lighting can emphasize architectural form, rhythm, materiality, entrances, structural elements, and significant features when its intensity, direction, colour, and position are carefully coordinated with the building envelope. However, when lighting is added independently of architectural design, fixtures, cables, mounting systems, and repetitive lighting patterns may compete with or obscure the architectural character of the building. This is particularly relevant where façade lighting is installed after construction without sufficient consideration of the original architectural composition. In such circumstances, the lighting system may become a visually dominant layer rather than a means of revealing the building's architectural qualities. Architectural lighting should therefore be understood as part of the broader visual composition of the built environment rather than as an isolated decorative treatment.

The chromatic relationship between illumination and the architectural environment is also relevant to visual quality. The colour characteristics of a light source can influence the appearance of building materials, façade colours, vegetation, and other elements of the nighttime environment. Consequently, the selection of warm or cool illumination should be considered in relation to the colours, materials, and intended character of the surrounding buildings. Similarly, the supporting pole, bracket, and luminaire contribute to the visual composition of the streetscape and may either complement or compete with the architectural background. Such relationships are

consistent with the broader principle that the visual identity and legibility of urban environments depend on how individual physical elements relate to the whole spatial composition (Lynch, 1960). The quality of illumination therefore depends not only on the amount of light provided but also on how light interacts with the physical and visual characteristics of the place**.**

The relationship between illumination and social use of public space provides another important consideration. Appropriate nighttime lighting can support pedestrian movement, increase the perceived usability of public spaces, reinforce orientation, and contribute to feelings of safety and security. It may also support commercial activity and nighttime vitality where illumination is coordinated with the functional and temporal characteristics of the surrounding urban environment. However, excessive or poorly directed lighting may produce glare, visual discomfort, light trespass, excessive contrast, or visual competition, potentially reducing rather than improving the quality of the nighttime environment. The objective should therefore not be to maximize brightness but to provide illumination that is appropriate to the activities, users, spatial conditions, and visual requirements of the place**.**

Accordingly, public-space quality can be understood as a multidimensional outcome through which urban illumination is evaluated**.** Effective illumination should support social use and safety, contribute to appropriate nighttime economic activity, reinforce architectural and spatial identity, maintain visual and spatial coherence, and operate within reasonable environmental and energy limits. These dimensions are interconnected: a lighting system that improves visibility but produces excessive glare may reduce visual comfort; a system that enhances nighttime appearance but consumes disproportionate energy may undermine environmental sustainability; and a technically effective installation that is poorly integrated with the building or streetscape may compromise architectural and spatial quality.

This approach therefore moves the evaluation of urban lighting beyond a narrow concern with illumination quantity toward an assessment of its relationship with the physical, social, economic, architectural, and environmental qualities of the urban corridor**.** For this study, these dimensions provide the conceptual basis for examining whether existing illumination practices in the inner-city corridor of Addis Ababa enhance or compromise the quality and sustainability of the nighttime public realm.

2.5 Urban Illumination as a Medium of Perception Rather Than an End in Itself

Urban illumination can be understood not merely as a technical provision for achieving adequate visibility, but as a medium through which the urban environment is perceived, experienced, and used after dark. In this sense, illumination involves the deliberate composition and distribution of artificial light across streets, building façades, public spaces, and other elements of the urban landscape. The quality, intensity, distribution, and colour characteristics of light influence the sensory relationship between people and their physical surroundings, thereby affecting how urban spaces are visually interpreted and experienced at night (Boyce, 2014; Narboni, 2016).

The relationship between illumination and perception can be further understood through Lynch's (1960) concept of urban legibility. Lynch argues that the ability of people to recognize and organize paths, edges, districts, nodes, and landmarks into a coherent mental image is fundamental to orientation and the experience of the city. At night, when natural light is absent or substantially reduced, illumination becomes an important means through which these spatial elements remain perceptible. Lighting can therefore reinforce the visual structure of an urban corridor by clarifying movement routes, identifying boundaries, emphasizing important nodes, and revealing landmarks. In this respect, illumination functions as a medium of spatial perception**,** allowing the physical structure of the city to remain understandable after dark (Lynch, 1960).

However, illumination can also undermine the very legibility it is intended to support when light becomes visually dominant rather than serving the spatial structure of the environment. Excessive brightness, glare, strong contrasts, poorly distributed light, or highly prominent decorative fixtures can attract attention away from paths, building edges, landmarks, and other elements that contribute to spatial understanding. Research on nighttime environments indicates that lighting conditions influence pedestrian perceptions and behaviour, including feelings of safety and the way people

move through urban space (Haans & de Kort, 2012). Thus, the effectiveness of urban illumination depends not simply on the amount of light provided, but on whether the light enables people to perceive and interpret the surrounding environment comfortably and effectively.

This distinction is particularly important in urban corridors where street lighting, façade lighting, landscape illumination, and decorative installations operate simultaneously. When these systems are appropriately coordinated, illumination can strengthen the visual identity of a place and contribute to its nighttime character. When they are applied independently or without sufficient consideration of the surrounding urban structure, however, individual lighting elements may compete with one another and obscure the hierarchy of the public realm. Illumination should therefore reveal and reinforce the existing spatial and architectural structure rather than become the primary visual object of the streetscape. This understanding is consistent with the broader relationship between imageability, spatial organization, and the ability of users to form a coherent mental image of the urban environment (Lynch, 1960).

From a comprehensive urban-design perspective, urban illumination is consequently more than a technical utility imposed upon the built environment. It is a spatial, aesthetic, perceptual, and environmental practice that interacts with architectural form, human scale, movement patterns, and the physical organization of public space. The effectiveness of illumination therefore depends on how lighting characteristics are coordinated with the geometry and character of streets, buildings, public spaces, and pedestrian environments. Principles of urban design that emphasize visual experience, human scale, movement, and the relationship between built-form elements provide a basis for understanding illumination as part of the wider urban environment rather than as an isolated engineering system (Cullen, 1961; Gehl, 2010; Narboni, 2016).

Accordingly, this study treats urban illumination as a means of enhancing the perception, use, and identity of public space rather than as an end in itself. The quality of illumination is therefore judged by its relationship with the urban environment it serves: whether it improves spatial legibility, supports pedestrian movement and safety, contributes to architectural and visual character, and operates within

appropriate energy and environmental limits. This conceptual position provides a basis for comparing established principles of urban illumination with actual practices in the study area and subsequently assessing the spatial, aesthetic, and energy

2.5 Dimensional and Spatial Proportions in the Streetscape

The dimensional and spatial proportions of a streetscape establish a three-dimensional geometric room where vertical lighting infrastructure must remain balanced with surrounding architectural boundaries to preserve a human scale. This spatial dynamic dictates that pole heights, setback distances, and luminaire spacing cannot be arbitrary; they must scale proportionally with building heights and road widths to maintain a comfortable sense of volumetric enclosure. Proper alignment prevents physical clutter within pedestrian zones, avoids the visual crowding of lower architectural registers, and ensures that illumination levels drop symmetrically with the formal classification of the corridor (Illuminating Engineering Society, 2020; Moughtin, 2003; Moughtin et al., 2003).

2.5.1 Street Hierarchy and Volumetric Enclosure

The geometric relationship between street infrastructure and the surrounding built fabric governs the spatial quality of the urban environment. The streetscape is a three-dimensional room bounded by building facades, where the ratio of building height to street width determines the pedestrian sense of enclosure, comfort, and safety (Moughtin, 2003).

Maintaining spatial balance in this volume, lighting poles must serve as subordinate elements in the architectural composition. Standard urban design principles dictate that street pole heights should ideally not exceed one-third of the height of adjacent building facades (Moughtin et al., 2003).This proportional restraint integrates the infrastructure into the human-scale pedestrian zone, preventing poles from dominating the vertical streetscape (Gehl, 2005).

In the end, the physical soundness and visual amenity of the urban streetscape depend completely on the ability to control vertical proportions between public vertical elements and private building boundaries. Planning heights and setback requirements without regard to the surrounding built fabric, causes the hierarchy of structure to fall apart and essential public safety equipment becomes a very intrusive disruption. In

order to preserve the three dimensional volumetric room and a human scale pedestrian experience, a coordinated and context adapted framework needs to be imposed on street lighting systems that imposes respect and smooth integration with the physical profiles of adjacent building envelopes.

2.5.2 Functional Zoning and Technical Clearances

To ensure physical harmony and operational safety, streetscapes are organized into distinct functional zones that govern the clearances between building boundaries, vertical infrastructure, and curbs:

Street Classification	Street Width (m)	Standard Pole Height (m)	Approximate Proportions
PAS	30 – 60	9 – 15	1:4 to 1:6
SAS	15 – 30	6 – 10	1:2.5 to 1:3
Local Street	6.7 – 12.8	3.0 – 4.5	1:2 to 1:4

Table 1 illustrates a significant street pole standard with street width, height and proportion

Source. The IES (International Engineering Society)

Strategic Clearance Zones:

The Frontage/Pedestrian Zone: A continuous, unobstructed clear path of 1.5 to 2.0 meters must be maintained directly adjacent to the building boundary to support accessible pedestrian movement (Moughtin, 2003).

The Furnishing/Service Zone: Streetlight poles, utility infrastructure, and street trees are restricted to a dedicated service strip, establishing a strict setback of 0.5 to 1.0 meter from both the building face and the curb line. This prevents visual crowding of the lower architecture and ensures structural maintenance clearances (Moughtin, 2003).

To summarize, the spatial integration of street utilities in these clearance zones is essential to avoiding two possible situations: the structural overlap of public right-of-way and private architectural envelopes. Use of these standardized dimensional matrices ensures that vertical systems continue to be seen as an enabling, non-invasive part of the street rather than an invasive structure. It is critical to maintaining engineering clearances between the curb and the frontage zone, ensuring the

operational maintenance corridors, and the visual hierarchy of the urban corridor remains intact, while maintaining pedestrian access.

2.5.3 Technical Pole Wattage and Illuminance Standards

According to roadway design criteria established by the Illuminating Engineering Society (2020) and empirical street infrastructure models (Hariyanto, 2023), luminaire wattage and mounting heights must scale symmetrically with the street classification to prevent glare and energy inflation:

Street Category	Mounting Height (m)	Target Illuminance (Lux)	Recommended LED Wattage
PAS	10-14	20-30 Lux	150W – 250W
SAS	6-10	10-20 Lux	50W – 100W
Local Street	4- 6	5 – 10 Lux	20W – 50W
Pedestrian/Plaza	3-5	5-10 Lux	15W – 40W
Landscape/park corridor	3-4	3-8 Lux	10W – 30W

Table 2. Illustrate the standard of street pole height and recommended LED wattage

Source. International Engendering Society (IES)

2.6 Illumination Infrastructure and Technology as Part of the Streetscape Composition

Illumination infrastructure, including poles, brackets, conduits, wiring, luminaires, and associated control components, forms part of the physical composition of the streetscape in which it is installed. Although these elements are primarily introduced to provide illumination, their scale, location, material, and visual appearance influence the character and perception of streets and building façades. From an urban-design perspective, illumination infrastructure should therefore be considered alongside other physical elements of the public realm rather than treated exclusively as a technical system. Poorly integrated infrastructure, such as exposed wiring, oversized luminaires, or visually dominant poles, can contribute to streetscape clutter and weaken the relationship between lighting installations and the surrounding architectural environment (Carmona & Tiesdell, 2007; Lynch, 1960).

The technological characteristics of illumination infrastructure also have direct implications for energy performance and visual quality. Lighting systems transform electrical energy into visible light and heat, while their performance is influenced by factors including luminous efficacy, optical distribution, operating duration, and the reflectance characteristics of surrounding surfaces. Consequently, the amount of electrical energy required to achieve an appropriate visual result depends not only on luminaire power but also on how effectively light is distributed and how the illuminated environment responds to that light. The Illuminating Engineering Society (2020) emphasizes the importance of considering lighting performance in relation to the characteristics and requirements of the space being illuminated. This reinforces the principle that appropriate illumination should be achieved through efficient and controlled distribution of light rather than through increased electrical input alone.

LED technology has become an important platform for contemporary outdoor illumination because of its high luminous efficacy, long potential service life, compact form, and ability to provide controlled optical distributions. These characteristics have also enabled the integration of lighting systems with digital controls and smart-city technologies, including adaptive dimming and other forms of responsive operation (Gaston et al., 2015; Illuminating Engineering Society, 2020). Such technological developments create opportunities to improve both energy efficiency and nighttime environmental performance. However, the adoption of LED technology does not by itself guarantee an efficient or contextually appropriate lighting environment. High-efficiency luminaires can still produce excessive energy consumption when installed at unnecessarily high wattages, operated for extended periods, or applied at densities that exceed the actual requirements of the street or public space.

The outdoor operating environment further influences the long-term performance of LED-based illumination infrastructure. Luminaires and their supporting components are exposed to temperature variation, moisture, ultraviolet radiation, dust, and other environmental conditions that can affect their optical, electrical, and mechanical performance over time. Consequently, infrastructure selection should consider not only initial lighting performance but also the environmental conditions under which the system will operate and the maintenance requirements necessary to sustain its

intended performance. The long-term reliability of an illumination scheme therefore depends on the relationship between technological specification, environmental exposure, installation quality, and maintenance practice (Bizjak & Knez, 2021).

The increasing availability and affordability of LED technology have also expanded the possibilities for decorative and architectural illumination in urban environments. Compact luminaires, improved optical control, and flexible installation options allow lighting to be incorporated into façades, streetscape elements, landscape features, and public spaces with greater design flexibility than many conventional systems. However, this flexibility can also encourage the proliferation of lighting installations without sufficient consideration of spatial context. As Narboni (2016) argues, landscape and urban lighting should be understood as part of the composition and identity of the nighttime environment rather than as the indiscriminate application of light. The availability of efficient technology should therefore be accompanied by appropriate design criteria governing where, how much, and for what purpose illumination is provided.

The specification of illumination infrastructure should also respond to the classification, dimensions, and function of the street or corridor. Different streets serve different movement patterns, pedestrian conditions, spatial dimensions, and nighttime activities; consequently, a single luminaire wattage, mounting height, spacing, or distribution pattern cannot be assumed to be appropriate for every urban context. Lighting design criteria should instead respond to the characteristics of the space being illuminated, including roadway and pedestrian requirements, mounting geometry, spacing, and the desired distribution of light. The Illuminating Engineering Society (2020) provides guidance for relating lighting system characteristics to roadway and outdoor-space requirements, while empirical studies of lighting infrastructure further demonstrate the importance of coordinating mounting conditions and luminaire characteristics with the spatial configuration of streets (Hariyanto, 2023). This relationship is particularly important where decorative lighting is introduced into corridors with different widths, building heights, and pedestrian functions.

The material and durability of poles, brackets, and other supporting infrastructure are also significant components of long-term lighting performance. Supporting elements

exposed to outdoor conditions may experience corrosion, material degradation, mechanical fatigue, and deterioration of connections. Such failures can affect not only the structural reliability of the system but also its visual appearance and maintenance requirements. Infrastructure durability should therefore be considered together with luminaire specification rather than as a separate issue. A lighting installation that performs well at the time of installation may nevertheless experience declining visual and functional performance if its supporting infrastructure is poorly matched to the environmental conditions of the site (Bizjak & Knez, 2021).

Overall, illumination infrastructure and technology should be understood as integrated components of the urban streetscape rather than independent technical equipment. Their effectiveness depends on the coordination of technological performance, spatial dimensions, architectural context, energy requirements, environmental exposure, and long-term maintenance. This perspective establishes an important distinction between the technological capacity to provide illumination and the urban-design responsibility to determine how that capacity should be applied. Accordingly, the evaluation of illumination infrastructure in this study considers not only its lighting and energy performance, but also its scale, placement, material expression, durability, and relationship with the surrounding public realm.

Analytical Implications for the Study of Lighing

- **Streetscape Integration:** Lighting poles, luminaires, wiring, and related infrastructure should be treated as elements of the streetscape whose scale, placement, and appearance affect spatial and architectural quality.
- **Spatial Responsiveness:** Lighting infrastructure should respond to street width, building height, setback, pedestrian space, and corridor hierarchy.
- **Energy and Technology:** Lighting efficiency depends on wattage, luminous efficacy, distribution, spacing, operating duration, and appropriate use of LED and control technologies.
- **Context-Responsive Design:** Mounting height, wattage, spacing, and light distribution should correspond to the function, dimensions, and nighttime activity of each corridor.

- **Durability and Maintenance:** Lighting infrastructure should be selected according to environmental exposure, material durability, maintenance requirements, and long-term performance.
- **Integrated Evaluation:** Urban illumination should be evaluated through the combined consideration of **spatial, architectural, perceptual, technological, energy, environmental, and management factors**, rather than lighting output alone.

2.7 Historical Development of Urban Lighting: From Scarce Localized Illumination to Abundant and Controllable Light

The historical development of urban lighting reflects a broader transformation in the relationship between people, darkness, technology, and the nighttime city. Rather than representing a purely technical progression, the history of urban illumination demonstrates how advances in energy production, lighting technology, and urban infrastructure progressively extended the duration, intensity, spatial coverage, and controllability of artificial light. This transition moved cities from environments characterized by scarce and localized sources of illumination toward contemporary urban environments in which light can be produced and distributed at large scales with considerable precision (Energy Cities, 2023; Peretz Architecture, 2017).

Before the development of modern public lighting systems, urban illumination was largely dependent on torches, candles, oil lamps, and other small-scale sources. These technologies provided limited illumination and were generally restricted in their spatial coverage and operating duration. Darkness consequently remained a significant characteristic of the nighttime city, while movement and social activity after dark were constrained by the availability of artificial light (Schivelbusch, 1988). The introduction of municipal gas lighting during the nineteenth century represented a major transformation because it enabled cities to establish more systematic networks for illuminating streets and public places. Gas lighting extended commercial and social activity into the evening and contributed to the emergence of lighting as an organized municipal service rather than an individually provided source of illumination (Nye, 1990; Schivelbusch, 1988).

The subsequent development of electric arc and incandescent lighting further transformed the nighttime urban environment by providing greater illumination and extending the practical use of streets beyond daylight hours. Electric lighting progressively altered perceptions of the nighttime city and enabled streets, commercial areas, public buildings, and other urban spaces to operate within an increasingly continuous cycle of activity. Later, high-intensity discharge technologies, particularly high-pressure sodium lighting, became widely adopted for street illumination from the latter part of the twentieth century. Their characteristic amber appearance subsequently became strongly associated with the visual identity of many urban streets and transportation corridors (Energy Cities, 2023; van Bommel, 2015).

The contemporary transition toward light-emitting diode (LED) technology represents another significant stage in this development. LEDs provide high luminous efficacy, long potential service life, compact physical dimensions, and greater opportunities for optical control than many earlier lighting technologies. Their digital controllability has also facilitated the integration of outdoor lighting with intelligent control systems, including dimming, scheduling, monitoring, and adaptive operation (Gaston et al., 2015; Illuminating Engineering Society, 2020). The significance of this transition extends beyond technological efficiency. The increased affordability, flexibility, and controllability of LED systems have made it possible to illuminate a much wider range of urban surfaces and elements, including streets, façades, landscapes, public spaces, and architectural features. Consequently, contemporary cities possess considerably greater capacity to shape the nighttime visual environment than earlier generations of urban lighting technology.

The development of urban lighting in Addis Ababa can similarly be understood as a gradual transition from localized artificial illumination toward increasingly centralized, networked, and technologically advanced systems. Early artificial lighting in the city was associated with the Imperial Palace and other limited areas of the emerging urban centre. The subsequent development of electricity generation and distribution expanded the availability of artificial lighting beyond these localized settings and established the foundations for a more extensive municipal electricity infrastructure. The development of organized electricity services and subsequent urban planning and infrastructure initiatives progressively integrated lighting into the

expanding urban environment (Addis Ababa City Administration, 2025; African Cities Research Consortium, 2021).

The institutional development of electricity and urban infrastructure also contributed to the formalization of lighting provision within Addis Ababa. As the city expanded, lighting increasingly became associated with public infrastructure, roadway development, urban beautification, and the modernization of major corridors. The establishment and development of formal electricity institutions provided a basis for extending electrical services, while subsequent planning and infrastructure initiatives increasingly introduced technical considerations into the provision of street lighting. More recent corridor redevelopment has expanded this role further through the introduction of decorative lighting, LED systems, façade illumination, and other visually oriented interventions (Addis Ababa City Administration, 2025; African Cities Research Consortium, 2021).

This historical trajectory is significant for the present study because the contemporary illumination environment of Addis Ababa is not simply the result of technological substitution. It represents the convergence of technological advancement, expanding electricity infrastructure, urban growth, public-space modernization, and city beautification objectives. As lighting has become more affordable, powerful, controllable, and visually flexible, the question has shifted from whether urban space can be illuminated to how much of the city should be illuminated, where illumination should be concentrated, and how it should relate to the existing urban structure**.** The contemporary beautification and corridor-illumination practices examined in this study therefore represent a later stage in the historical development of urban lighting, in which the availability of abundant artificial light creates both new opportunities for nighttime urban experience and new challenges concerning spatial integration, visual quality, energy consumption, and environmental responsibility.

Key Historical Development

- Urban lighting evolved from scarce and localized sources such as torches, candles, and oil lamps to organized gas and electric lighting networks**.**
- Technological development progressively increased the intensity, coverage, efficiency, and controllability of artificial illumination.

- High-pressure sodium lighting enabled widespread roadway illumination, while LED technology introduced greater efficiency, flexibility, and digital control.
- In Addis Ababa, illumination similarly developed from localized early electric lighting to centralized infrastructure and, more recently, decorative street and façade lighting associated with corridor redevelopment and city beautification.
- Contemporary urban illumination has therefore shifted the main challenge from simply providing light to determining where, how much, how, and for what purpose urban spaces should be illuminated**.**

2.8 Urban-Design Dimensions of Street and Corridor Lighting

Street and corridor lighting is an integral component of the urban environment, influencing the spatial organization, visual and architectural character, energy performance, and environmental quality of urban corridors. Its effectiveness therefore depends on how lighting infrastructure and illumination levels respond to the physical and functional characteristics of the surrounding environment. Accordingly, this section examines four interrelated urban-design dimensions: **spatial context, aesthetic relationship with the built environment, energy efficiency, and environmental and visual effects**.

2.8.1 Spatial Context of Illumination in the Urban Corridor

Street and corridor lighting should be understood in relation to the **dimensional, spatial, and functional characteristics of the urban corridor**. Its effectiveness depends not only on luminaire performance but also on its relationship with street width, building height, setbacks, pedestrian zones, and road hierarchy. From an urban-design perspective, lighting infrastructure should therefore be proportionate to the spatial enclosure and function of the corridor. A luminaire or pole that is appropriately scaled for a wide arterial road may become visually dominant in a narrower corridor with closely positioned buildings. Similarly, inappropriate mounting positions or excessive light output can increase glare and light trespass toward adjacent façades and windows (Illuminating Engineering Society, 2020; Moughtin, 2003).

Street hierarchy provides an important basis for establishing appropriate lighting conditions because different road categories have different movement functions,

spatial dimensions, pedestrian requirements, and levels of nighttime activity. Lighting characteristics should therefore respond to these differences. The Illuminating Engineering Society (2020) relates lighting requirements to roadway classification, including mounting height, luminaire distribution, spacing, and illuminance. This establishes a relationship between street width, pole height, luminaire output, and required illuminance**,** rather than treating illumination as a uniform solution across different urban contexts.

The relationship between pole height and street width is particularly important because lighting infrastructure contributes to the perceived proportion of the street. Excessively tall poles can increase the visual dominance of infrastructure, while poorly positioned or underscaled poles may result in inadequate distribution, excessive contrast, or localized glare. Lighting design should therefore consider mounting height and spacing in relation to the dimensions and functional requirements of the illuminated area (Hariyanto, 2023).

Spatial coordination also extends to the ground plane and pedestrian environment**.** Lighting poles should maintain clear pedestrian movement while allowing sufficient space for trees, utilities, signage, seating, and other streetscape elements. Moughtin (2003) emphasizes the importance of organizing streetscape elements to protect pedestrian movement and establish an appropriate relationship between buildings, circulation spaces, and street furniture. Lighting infrastructure should consequently be located within an appropriate furnishing or service zone rather than occupying the primary pedestrian movement zone or being placed immediately against building frontages.

Building setback is also important because it determines the spatial relationship between lighting infrastructure and the building edge. Where poles are positioned too close to façades, high-intensity light sources may create excessive brightness, glare, or unwanted illumination of windows and private interiors. Adequate separation, by contrast, can improve light distribution within the public realm and reduce direct visual competition between the luminaire and adjacent buildings (Illuminating Engineering Society, 2020).

2.8.2 Aesthetic Relationship with the Built Environment

Beyond dimensional coordination, street lighting should achieve visual and architectural integration with the surrounding built environment. The scale, profile, material, and form of poles and brackets contribute to the visual character of the streetscape, while the characteristics of the light source influence how architectural materials and colours are perceived.

Different light sources can produce different visual effects on masonry, concrete, vegetation, painted surfaces, and glazed façades. Consequently, lighting characteristics should respond to the architectural and material qualities of the environment in which they are installed. A warm-toned source may reinforce certain historic or traditional materials, while a cooler source may produce a different relationship with contemporary materials such as glass and metal. When the characteristics of the light source conflict with the surrounding architectural environment, visual coherence may be reduced even when the lighting system satisfies its basic technical requirements (Boyce, 2014; Narboni, 2016).

The aesthetic quality of corridor illumination therefore depends on more than the appearance of the lighting fixture itself. It involves the relationship between lighting infrastructure, building form, architectural materials, façade character, and the overall visual composition of the street**.** Lighting should contribute to the identity of the corridor without becoming visually dominant or disconnected from the surrounding built environment.

2.8.3 Energy and Illumination Efficiency

The spatial and aesthetic quality of corridor lighting is also related to the **amount and distribution of illumination required to perform its intended function**. The relationship between street width, pole height, luminaire output, and required illuminance indicates that lighting should provide an appropriate level of illumination rather than simply maximize brightness. The Illuminating Engineering Society (2020) establishes lighting recommendations according to roadway classification and use, reinforcing the principle that illumination levels should correspond to the functional and spatial characteristics of the street.

From this perspective, energy efficiency begins with appropriate illumination rather than maximum illumination**.** Excessive light output, when not justified by the function or geometry of the corridor, represents an inefficient use of lighting infrastructure. Similarly, applying the same lighting intensity and installation characteristics across streets with different dimensions and functions can result in unnecessary energy demand. Urban lighting should therefore balance functional visibility with appropriate illuminance, spatial distribution, and the physical characteristics of the corridor (Illuminating Engineering Society, 2020).

This establishes an important urban-design principle for the present study: the energy performance of urban illumination is partly determined by how appropriately lighting infrastructure is matched to the spatial and functional requirements of the corridor**.**

2.8.4 Environmental and Visual Effects of Illumination

Urban illumination also interacts directly with the surrounding environmental and visual conditions. Inappropriate mounting positions and excessive light output can produce glare, light trespass, excessive brightness, and unwanted illumination of façades and windows. These effects demonstrate that lighting performance cannot be assessed only by whether sufficient light reaches the road surface. The distribution and direction of light also determine how the surrounding urban environment is experienced.

Where lighting is positioned too close to building façades or directed toward windows, it may interfere with private interiors and the visual field of occupants. At the street level, excessive brightness and poorly controlled light can affect visual comfort and create strong contrasts within the corridor. The environmental performance of lighting therefore requires attention to where light is directed, how much light is produced, and which surrounding surfaces and spaces receive it (Illuminating Engineering Society, 2020).

From an urban-design perspective, illumination should consequently be evaluated not only according to its intended target but also according to its secondary effects on adjacent buildings, pedestrian spaces, windows, façades, and the wider nighttime environment**.**

2.9 Landscape, Tree, Garden, and Water-Feature Lighting as Part of the Corridor's Nighttime Image

Landscape illumination forms an important component of the nighttime public realm because trees, gardens, planted medians, fountains, and other landscape features contribute to the visual identity and spatial experience of urban corridors. Unlike purely functional street lighting, landscape lighting is often intended to reveal particular elements of the environment, establish visual hierarchy, create focal points, and contribute to the atmosphere and identity of public spaces. Its effectiveness therefore depends on the relationship between the illuminated landscape element, the surrounding architecture, pedestrian viewpoints, and the overall composition of the nighttime streetscape (Narboni, 2016; Cullen, 1961).

Tree and Garden Lighting

Street trees, planted medians, gardens, and other softscape elements contribute to the visual structure of public space and can become important components of a corridor's nighttime image. Their illumination can reveal trunk structure, branching patterns, foliage, planting arrangements, and seasonal characteristics that would otherwise become less perceptible after dark. Low-level uplighting, grazing, and carefully directed accent lighting can be used to emphasize selected vegetation while maintaining visual comfort for pedestrians and avoiding unnecessary illumination of surrounding façades and upper canopies. The objective is therefore not to illuminate vegetation uniformly, but to selectively reveal its form and integrate it into the wider spatial composition of the corridor (Narboni, 2016).

The ecological implications of landscape illumination also require consideration. Artificial light introduced into planted areas can alter the natural dark period experienced by vegetation and may interfere with biological processes that depend on regular light-dark cycles. The effects can include changes in flowering, growth patterns, leaf development, dormancy, and other photoperiod-dependent processes. Consequently, the intensity, duration, direction, and timing of landscape lighting should be controlled according to the sensitivity and function of the planted environment rather than treated as purely decorative illumination (Gaston et al., 2015).

Because trees and planted medians frequently extend continuously along streets and corridors, their lighting also establishes a visual rhythm at the corridor scale**.** Repeated luminaires, consistent spacing, and coordinated colour characteristics can reinforce continuity and establish a coherent nighttime sequence. Conversely, irregular fixture spacing, inconsistent brightness, or abrupt changes in colour temperature can fragment the visual experience of the corridor. Landscape illumination therefore operates simultaneously at two scales: it reveals individual trees and planting features while also contributing to the larger visual rhythm and identity of the streetscape (Cullen, 1961; Narboni, 2016).

Garden and Public-Space Lighting

Garden and public-space illumination requires a balance between revealing landscape features and maintaining the spatial character of the open space. Rather than treating every planting bed, tree, or garden element as an independent object for illumination, lighting should establish a hierarchy between circulation routes, vegetation, focal elements, seating areas, and architectural features. Controlled accent lighting can draw attention toward significant landscape elements while lower ambient illumination maintains depth and allows darker areas to remain part of the spatial composition. Such differentiation can contribute to visual hierarchy and spatial legibility while avoiding the uniform brightness that can flatten the perceived structure of a garden or public space (Lynch, 1960; Narboni, 2016).

Water-Feature and Fountain Lighting

Water features, particularly architectural fountains, offer a distinctive opportunity for integrating light, water, movement, and architectural form into a single nighttime composition. Unlike static surfaces, water is continuously changing through reflection, refraction, movement, splash, and transparency. When illumination is carefully positioned in relation to these properties, light can become visually integrated with the movement of water rather than simply being placed beside the fountain. The combination can transform a fountain into a dynamic nighttime focal point in which the illuminated water, fountain structure, surrounding landscape, and adjacent architecture operate as a unified visual composition (Narboni, 2016; Illuminating Engineering Society, 2020).

The relationship between projected water and light is particularly important in fountain design. A projected jet of water provides a moving and partially transparent surface through which light can travel and against which it can be reflected. When an underwater or concealed light source is aligned with the trajectory of the water jet, the illuminated stream can appear to carry the light itself, creating a direct visual connection between the source, water movement, and fountain geometry. Light projected through or onto moving water can produce changing patterns of reflection, refraction, highlights, and shadows, allowing the fountain to become a dynamic visual element rather than simply a water installation with lighting attached to it. The strongest design effect is therefore achieved when the direction of water movement and the direction of projected light are intentionally coordinated (Illuminating Engineering Society, 2020; Narboni, 2016).

This relationship makes fountain lighting particularly suitable for establishing landmark and focal-point effects within urban corridors. A fountain can function as a node within the public realm, while controlled illumination can increase its nighttime visibility and reinforce its significance within the spatial sequence of the corridor. In Lynch's (1960) terms, the combination of a recognizable physical feature and carefully controlled illumination can strengthen the imageability of a place by making the feature more identifiable within the nighttime environment. The fountain consequently becomes not merely a decorative object but a spatial reference point that can assist orientation, establish hierarchy, and contribute to the identity of the public space.

The effectiveness of fountain illumination depends strongly on the position, beam angle, colour characteristics, and optical control of the luminaires**.** Submerged luminaires can project light upward through water jets or across water surfaces, while perimeter and above-water fixtures can emphasize the edges, architectural details, and surrounding surfaces of the fountain. Each approach produces a different visual relationship between water, structure, and light. Careful beam control is necessary to ensure that the intended water feature is illuminated without creating direct glare for pedestrians or unnecessary illumination of adjacent buildings and circulation areas (Illuminating Engineering Society, 2020).

Colour can further intensify the relationship between water and light. Neutral or white illumination can reveal the natural transparency and movement of water while preserving the appearance of surrounding materials. Coloured LED systems, by contrast, can transform the fountain into a more theatrical or symbolic feature and may be appropriate where the fountain has a landmark, cultural, ceremonial, or city-branding function. However, colour-changing sequences should be used selectively because continuous dynamic colour changes can shift the visual emphasis from the fountain and surrounding urban environment toward the lighting technology itself. A restrained lighting strategy can therefore maintain the fountain as the primary object while using colour as an occasional enhancement rather than its permanent visual identity (Illuminating Engineering Society, 2020; Narboni, 2016).

The relationship between fountain illumination and the surrounding public space is also important. Because water features are often located in plazas, gardens, traffic islands, or major pedestrian spaces, their lighting should be coordinated with surrounding street lighting, landscape lighting, façade illumination, and pedestrian routes. If the fountain is significantly brighter than its surroundings, it may become visually dominant and create excessive contrast for observers approaching or moving past it. Conversely, insufficient differentiation may prevent the feature from functioning as a focal point. Appropriate fountain lighting therefore requires a hierarchy of brightness**,** in which the fountain receives sufficient emphasis to establish its visual role without overwhelming the surrounding public realm (Boyce, 2014; Illuminating Engineering Society, 2020).

This is relevant to urban beautification schemes where fountains are combined with decorative street and architectural lighting. When coordinated, the fountain can serve as the main visual focus, while trees, gardens, façades, and pedestrian areas provide supporting layers of illumination. This creates a visual hierarchy in which the water feature acts as the focal element, the landscape provides the spatial frame, architecture forms the background, and street lighting supports movement and accessibility. Such coordination can strengthen the nighttime identity of the corridor when the intensity, colour, scale, and direction of each lighting layer are carefully balanced (Cullen, 1961;)

2.10 Building and Façade Lighting as an Interface between Architecture and the Nighttime City

Building and façade illumination forms an important interface between individual architectural expression and the collective image of the nighttime city. While street lighting primarily supports movement, orientation, and the illumination of public space, façade lighting interacts directly with the physical characteristics of buildings and can determine how their form, materials, rhythm, and relationship with the street are perceived after dark. Illumination therefore should not be considered an independent layer applied to a completed building; rather, it should respond to the architectural composition of the building envelope and contribute to the visual structure of the surrounding urban environment (DiLaura et al., 2011; Narboni, 2016).

Building Envelope and Architectural Features

The building envelope provides the principal surface through which architectural form is perceived at night. Its characteristics include façade geometry, building height, setbacks, projections and recesses, windows and openings, balconies, columns, arcades, entrance features, rooflines, parapets, cornices, structural frames, cladding materials, glazing, and changes in surface texture. These elements determine how light is reflected, absorbed, transmitted, or concealed. Consequently, façade illumination should respond to the hierarchy of these architectural features rather than treating the entire building as a single uniform surface. A projecting balcony, recessed opening, vertical structural frame, or textured wall, for example, can produce different patterns of shadow and reflection and therefore requires a different lighting relationship from a flat façade plane (DiLaura et al., 2011; Boyce, 2014).

Architectural Form and Massing

Architectural form and massing are equally important in determining the appropriate lighting strategy. The overall proportion of the building, its horizontal and vertical emphasis, articulation of the base, middle, and upper levels, and its relationship to adjacent buildings influence the way it contributes to the nighttime streetscape. Lighting can reinforce these characteristics by emphasizing selected edges, vertical elements, entrances, rooflines, or changes in massing. Conversely, indiscriminate

floodlighting of the entire façade can flatten three-dimensional form, weaken architectural hierarchy, and create excessive brightness. The objective is therefore not necessarily to illuminate the greatest possible surface area, but to reveal the architectural features that contribute most strongly to the building's identity and its relationship with the street (Narboni, 2016; van Bommel, 2015).

Integration with the Urban Context

Integration is particularly important because buildings do not exist as isolated objects within the nighttime city. Their façades form continuous visual walls along streets and public spaces, while individual buildings collectively establish the scale, rhythm, enclosure, and character of the corridor. A façade lighting scheme that is appropriate when viewed in isolation may therefore become inappropriate when considered alongside neighbouring buildings, streetlights, landscape illumination, advertising, illuminated signs, and other sources of artificial light. Integrated lighting design should consequently establish a hierarchy between the building, the street, landscape elements, and significant urban landmarks rather than allowing each element to compete for visual attention (Carmona et al., 2010; Narboni, 2016).

Façade Materials and Light Interaction

The relationship between **façade materials and light** is also fundamental. Different envelope materials have different reflective and absorptive characteristics, meaning that the same luminaire and wattage can produce substantially different visual results on concrete, stone, brick, painted surfaces, metal panels, or glass. Light colour and surface reflectance should therefore be considered together during design. Highly reflective or glazed surfaces can produce strong reflected luminance and glare, while darker or textured materials may require carefully controlled illumination to reveal their surface characteristics. For this reason, façade lighting should be calibrated according to the material and intended visual effect rather than applying a uniform lighting output to all surfaces (DiLaura et al., 2011; Boyce, 2014).

Fenestration, Glazing, Reflection, and Glare

The **fenestration and glazed components of the building envelope** require particular attention. Windows are not simply openings in a façade; at night they can become luminous elements themselves through interior lighting and can also reflect external sources. Poorly positioned façade luminaires may therefore create strong reflections on glass surfaces, producing glare for pedestrians and drivers while simultaneously transmitting unwanted light into interior spaces. The relationship between external luminaires, glazing, viewing angles, and interior activities should consequently be considered as part of the façade lighting design. This is especially relevant along commercial and mixed-use corridors where extensive glazed façades can substantially influence the nighttime visual environment (Boyce, 2014; van Bommel, 2015).

Façade Lighting Techniques and Architectural Articulation

Façade lighting can employ different techniques according to the architectural characteristics being emphasized. Floodlighting may be appropriate where a broad surface or monumental building mass is intended to be revealed; silhouette or grazing techniques can emphasize edges, columns, arches, recesses, and textured surfaces; wall-mounted decorative luminaires can provide illumination at pedestrian scale; and linear LED systems can be integrated into architectural joints, reveals, parapets, or structural lines where concealed detailing is possible. The appropriate technique depends on the geometry, material, scale, and architectural significance of the feature being illuminated. The objective should be controlled architectural articulation rather than the indiscriminate addition of luminous elements (Narboni, 2016; Phillips, 2014).

Integration of Lighting into Architectural Design

This relationship demonstrates why façade lighting should be integrated during architectural design rather than introduced only after construction. Early integration allows luminaires, conduits, electrical connections, control systems, mounting locations, and recesses to be coordinated with the building envelope. Lighting equipment can consequently be concealed within architectural details, positioned behind parapets, incorporated into reveals, or coordinated with structural elements.

Such integration reduces visible technical components and allows the lighting system to support the intended architectural composition. In contrast, when lighting is treated as an aftermarket addition, technical requirements are often forced onto surfaces that were not designed to accommodate them, increasing the likelihood of exposed cables, conduits, brackets, junction boxes, and visually incompatible fixtures (Carmona et al., 2010; Narboni, 2016).

Visual Clutter and Dominance of Lighting Infrastructure

The consequences of poor integration extend beyond visual appearance. Surface-mounted equipment can interrupt façade rhythm, obscure architectural details, and introduce competing lines and objects into the building envelope. Excessive fixture density can also produce a fragmented appearance in which the lighting infrastructure becomes more visually dominant than the architecture itself. In this situation, illumination no longer functions primarily as a means of revealing architectural form; instead, the equipment becomes a new layer of visual clutter. The distinction is therefore between lighting the architecture and adding lighting equipment to the architecture. Effective design seeks the former by making the source of illumination visually subordinate to the architectural features being revealed (Narboni, 2016; Carmona et al., 2010).

Corridor-Scale Integration and Nighttime Urban Hierarchy

Integration should also extend beyond the individual building to the **corridor scale**. Along an urban corridor, façade illumination should consider building height, street width, setback, adjacent building rhythm, streetlight position, pedestrian movement, landscape elements, and significant landmarks. A low-rise building, a tall tower, a historic façade, and a contemporary glazed building should not necessarily receive the same lighting treatment. Instead, their different architectural characteristics can contribute to a differentiated nighttime hierarchy. Such coordination helps prevent the nighttime streetscape from becoming a collection of independently illuminated buildings and supports a more coherent relationship between architectural identity and the overall urban image (Lynch, 1960; Cullen, 1961; Narboni, 2016).

Hierarchical Illumination of Building Components

The **base, middle, and upper portions of a building** can also be considered separately in façade lighting design. The base is closely related to pedestrian movement, entrances, shops, arcades, and street-level activities and may therefore require a finer-grained and more human-scaled treatment. The middle portion contributes to the dominant façade plane and architectural rhythm, while the upper portion, including rooflines, cornices, parapets, and towers, can influence the skyline and long-distance visibility. Treating these components according to their different spatial roles can create a more coherent hierarchy than applying the same illumination intensity across the entire building height (Cullen, 1961; Narboni, 2016).

Architectural Colour and Illumination Colour

Another important consideration is the relationship between architectural colour and illumination colour. The perceived appearance of façade materials changes according to the spectral characteristics of the light source. Warm light can reinforce certain masonry, earth-toned, or historic materials, while neutral or cooler light may reveal the character of contemporary materials such as concrete, metal, and glass. However, colour should be selected in relation to the existing architectural palette and surrounding lighting environment rather than solely for decorative effect. Excessive colour variation or rapidly changing lighting can weaken architectural legibility and create visual competition between buildings (Boyce, 2014; van Bommel, 2015).

Energy Efficiency and Adaptive Façade Illumination

From a sustainability perspective, integration also provides an opportunity to reduce unnecessary energy use. Concealed and accurately aimed luminaires can direct light toward intended architectural surfaces while reducing spill and excessive output. Similarly, dimming, scheduling, zoning, and adaptive controls can allow façade illumination to respond to patterns of nighttime activity. This is particularly important where multiple buildings are illuminated along a corridor, because individually moderate systems can collectively create a high nighttime energy demand. Energy efficiency should therefore be considered at both the building and corridor scales

rather than evaluated only by the efficiency of individual LED luminaires (IES, 2020; Gaston et al., 2015).

Durability, Maintenance, and Long-Term Performance

Finally, the long-term performance of façade illumination depends on the environmental conditions of the building envelope. Outdoor-mounted luminaires are exposed to temperature variation, moisture, dust, ultraviolet radiation, and other environmental stresses. Fixture selection should therefore correspond to the specific exposure and mounting location, while maintenance and accessibility should be considered during the initial design. A technically efficient LED system can still become visually and economically problematic if its components deteriorate, fail, or require frequent replacement. Thus, architectural integration should encompass not only the initial visual composition but also installation, durability, maintenance, control, and eventual replacement (Bizjak & Knez, 2021).

Façade Lighting as a Mediating Layer Between Architecture and Public Space

Overall, building and façade lighting should be understood as a mediating layer between architecture and the public realm**.** Its role is to reveal the building envelope, strengthen architectural form, support nighttime identity, and contribute to the coherence of the urban corridor without allowing lighting equipment or excessive brightness to dominate the visual environment. The most successful approach is therefore one in which the architectural form establishes the structure of the lighting composition, the envelope determines where and how light is applied, and the lighting system remains visually subordinate to the architectural and urban qualities it is intended to reveal (Narboni, 2016; Boyce, 2014).

2.11 Marketing, Branding, and City Image as Communication through Illumination

Illumination as a Medium of City Identity and Image

Beyond its spatial, functional, and architectural roles, urban illumination can operate as a medium through which a city communicates its identity and image. City branding is concerned not only with formal promotional activities but also with the ways in

which the physical environment, infrastructure, public spaces, and everyday experiences communicate what a city represents. Kavaratzis (2004) argues that city branding is closely related to the construction, communication, and management of city image, with the built environment forming an important channel through which the image of a place is experienced. From this perspective, nighttime illumination becomes part of the city's visual communication system because residents, visitors, and other users encounter the illuminated urban environment directly as part of their everyday experience.

Nighttime Illumination as Visual Communication

The nighttime city can therefore function as a form of **visual communication.** Street lighting, façade illumination, illuminated landscapes, monuments, fountains, commercial frontages, and other luminous elements collectively contribute to what people see, remember, and associate with a particular urban place. Unlike conventional advertising, these elements are embedded within the physical environment and are experienced while people move through streets and public spaces. Illumination can consequently strengthen the visibility of important urban elements and contribute to the recognition and memorability of particular places. In this sense, lighting does not merely make the city visible at night; it can influence what aspects of the city become visually prominent and how the city is interpreted by its users (Kavaratzis, 2004; Lynch, 1960).

Urban Corridors as Nighttime Visual Sequences

This relationship is particularly important for urban corridors**,** where repeated movement exposes users to a sequence of illuminated buildings, streets, landscape elements, commercial activities, and landmarks. The corridor can therefore be understood as a nighttime visual sequence rather than a collection of independent lighting installations. Changes in brightness, colour, building form, landscape, signage, and illuminated architectural features can establish visual hierarchy and contribute to a recognizable nighttime character. Cullen's (1961) concept of serial vision is relevant here because the urban environment is experienced progressively through movement, with successive views contributing to the overall perception of

place. Illumination can reinforce this sequence by revealing selected spatial elements at different points along the corridor.

Place-Specific Identity and Coherent City Branding

City branding through illumination, however, depends on the specificity and coherence of what is being communicated. A lighting scheme may make a corridor appear attractive or modern without necessarily communicating a distinctive identity. When the same pole design, colour treatment, façade illumination, or decorative lighting pattern is repeatedly applied without responding to local architectural and spatial characteristics, the result may become visually generic.

The distinction is therefore between illumination that creates place-specific identity and illumination that produces only a generalized image of beautification or modernization. A successful city-image strategy should use lighting to reveal characteristics that already belong to the place rather than relying exclusively on decorative elements that could be reproduced in any city (Kavaratzis, 2004; Narboni, 2016).

Branding and Architectural Identity

The relationship between branding and architectural identity is consequently significant. Buildings, façades, public spaces, historic structures, streetscapes, and landscape features constitute important physical components of a city's image. When illumination is carefully coordinated with these elements, it can strengthen their visibility and contribute to a coherent nighttime identity. Architectural details such as façades, columns, arches, rooflines, entrances, structural rhythms, materials, and distinctive building forms can become recognizable components of the nighttime image. Conversely, when decorative luminaires, excessive brightness, exposed cables, or poorly positioned fixtures dominate the visual field, the lighting infrastructure may compete with the very architectural qualities that should communicate the identity of the place (Lynch, 1960; Narboni, 2016).

Illumination and the Nighttime Economy

Illumination also has a relationship with the nighttime economy**.** The extension of urban activity into the evening has increased the importance of lighting in commercial streets, entertainment areas, tourism destinations, public spaces, and cultural environments. Appropriate illumination can support visibility, orientation, pedestrian activity, and the attractiveness of places after dark, thereby contributing to the conditions in which nighttime economic and social activities occur. However, lighting should not be interpreted as independently generating economic activity. Its contribution is better understood as one component of a wider urban environment that includes accessibility, land use, public-space quality, commercial activity, safety, and cultural attractions (Narboni, 2016; Gehl, 2010).

Visual Hierarchy in the Nighttime City

The branding role of illumination can also be understood through visual hierarchy**.** Not every building, street, landscape feature, or public facility needs to have the same lighting intensity or visual prominence. A coherent nighttime image requires differentiation between ordinary background elements and significant landmarks or focal points. Excessive uniformity can suppress this hierarchy, while excessive variation can produce visual competition. A balanced approach can therefore establish primary, secondary, and background levels of illumination, allowing important places to become identifiable without turning the entire corridor into a field of competing luminous objects (Lynch, 1960; Cullen, 1961; Narboni, 2016).

Colour and Lighting Character in City Image

Colour and lighting character can further contribute to city image. The colour temperature, colour rendering characteristics, brightness, and temporal behaviour of illumination influence the atmosphere through which a place is perceived. Consistent lighting characteristics can contribute to visual continuity along a corridor, while carefully selected differences can identify particular districts, landmarks, cultural spaces, or commercial areas. However, the use of changing colours and highly decorative effects should be carefully controlled because excessive visual variation

may weaken architectural legibility and create a fragmented nighttime image (Boyce, 2014; Narboni, 2016).

Public Perception, Memory, and Urban Imageability

The communication function of illumination is also closely connected to public perception and memory**.** A distinctive illuminated landmark, fountain, façade, gateway, or streetscape may become an identifiable reference point within the nighttime city. This corresponds with Lynch's (1960) concept of imageability, in which recognizable physical elements contribute to the formation of a mental image of the city. Illumination can increase the nighttime visibility of such elements and potentially strengthen their role as landmarks or nodes. The value of lighting in this context therefore lies not simply in increasing brightness but in selectively reinforcing elements that help users understand and remember the urban environment.

Image-Led Beautification and Its Consequences

At the same time, city branding through illumination creates a risk of image-led beautification when visual attractiveness becomes the primary objective without sufficient consideration of spatial, architectural, environmental, and energy consequences.

A city may appear brighter and more visually active while simultaneously experiencing excessive energy consumption, glare, façade clutter, or weakened architectural character. This indicates that branding objectives should not be separated from broader urban-design objectives. The attractiveness of a nighttime image should be evaluated together with spatial integration, pedestrian comfort, architectural coherence, energy performance, and the long-term management of the lighting system (Gaston et al., 2015; Boyce, 2014).

Physical and Landscape-Based Communication of the City

Kavaratzis's (2004) framework is particularly useful in this respect because city image is communicated through multiple channels rather than through formal promotional material alone. The built environment, infrastructure, public spaces, services, behaviour, and communication activities all contribute to the image experienced by users. Urban illumination can therefore be positioned within the physical and

landscape-based communication of the city. Because illuminated streets and buildings are encountered directly and repeatedly, their contribution to the perception of place may extend beyond the moment of installation and become part of everyday urban experience.

Addis Ababa and the Development of a Nighttime City Identity

For Addis Ababa, urban illumination is increasingly relevant to the development of a recognizable and active nighttime city environment. Recent corridor development has used modern street lighting and public-space improvements to enhance nighttime attractiveness, safety, and activity (Addis Media Network, 2024). However, lighting can contribute more meaningfully to city identity when it responds to local architectural character, landmarks, public spaces, streetscape, and cultural **qualities**, rather than simply increasing brightness or decorative intensity. Research on Addis Ababa's nightscape also indicates that artificial lighting influences place recognition and highlights the importance of landmarks, historic buildings, and public spaces in shaping nighttime identity (Abebe, 2023).

Therefore, illumination should be used to reinforce the distinctive spatial and architectural characteristics of Addis Ababa**,** helping to establish a recognizable nighttime identity rather than a generic image of urban modernization.

Evaluating the Branding Value of Urban Illumination

Ultimately, the branding value of illumination should be evaluated according to what the lighting communicates, how coherently it communicates it, and whether the communicated image is supported by the physical character of the place**.** A successful nighttime image is therefore not necessarily the brightest or most decorative one. It is one in which lighting establishes a meaningful relationship between infrastructure, architecture, landscape, public activity, and local identity. This provides an important basis for evaluating whether illumination projects strengthen the identity of an urban corridor or simply add another layer of visual decoration to the existing cityscape (Kavaratzis, 2004; Lynch, 1960; Narboni, 2016).

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This perspective provides a basis for assessing whether illumination strengthens the identity and character of an urban corridor or simply adds another layer of visual decoration to the existing cityscape.

In general, the paragraphs establish that urban illumination functions as a tool for communicating city identity and shaping the nighttime image of urban corridors**.** Its value depends on how well lighting relates to architecture, landmarks, landscape, public activity, and local characteristics rather than simply increasing brightness. A coherent lighting hierarchy can improve place recognition and memorability, while repetitive or excessive decoration can create a generic nighttime image. For Addis Ababa, illumination should therefore reinforce local spatial and architectural identity while balancing visual quality, public activity, energy performance, and environmental effects.

2.12 Sustainable Urban Illumination: Principles, System Performance, and Governance

Sustainable urban illumination considers lighting as part of the wider environmental, spatial, and energy system of the city rather than as an isolated technical service. Its objective is not simply to increase visibility or replace conventional lamps with more efficient technologies, but to provide the right amount of light, in the right location, at the right time, and with appropriate optical and spectral characteristics. Energy efficiency, control of unwanted light, environmental responsibility, visual comfort,

and sensitivity to local context therefore become interconnected components of sustainable lighting practice (Boyce, 2014; van Bommel, 2015).

The sustainability of an illumination system is particularly important because the environmental effect of artificial light depends not only on the efficiency of individual luminaires but also on their number, output, distribution, operating duration, and relationship to the surrounding environment. A highly efficient LED system can still produce excessive energy consumption or unwanted environmental effects when large numbers of high-output fixtures are operated continuously or when light is directed beyond the intended area. Sustainable illumination therefore requires consideration of the complete lighting system—from fixture selection and optical distribution to operating schedules, maintenance, and spatial planning (Gaston et al., 2015; Illuminating Engineering Society [IES], 2020).

The literature consistently identifies several complementary principles for reducing unnecessary artificial illumination and its associated environmental impacts. For this study, these principles can be organized into five closely related areas: shielding, targeting, intensity calibration, temporal control, and spectral selection. Together, they provide a practical framework for evaluating whether an urban lighting installation provides useful illumination while limiting unnecessary energy consumption, glare, spill, and ecological disturbance (Commission Internationale de l'Éclairage [CIE], 2010; IES, 2020).

2.13. Fundamental Principles of Sustainable Illumination

Shielding: Controlling the Direction of Light

Shielding is concerned with preventing light from being emitted into directions where it does not contribute to the intended lighting task. Properly shielded luminaires use housing, reflectors, lenses, or other optical components to control the distribution of luminous flux and reduce unwanted high-angle emission. In outdoor environments, this can help reduce glare and unnecessary illumination of the sky and surrounding properties. Full-cutoff or similarly controlled optical systems can therefore be useful where the objective is to keep illumination concentrated within the required area (IES, 2020; International Dark-Sky Association [IDA], 2022).

Shielding is particularly important where luminaires are positioned close to building façades, pedestrian routes, or residential windows. An exposed or poorly shielded source may be directly visible to users and can create a high-brightness source against a darker background, reducing visual comfort. In façade and streetscape applications, the luminaire should therefore be visually and optically controlled so that the illuminated surface, rather than the lamp itself, becomes the dominant visual element (Boyce, 2014; IES, 2020).

Targeting: Keeping Light within the Intended Spatial Boundary

Targeting concerns the precise direction and distribution of light toward the surface or area for which illumination is intended. While shielding controls unwanted emission from the luminaire, targeting determines where the useful light actually falls. Precision optics, appropriate mounting positions, beam control, and careful aiming can reduce light falling onto adjacent buildings, private properties, pedestrian areas where it is unnecessary, or other unintended locations (IES, 2020).

This principle is particularly relevant to façade and landscape illumination. A luminaire intended to reveal a building column, tree canopy, monument, or fountain should be positioned and aimed according to the geometry of that feature. When targeting is poor, additional fixtures or higher wattage may be used simply to compensate for inefficient distribution. Sustainable design therefore requires the relationship between fixture position, beam angle, mounting height, target geometry, and required illuminance to be considered together rather than increasing output whenever the desired visual effect is not achieved (Boyce, 2014; Narboni, 2016).

Targeting also has an important relationship with the building envelope. Luminaires placed too close to façades or aimed at highly reflective surfaces may produce excessive reflected luminance and glare. Conversely, appropriately positioned fixtures can reveal architectural features with less luminous output. The objective is therefore not maximum illumination of the façade but controlled illumination of the architectural features that contribute to the intended nighttime image.

Intensity Calibration: Providing Sufficient Rather Than Excessive Light

Intensity calibration refers to establishing an appropriate lighting level according to the function, hierarchy, geometry, and use of the space. Sustainable lighting does not mean that every location should receive the lowest possible illuminance; rather, the lighting level should be sufficient for the intended activity and consistent with the applicable standards. Excessive illumination beyond this requirement provides diminishing functional benefit while increasing energy consumption, glare, contrast, and environmental exposure (IES, 2020; Boyce, 2014).

This principle is particularly important in corridors where decorative lighting may be added to an already illuminated street. Streetlights, façade lights, landscape lights, commercial signs, and architectural features can collectively produce a much higher nighttime luminous environment than any individual installation suggests. Consequently, intensity should be assessed at the system and corridor level**,** not only by checking whether each individual luminaire is technically compliant.

Intensity calibration also supports visual hierarchy. Important intersections, pedestrian crossings, entrances, landmarks, and other points requiring greater visual attention may appropriately receive different lighting levels from ordinary background areas. Uniformly high illumination across an entire corridor can reduce this hierarchy and create a visually monotonous environment while consuming more energy. Sustainable illumination therefore involves both quantitative control of illuminance and qualitative control of where visual emphasis is created (Lynch, 1960; Cullen, 1961).

Temporal Control: Lighting Only When It Is Needed

Temporal control addresses the duration for which lighting operates and the possibility of adjusting output according to changing nighttime conditions. Astronomical time controls, programmable schedules, dimming systems, occupancy detection, and adaptive controls can reduce unnecessary operation during periods when pedestrian and vehicular activity is low. The objective is to match lighting provision more closely with actual patterns of use rather than maintaining maximum output throughout the entire night (IES, 2020; IDA, 2023).

Temporal control is particularly relevant to decorative and façade lighting because these systems may remain illuminated long after the primary period of nighttime activity. A building façade or landscape feature may require strong visual emphasis during an evening peak period but considerably less illumination later at night. Dimming and scheduled switching can therefore maintain the intended nighttime image while reducing energy consumption and environmental exposure. Such controls are most effective when incorporated during the initial design rather than added later as a corrective measure.

The temporal dimension also reinforces the idea that sustainable illumination is a dynamic urban-management issue**.** Lighting requirements are not necessarily constant throughout the night. Patterns of traffic, pedestrian movement, commercial activity, security requirements, and public-space use change over time. A sustainable system should therefore have the capacity to respond to these changes where technically and operationally appropriate.

Spectral Selection: Considering the Colour Characteristics of Light

Spectral selection concerns the colour characteristics of artificial light and the environmental and perceptual consequences associated with different light spectra. The spectral composition of outdoor lighting can influence colour appearance, visual perception, human circadian responses, and ecological systems. Research has particularly identified concerns associated with short-wavelength-rich light in relation to some ecological and biological responses, although the magnitude of these effects depends on the species, environment, intensity, timing, and duration of exposure (Gaston et al., 2015).

For urban applications, spectral selection should therefore be considered alongside the architectural and environmental context. Warm or neutral-white lighting may be appropriate in locations where visual comfort, historic character, residential sensitivity, or reduced short-wavelength emission is important. However, colour temperature should not be selected as an isolated sustainability measure. The overall environmental effect also depends on intensity, duration, optical distribution, and the sensitivity of the surrounding environment (Boyce, 2014; Gaston et al., 2015).

Spectral selection is also relevant to architectural identity. The appearance of stone, concrete, vegetation, painted façades, metal, and glass changes according to the spectral characteristics of the light source. Consequently, the choice of light colour should balance environmental considerations with colour rendering, material appearance, architectural character, and the existing nighttime lighting environment (Boyce, 2014).

2.13.1 Corridor-Scale Energy and Environmental Performance

The five principles should not be treated as independent technical requirements. Their effectiveness depends on how they operate together. A luminaire may have effective shielding but still consume excessive energy if its output is unnecessarily high. A fixture may have appropriate intensity but produce unwanted glare if it is poorly aimed. A well-targeted system may still have an unnecessary environmental impact if it remains at full output throughout the entire night. Similarly, a warm-colour light source does not automatically constitute sustainable lighting if it is excessively bright or poorly controlled.

Sustainable illumination can therefore be understood through the following sequence:

Shield the source → target the intended surface → calibrate the intensity → control the operating time → select an appropriate spectrum.

This sequence shifts the emphasis from the efficiency of the lamp alone toward the performance of the complete lighting system**.** LED technology can contribute significantly to energy efficiency, but its sustainability benefits depend on appropriate specification, optical control, operating schedules, maintenance, and actual lighting demand (Gaston et al., 2015; IES, 2020).

The sustainability of urban illumination becomes more complex when individual fixtures are combined across an entire corridor. A large number of moderately efficient luminaires can collectively produce substantial energy demand, particularly where decorative streetlights, façade lighting, landscape illumination, signage, and other sources operate simultaneously. Consequently, sustainable assessment should

move from the performance of individual fixtures toward the cumulative performance of the corridor lighting system**.**

This corridor-scale perspective is particularly important in rapidly changing urban environments where beautification and modernization projects can introduce substantial amounts of new illumination within a relatively short period. The cumulative effect may not be apparent when individual installations are assessed independently. Corridor-level inventories, energy calculations, illuminance assessment, nighttime observation, and spatial mapping can therefore provide a more complete understanding of the environmental and energy consequences of urban illumination.

At a broader scale, satellite-based nighttime-light (NTL) imagery provides an additional means of observing changes in the spatial distribution and intensity of artificial light over time. Such imagery cannot replace fixture-level measurements or field assessment because it operates at a much coarser spatial scale, but it can provide useful evidence of changes in the overall nighttime luminous footprint of urban areas. NTL data can therefore complement detailed lighting assessment by connecting individual or corridor-scale interventions with broader patterns of urban illumination (Ticleanu et al., 2021).

2.13.2 Regulation, Implementation, and the Sustainability Gap

Sustainable urban illumination ultimately depends not only on design principles but also on regulation, implementation, monitoring, and maintenance. Lighting standards can establish acceptable levels of illuminance, equipment performance, optical control, energy efficiency, and environmental protection. However, the existence of a standard does not necessarily guarantee that installed systems will perform according to its requirements. Differences between design documents and constructed installations, inadequate supervision, maintenance limitations, changes made during construction, and weak enforcement can all produce a gap between regulatory intention and actual nighttime conditions.

This distinction is important for evaluating urban illumination in Addis Ababa. Where municipal lighting or façade-lighting guidelines establish requirements for fixture placement, intensity, colour, optical control, or architectural treatment, their

effectiveness ultimately depends on how consistently these requirements are incorporated into design and construction and subsequently maintained. The sustainability question is therefore not simply whether a regulation exists, but whether the regulation's principles are visible in the actual lighting environment**.**

For this reason, sustainable urban illumination should be evaluated at three interconnected levels**:** fixture performance, spatial/corridor performance, and governance performance**.** Fixture performance concerns efficiency, shielding, targeting, intensity, spectrum, and durability. Corridor performance concerns cumulative brightness, energy demand, visual hierarchy, glare, spill, and relationship with buildings and public space. Governance performance concerns standards, approval procedures, implementation, monitoring, maintenance, and enforcement. Together, these levels provide a more comprehensive basis for understanding sustainable illumination practice than technological efficiency alone (Boyce, 2014; Gaston et al., 2015; IES, 2020).

Overall, sustainable urban illumination requires a shift from the principle of **"**more light for a better city" toward "appropriate light for the intended urban function and context**."** The five principles of shielding, targeting, intensity calibration, temporal control, and spectral selection provide a practical framework for achieving this shift. When combined with corridor-scale planning, energy assessment, environmental consideration, regulation, and maintenance, they allow illumination to support nighttime visibility and urban identity without unnecessarily increasing energy demand or compromising the spatial and environmental quality of the city.

2.14 International Examples Showing the Range of Outcomes Associated with Managing Street Lighting in Relation to Spatial Context

Comparative examples from different urban environments demonstrate that the effectiveness of street lighting depends not only on the technical performance of the luminaire but also on the relationship between lighting infrastructure and the spatial structure of the street. Contemporary approaches to managing the nighttime environment seek to provide adequate visibility, orientation, safety, and nighttime

activity without simply reproducing daytime illumination conditions. The appropriate lighting solution therefore depends on the characteristics of the receiving urban environment, including street width, building height, building setback, pedestrian space, landscape structure, architectural character, and patterns of movement (Boyce, 2014; Narboni, 2016).

Street-lighting infrastructure is consequently both a technical system and a spatial component of the streetscape**.** Pole height, luminaire output, spacing, mounting position, outreach, and optical distribution influence not only lighting performance but also the visual scale and character of the corridor. The current IES recommended practice recognizes pole placement and spacing as important design considerations and notes that pole selection is influenced by road width, luminaire characteristics, project location, and surrounding conditions. It also indicates that shorter poles are generally associated with narrower roads, while taller poles are more appropriate for wider roads, reinforcing the need to coordinate lighting infrastructure with the physical characteristics of the corridor (IES, 2022).

This relationship is also explicitly recognized in Addis Ababa's own street-lighting guidance. The **AACRA Street Lighting Design Manual** identifies the primary function of poles as supporting luminaires in the correct location while maintaining an appropriate setback from the roadway. It further explains that pole setback and outreach-arm length together determine the position of the luminaire relative to the roadway and states that, where standard setback distances cannot be achieved, poles should be located as close to the property boundary as practical. The manual also notes that pole spacing depends on required illumination, uniformity, light distribution, and lamp output.

The international cases considered below—Tianfu Avenue in Chengdu, Avenue Montaigne in Paris, and selected inner-city corridors in Addis Ababa—therefore provide contrasting examples of how lighting infrastructure interacts with urban spatial context. The purpose is not to identify one city as universally successful and another as unsuccessful. Instead, the cases demonstrate how similar objectives of nighttime visibility, beautification, attractiveness, and urban image can produce different spatial outcomes depending on the relationship between lighting infrastructure and the physical environment.

2.14.1 Chengdu Tianfu Urban Corridor: Large-Scale Lighting Supported by Large-Scale Spatial Conditions

The Tianfu Avenue axis in Chengdu provides an example of a major metropolitan corridor in which prominent decorative street-lighting infrastructure is accommodated within a broad boulevard structure.

The corridor incorporates substantial roadway and landscape areas, green buffers, and considerable separation between the street edge and adjacent buildings. These characteristics create a relatively large physical and visual field within which substantial lighting infrastructure can participate in the overall boulevard composition (Driving in China, 2025).



Figure 2. The axis of Tianfu Avenue, Chengdu, showing the relationship between the green buffer, building setback, and street-lighting infrastructure.
Source: Driving in China (2025).

The significance of this case is not simply the use of large decorative poles, but the relationship between infrastructure scale and corridor scale**.** A large lighting pole occupies a different visual proportion when positioned within a broad boulevard than when positioned immediately beside a building façade or within a narrow pedestrian environment. The spatial structure of Tianfu Avenue provides greater separation between lighting infrastructure, pedestrian areas, landscape, roadway, and buildings, allowing the poles to contribute to the axial composition without necessarily becoming the dominant element of the adjacent building frontage.

The case therefore illustrates the importance of spatial capacity in determining the suitability of lighting infrastructure. Large-scale lighting is not inherently

incompatible with urban design. Its appropriateness depends partly on whether the surrounding street structure can absorb its physical and visual scale. This supports the broader principle that mounting height, spacing, optical distribution, and luminous output should be considered in relation to the characteristics of the roadway and surrounding development rather than selected independently (IES, 2020; IES, 2022). The Chengdu example consequently provides an important lesson for comparative analysis: the visual dominance of a lighting pole is relative to the spatial environment in which it is installed. A large pole may become an integral element of a metropolitan boulevard where sufficient distance and landscape structure are available, while the same pole could become visually intrusive in a narrow and densely enclosed corridor.

2.14.2 Avenue Montaigne, Paris: Lighting Integrated within an Established Urban Rhythm

Avenue Montaigne in Paris represents a contrasting urban condition in which lighting infrastructure operates within an established architectural and streetscape framework. The avenue is characterized by continuous building frontages, mature trees, pedestrian areas, commercial activities, and a recognizable architectural rhythm. Within such an environment, the visual role of street lighting is closely related to the existing spatial structure rather than functioning as an independent decorative layer.

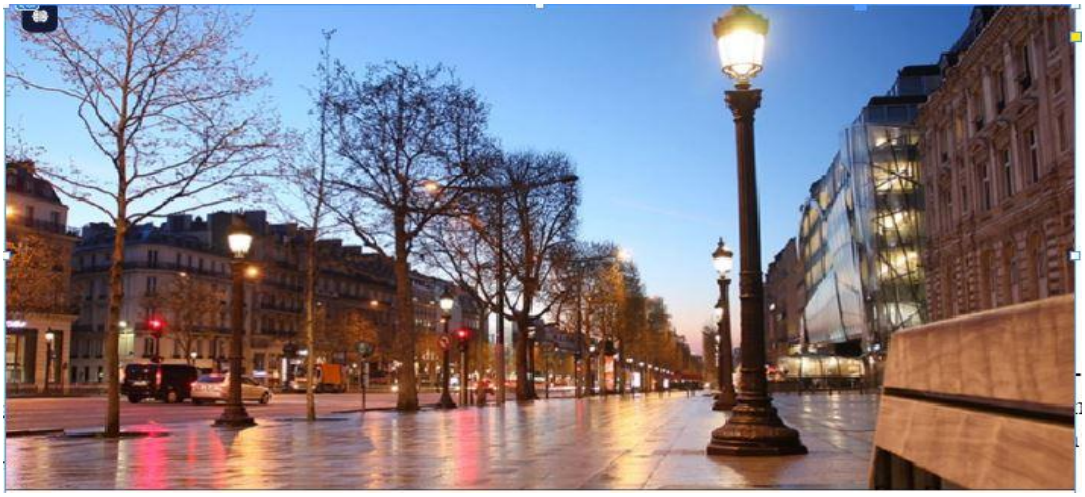


Figure 3. Street-lighting infrastructure in relation to the axial urban environment, Avenue Montaigne, Paris.
Source: A Walk in Paris (2025).

The importance of this case lies in the relationship between repetition, rhythm, alignment, and visual hierarchy**.** Streetlights, trees, façades, entrances, and other streetscape components collectively establish a sequence experienced by pedestrians and drivers. When lighting infrastructure follows this established rhythm, it can become part of the visual order of the avenue rather than competing with the architecture.

This approach illustrates a different form of integration from that observed in Tianfu Avenue. Chengdu demonstrates how substantial spatial separation can accommodate relatively large infrastructure, whereas the Paris example demonstrates how lighting can be integrated through contextual coordination and visual restraint**.** The appropriate solution is therefore not determined solely by the physical size of the luminaire but by its relationship with the elements that establish the character of the street.

The Paris case also illustrates the role of public-realm management. The City of Paris maintains procedures and technical requirements for works affecting public streets and public lighting, demonstrating that lighting infrastructure can be treated as part of a wider system of public-space management rather than as an isolated beautification element. Such institutional coordination is important where the visual continuity of an established urban environment must be maintained.

2.14.3 Addis Ababa Inner-City Corridors: Decorative Lighting within Constrained Spatial Conditions

Selected inner-city corridors in Addis Ababa provide a substantially different spatial condition. Corridors associated with major urban routes, including Churchill Avenue and other central corridors, contain more constrained relationships between roadway, pedestrian space, building frontage, and street infrastructure. Recent urban improvement and beautification initiatives have introduced decorative lighting as part of broader efforts to improve the nighttime appearance and attractiveness of major corridors.



Figure 4. Street-lighting infrastructure along an Addis Ababa corridor.
Source: Fana Broadcasting Corporate (2025).

The principal issue identified through comparison with the international cases is not the objective of using decorative lighting, but the relationship between the scale of the lighting infrastructure and the spatial capacity of the corridor**.** Where building frontages are close to the right-of-way and pedestrian space is limited, a large and high-output decorative lighting installation occupies a greater proportion of the pedestrian visual field than the same infrastructure would occupy within a broad boulevard with deep setbacks and landscape buffers.

This condition can produce a scale mismatch between lighting infrastructure and surrounding built form**.** The problem becomes particularly significant where mounting height, fixture dimensions, luminous output, and spacing are not sufficiently calibrated to street width and building scale. IES guidance emphasizes that pole selection and placement should respond to road width and surrounding development, while the Addis Ababa AACRA manual similarly establishes pole setback, outreach, and spacing as design considerations.

The issue can therefore be understood as a spatial-calibration problem rather than simply a technology problem**.** A luminaire can be technically efficient and still be inappropriate in scale, position, or output for the corridor in which it is installed. Similarly, a decorative pole designed for a broad boulevard may become visually dominant when positioned close to low- or medium-rise façades.

The relationship with the building envelope is particularly important. Where poles are positioned close to buildings, the lighting system interacts directly with windows, balconies, façade surfaces, entrances, and architectural details. Excessive or poorly controlled light may consequently create glare, reflected glare, or unwanted illumination of adjacent surfaces and interiors. The issue is therefore not only how much light reaches the roadway but how the lighting system distributes light across the entire urban section.

2.14.4 The Addis Ababa Case Is Not a Lack of Standards but a Question of Application

An important finding from the comparative literature is that Addis Ababa should not be characterized simply as a city without street-lighting guidance. The AACRA Street Lighting Design Manual, prepared as a technical guide for Addis Ababa, was developed to standardize street-lighting design practices and explicitly addresses pole selection, setback, outreach arms, spacing, illumination performance, and aesthetic considerations. It also states that the manual should be adapted to Addis Ababa conditions and that professional judgment remains necessary in applying the standards.

This is significant for the present study because it changes the nature of the research question. The issue is not simply whether standards exist, but whether the principles contained in existing guidance are reflected in contemporary lighting interventions. The manual's emphasis on locating poles safely relative to the roadway, positioning them as far from traffic lanes as practical where constraints exist, and determining spacing according to lighting performance provides a local technical foundation against which contemporary practice can be examined.

The existence of this earlier guidance also indicates that the spatial relationship between lighting infrastructure and the urban environment has long been recognized within Addis Ababa's road-lighting practice. Contemporary decorative lighting therefore represents not an entirely new technical problem but a more complex application in which functional roadway lighting, decorative expression, architectural context, pedestrian space, and energy performance must be considered simultaneously.

2.14.5 Comparative Interpretation: Three Spatial Conditions, Different Street Lighting Outcomes

The three cases demonstrate that similar intentions can produce different outcomes because the receiving urban environments differ.

Comparative factor	Chengdu Tianfu Avenue	Montaigne, Paris Avenue	Addis Ababa inner-city corridors
General spatial condition	Broad metropolitan boulevard	Established urban/historic avenue	Dense and more spatially constrained corridors
Relationship to buildings	Greater physical separation	Strongly defined architectural frontage	Often closer relationship to building frontage
Landscape structure	Significant green buffers	Integrated tree and streetscape structure	Often closer relationship to building frontage
Lighting scale	Large infrastructure accommodated by broad corridor	Coordinated with established streetscape rhythm	Large decorative infrastructure may become visually prominent
Main integration mechanism	Spatial capacity and separation	Rhythm, coordination, and management	Requires stronger dimensional and contextual calibration
Principal lesson	Large lighting can be appropriate where the corridor absorbs its scale	Lighting can reinforce character when subordinate to urban order	Lighting scale and output must respond to constrained spatial conditions

Table 3. Comparative Analysis of Street Lighting and Spatial Relationships in Selected Urban Corridors

Source: Author's synthesis based on literature and case-study analysis.

2.14.6 What the Comparison Reveals for Addis Ababa

The international comparison should not be interpreted as an argument for the direct replication of the lighting systems implemented in Chengdu or Paris. Rather, the comparative cases provide transferable design principles that can inform the development of context-sensitive illumination strategies for Addis Ababa. Their relevance lies not in reproducing their specific lighting configurations, but in understanding how lighting infrastructure can be appropriately related to the spatial, architectural, and functional characteristics of an urban corridor.

The Chengdu case demonstrates the importance of establishing an appropriate relationship between the scale of lighting infrastructure and the spatial capacity of the boulevard, particularly in relation to street width, building height, setback, pedestrian space, and landscape structure. The Paris case, in contrast, demonstrates the importance of integrating illumination with architectural rhythm, streetscape elements, public-realm structure, and overall urban management**.** The Addis Ababa case highlights the need to adapt such principles to corridors characterized by different spatial constraints, existing building configurations, pedestrian movement patterns, infrastructure conditions, and development patterns. The comparison therefore suggests that the effectiveness of urban illumination depends less on the adoption of a particular lighting model than on its spatial appropriateness, technical performance, and contextual integration**.**

Accordingly, the comparative analysis shifts the central consideration from whether decorative street lighting should be provided to the more fundamental question of how lighting infrastructure should be proportioned, positioned, distributed, and operated in relation to the specific characteristics of each urban corridor**.** This distinction is significant because urban beautification, in itself, does not necessarily result in improved spatial or visual quality. The intended aesthetic and functional outcomes of illumination depend on whether the scale, intensity, location, optical distribution, and spatial arrangement of lighting are compatible with the physical structure and activities of the urban environment.

For Addis Ababa, the principal spatial, architectural, optical, and technical parameters requiring consideration include:

- Street width and spatial cross-section;
- Building height and vertical enclosure;
- Building setback from the street edge;
- Pedestrian movement and required clearances;
- Landscape and green-space buffers;
- lighting-pole height in relation to surrounding buildings and street dimensions;
- Pole spacing and continuity of illumination;
- Luminaire luminous output and optical distribution;
- outreach-arm length and its relationship to the roadway and pedestrian realm;
- Luminaire mounting position and orientation;
- Façade proximity and potential interaction with adjacent buildings;
- Architectural form, rhythm, and visual hierarchy;
- Existing nighttime lighting conditions and cumulative illumination;
- Glare control and visual comfort;
- Relationship between illumination and architectural character; and
- Energy demand, operating duration, and control requirements.

These parameters should not be assessed independently but considered collectively during the lighting-design process**,** since a change in one parameter can directly influence the performance and appropriateness of the others. For example, pole setback cannot be considered separately from luminaire position, outreach-arm length, and optical distribution. The treatment of pole setback and outreach in the AACRA manual illustrates this relationship: an appropriately designed outreach arm can enable the supporting pole to remain farther from the roadway while positioning the luminaire to provide the required illumination over the intended roadway area. Consequently, the assessment of pole location should consider not only the physical position of the supporting structure but also the resulting position, orientation, and distribution of light produced by the luminaire.

This integrated approach is particularly relevant to Addis Ababa, where constrained setbacks, variable street widths, existing building forms, pedestrian movement, landscape elements, and established infrastructure may limit the suitability of standardized lighting arrangements. The selection and positioning of lighting

infrastructure should therefore respond to the specific spatial configuration and functional requirements of each corridor, rather than applying a uniform decorative-lighting solution across different urban conditions.

The comparative cases consequently provide a basis for developing a context-sensitive lighting design framework in which spatial proportion, architectural compatibility, optical performance, visual comfort, energy efficiency, and operational requirements are considered simultaneously. Such an approach would allow urban illumination to contribute to nighttime identity and public-space quality without compromising the spatial and architectural characteristics of the existing urban environment.

2.14.7 International Comparison to the Research Evaluation Framework

The comparative cases provide a direct foundation for the empirical assessment undertaken in the subsequent chapters. They suggest that street-lighting performance should be evaluated through several interconnected relationships:

Street width ↔ pole height ↔ pole spacing

Building height ↔ pole height

Building setback ↔ pole position

Pole position ↔ luminaire position/outreach

Luminaire output ↔ required illuminance

Lighting distribution ↔ intended illuminated area

Lighting infrastructure ↔ architectural character

Lighting intensity ↔ pedestrian visual comfort

Lighting operation ↔ energy demand

These relationships allow the international examples to function not simply as descriptive precedents but as **analytical benchmarks**. The question is not whether Addis Ababa visually resembles Chengdu or Paris, but whether its lighting

infrastructure demonstrates an appropriate relationship between technical performance and spatial context.

The comparative framework also helps distinguish between three possible outcomes of urban lighting intervention. First, lighting may be spatially integrated**,** where infrastructure supports the existing street structure and architectural character. Second, it may be spatially neutral**,** where it provides functional illumination without substantially contributing to or disrupting the urban composition. Third, it may become spatially dominant**,** where the scale, intensity, position, or visual expression of the infrastructure competes with buildings, pedestrians, landscape, or other elements of the public realm.

This distinction is particularly relevant to the Addis Ababa study because the research examines not only whether lighting provides sufficient illumination but also whether the infrastructure contributes to or conflicts with spatial quality, architectural identity, and energy sustainability.

2.14.8 Implication for the Addis Ababa Lighting Framework

The comparative evidence ultimately suggests that Addis Ababa requires a context-responsive street-lighting framework rather than a uniform decorative-lighting model. Such a framework should establish relationships among street hierarchy, street width, building height, building setback, pole height, pole spacing, luminaire output, pedestrian space, and architectural character. The existing AACRA guidance provides an important local starting point because it already recognizes pole setback, outreach, spacing, lighting performance, and aesthetic considerations as components of street-lighting design.

The next step is therefore not necessarily the creation of an entirely new technical system but the integration and updating of existing principles for contemporary urban illumination**.** Decorative lighting, façade illumination, landscape lighting, and energy-performance requirements need to be considered together with conventional roadway-lighting requirements. This would enable lighting design to respond to the actual spatial characteristics of different Addis Ababa corridors rather than applying similar

infrastructure to streets with substantially different widths, building relationships, pedestrian conditions, and architectural identities.

The international cases consequently provide a basis for understanding why lighting interventions produce different spatial outcomes, while the Addis Ababa-specific manual demonstrates that local principles for appropriate pole placement and lighting performance already exist. The critical issue for this research is therefore the relationship between standards, design decisions, physical implementation, and actual nighttime performance.

Overall, the comparison reinforces the central proposition of this literature review: urban illumination is most effective when it is designed as part of the urban spatial structure rather than added independently to it. Chengdu, Paris, and Addis Ababa demonstrate different spatial conditions under which lighting infrastructure can be accommodated by the corridor, coordinated with an established urban order, or become visually dominant. These cases consequently establish a theoretical and practical basis for examining Addis Ababa's corridors in terms of scale, proportion, spatial integration, architectural relationship, visual comfort, and energy performance.

International precedent should therefore not be treated as a model to be copied. Its value lies in identifying the relationships and principles that can be tested against local conditions. The Addis Ababa case can then be evaluated according to whether its lighting infrastructure is appropriately calibrated to the physical and functional characteristics of each corridor and whether the pursuit of nighttime attractiveness is balanced with spatial quality, architectural identity, pedestrian comfort, and energy sustainability.

2.15 Four Domains for Evaluating Urban Illumination Practice

The preceding literature review establishes that urban illumination should not be evaluated only according to the amount of light produced or its visual attractiveness. Its performance is shaped by the way lighting is planned and regulated, its relationship with the physical structure of the street, its contribution to architectural and urban perception, and its energy and operational performance. The international examples discussed in the preceding section demonstrate the importance of responding to local spatial conditions; however, they are not treated as direct benchmarks for Addis Ababa. Instead, the evaluation criteria used in this study are derived from the theoretical concepts, design principles, standards, and empirical literature reviewed in this chapter.

On this basis, four domains are established for evaluating urban illumination practice in the study area:

1. Formal Process and Regulatory Consistency
2. Spatial and Visual Integration
3. Illumination as a Medium of Architectural and Urban Perception
4. Sustainability and Operational Management

These domains synthesize the principal issues identified throughout the literature review and provide a consistent analytical framework for examining urban illumination practices in the Addis Ababa inner-city corridor

2.15.1 Formal-Process and Regulatory Consistency

The first domain evaluates how illumination is planned, approved, implemented, and reviewed. The preceding discussion of formal urban development and city beautification established that urban interventions are not produced only through physical construction but also through institutional processes of design, approval, coordination, implementation, and subsequent correction. Lighting practice should therefore be examined not only through the physical installation that appears in the street but also through the process by which that installation was produced.

The evaluation considers the existence and application of relevant design procedures, approval mechanisms, institutional responsibilities, coordination between responsible offices, and applicable lighting requirements. Where specific local standards are available, their relevant provisions are also considered. This includes requirements related to façade lighting, fixture arrangement, colour characteristics, energy considerations, and other applicable design controls.

This domain is kept separate from the physical quality of the lighting installation. A project may pass through an approval process and nevertheless produce poor spatial or visual outcomes. Conversely, an installation may demonstrate satisfactory physical qualities without having been supported by an adequate formal review process. Separating these conditions allows the study to identify whether an observed problem is associated with design quality, regulatory application, implementation, or the relationship between them**.**

2.15.2 Spatial and Visual Integration

The second domain evaluates whether lighting infrastructure is appropriately related to the physical structure and visual composition of the urban corridor. The literature review established that lighting design should respond to street hierarchy, street width, building height, building setback, pedestrian space, mounting height, pole spacing, luminaire position, and lighting output. These relationships determine whether lighting infrastructure fits within the scale and enclosure of the street.

The principal relationships examined under this domain are:

- street width ↔ pole height**;**
- street width ↔ pole spacing**;**
- building height ↔ pole height**;**
- building setback ↔ pole position**;**
- pole position ↔ luminaire position and outreach**;**
- luminaire output ↔ required illuminance**; and**
- Lighting distribution ↔ intended illuminated area**.**

These relationships are consistent with roadway-lighting guidance, which treats mounting height, spacing, light distribution, visual quality, glare, and energy performance as interconnected aspects of lighting design rather than independent variables.

This domain is therefore the most directly measurable of the four. Physical dimensions, illuminance levels, fixture characteristics, pole locations, spacing, and relationships with surrounding buildings can be examined through field observation, spatial measurement, GIS analysis, and lighting simulation. The purpose is not to impose one universal dimensional standard on every street, but to determine whether the lighting system is appropriately calibrated to the spatial and functional characteristics of its particular corridor**.**

2.15.3 Illumination as a Medium of Architectural and Urban Perception

The third domain evaluates whether illumination supports the perception of architecture and urban space or whether the lighting installation itself becomes the dominant visual element.

The literature review presented illumination as a medium through which the built environment is perceived at night. Lighting can reveal architectural form, emphasize significant features, clarify spatial boundaries, strengthen landmarks, and contribute to the legibility of streets and public spaces. At the same time, excessive brightness, poorly positioned fixtures, repetitive lighting arrangements, exposed equipment, or strong visual contrasts can cause the lighting infrastructure to compete with the architecture and streetscape.

The evaluation therefore considers whether illumination:

- reveals rather than conceals architectural form;
- reinforces important architectural features and building composition;
- supports the legibility of streets, nodes, landmarks, and other urban elements;
- establishes an appropriate visual hierarchy between buildings, landscape, streets, and lighting infrastructure;
- contributes to the identity and image of the corridor; and

- avoids excessive visual dominance, glare, clutter, or competition with the surrounding architecture.

This domain is primarily qualitative because architectural expression, visual hierarchy, identity, and legibility cannot be fully represented by numerical lighting levels. Lynch's (1960) concept of environmental legibility provides a basis for considering whether lighting helps users recognize and understand important elements of the urban environment, while Cullen's (1961) concept of serial vision supports consideration of the changing visual experience along a corridor.

The central issue is therefore whether the installation lights the place or becomes the place's dominant visual object**.** This distinction is particularly important when assessing decorative and façade lighting, where the objective is not simply to make buildings and streets brighter but to reveal their architectural and spatial qualities.

2.15.4 Sustainability and Operational Management

The fourth domain evaluates whether illumination achieves its intended function with appropriate energy use and operational management. The preceding literature identified sustainable illumination as a combination of appropriate intensity, accurate targeting, shielding, temporal control, suitable spectral characteristics, and effective management. Sustainability therefore extends beyond the efficiency of the lamp or luminaire itself.

The evaluation considers:

- whether lighting intensity is appropriate for the intended function;
- whether luminaires direct light toward the intended area;
- whether unnecessary light output or excessive fixture density occurs;
- whether lighting is controlled according to time and nighttime activity;
- whether dimming, scheduling, adaptive control, or curfew strategies are available where appropriate;
- whether the selected spectral characteristics are appropriate to the context;
- whether energy consumption is proportionate to the lighting benefit obtained; and

- whether maintenance and long-term operational requirements have been considered.

Current IES guidance similarly treats quality roadway lighting as a combination of visual performance, environmental considerations, maintenance, and energy use rather than as an illuminance-only problem.

The branding, beautification, and nighttime activity objectives discussed earlier in the literature review are considered within this domain as the intended benefits of illumination. However, these objectives are not treated as justification for excessive energy consumption. Instead, the analysis considers the relationship between the benefit intended by the lighting intervention and the resources required to achieve that benefit**.** This makes it possible to distinguish between lighting that achieves an appropriate nighttime effect efficiently and lighting whose intensity, density, or operating duration produces disproportionate energy demand.

2.15.5 Integration of the Four Domains

The four domains are applied together because no single criterion is sufficient to explain the performance of urban illumination. A lighting system may meet a required illuminance level but remain poorly integrated with the surrounding buildings. It may produce an attractive nighttime image while consuming excessive energy. It may have an appropriate physical design but lack an adequate institutional process for approval, coordination, or maintenance. Consequently, the framework treats illumination performance as a combination of process, spatial integration, perception, and sustainability.

The relationship between the four domains can therefore be summarized as follows:

Evaluation domain	Central evaluation question	Main criteria	Principal Evidence
1 Formal-process and regulatory	Was the lighting appropriately planned,	Planning process, institutional responsibility,	Institutional documents, interviews/questionnaires, field observation

consistency	reviewed, approved, and regulated?	approval, coordination, regulatory compliance	
.2. Spatial and visual integration	Is the lighting appropriately scaled and positioned within the corridor?	Street width, pole height, spacing, building height, setback, illuminance, output, distribution	Field observation, GIS, photographs,
3. Illumination as a medium of architectural and urban perception	Does lighting reveal and support architecture, spatial structure, and corridor identity?	Architectural expression, legibility, visual hierarchy, identity, glare, visual dominance	Visual observation, photographs, questionnaire responses
4. Sustainability and operational management	Does the lighting achieve its intended function with appropriate energy and management performance?	Intensity, targeting, shielding, temporal control, spectrum, energy consumption, maintenance	Energy data, luminaire specifications, simulation, institutional evidence

Table 4. Analytical Framework for Evaluating Urban Illumination Practice

Source: Author's analytical framework developed from the reviewed literature, theoretical perspectives, applicable standards, and the research objectives.

2.16 Management of Urban Illumination: Capacity, Instruments, Scope, and Strategy

Urban illumination practice also depends on the institutional capacity through which lighting is planned, implemented, regulated, operated, and maintained. The physical

quality of a lighting installation cannot therefore be separated entirely from the management system responsible for producing and controlling it. Urban lighting master planning literature emphasizes the need for coordination among urban planning, transportation, lighting, architectural, environmental, operational, and other relevant actors, together with clear objectives and mechanisms for implementation and long-term management (CIE, 2019).

Four management components are particularly relevant to the evaluation of urban illumination practice. Management capacity concerns whether the responsible institutions and professionals possess the technical, organizational, and financial capacity required to plan, approve, implement, monitor, and maintain lighting systems. Management instruments refer to the mechanisms through which lighting is controlled, including urban plans, design guidelines, building regulations, lighting manuals, technical standards, approval procedures, specifications, and monitoring mechanisms. Management scope concerns the spatial and functional extent of management, ranging from individual buildings and streets to corridors, districts, and the city as a whole. Management strategy concerns the longer-term direction of lighting practice, including lighting master planning, coordination of public and private lighting, energy management, maintenance, adaptive operation, and mechanisms for reviewing and correcting inappropriate installations.

These components are important because the existence of a standard or design guideline does not necessarily demonstrate effective management. A regulation may exist without being consistently applied; a lighting system may be technically installed without adequate coordination with architecture and public space; and an installation may function initially but deteriorate when maintenance, monitoring, or institutional responsibility is unclear. Consequently, the evaluation of urban illumination should consider not only what has been installed**,** but also the institutional capacity and instruments through which the installation is planned, controlled, operated, and corrected**.** CIE's urban lighting master planning guidance similarly emphasizes the organizational and operational dimensions of lighting alongside its visual, environmental, and technical aspects.

2.16.1 Managing the Night Rather Than Converting Night into Day

The broader objective of urban illumination is to manage the challenges and opportunities created by nighttime rather than to reproduce daytime conditions through continuous or excessive illumination. Nighttime lighting can support movement, orientation, safety, social interaction, economic activity, architectural expression, urban identity, and the use of public space. At the same time, excessive or poorly controlled illumination can create visual discomfort, spatial conflict, unnecessary energy demand, and maintenance burdens. Urban lighting masterplanning therefore requires decisions about where illumination is needed, what should be illuminated, how much light is appropriate, when it should operate, and how it should be managed over time. CIE 234:2019 specifically frames urban lighting as a planning issue involving functional and expressive lighting as well as environmental, organizational, technical, financial, and operational considerations.

This principle provides the overarching basis for the evaluation undertaken in this study. The question is not whether an urban corridor can be made brighter, but whether illumination is appropriate to the activities, spatial structure, architectural character, nighttime identity, and resource conditions of the place**.** The international examples reviewed previously are therefore used to demonstrate different approaches to managing the nighttime environment rather than to establish a universal model that Addis Ababa should reproduce.

Accordingly, the evaluation considers urban illumination as a managed urban system in which formal processes establish how lighting is produced and regulated; spatial conditions determine where and at what scale lighting should occur; illumination mediates the perception of architecture and public space; and sustainability and management determine how the system operates over time. These relationships provide the basis for the four evaluation domains that follow.

2.17 Local Regulatory Framework for Façade Lighting in Addis Ababa

The Addis Ababa City Administration has introduced regulatory guidance for the illumination of building façades as part of the broader effort to improve the visual

quality and nighttime character of the city. The façade lighting regulation provides a local framework for controlling the installation, positioning, spacing, and visual characteristics of exterior lighting systems. It is particularly relevant to major urban corridors where buildings, streets, and public spaces collectively contribute to the nighttime image of the city. The regulation therefore provides a basis for moving façade illumination from an individual decorative intervention toward a more coordinated component of urban and architectural design.

The regulatory framework establishes requirements concerning the type, positioning, spacing, intensity, and visual treatment of façade lighting fixtures**.** These requirements are intended to promote an appropriate distribution of light across building surfaces and to reduce undesirable visual effects associated with poorly positioned or excessively concentrated luminaires. From an urban design perspective, these provisions are important because the location of a luminaire relative to the façade influences the way architectural form, building proportions, materials, openings, and surface articulation are perceived after dark.

A key consideration of the regulation is the spacing of façade lighting fixtures according to the lighting technique employed. The specified maximum spacing provides a technical basis for assessing whether luminaires are sufficiently coordinated to achieve an appropriate and continuous illumination effect. The principal spacing criteria identified in the local regulatory framework include:

Façade lighting technique	Maximum Spacing
Wall-washing fixtures	2.4 m
Up-lighting and grazing systems	2.0 m
Linear LED arrays	4.0 m
Floodlighting systems	5.0 m

Table 5. Maximum Spacing Requirements for Selected Façade Lighting Techniques

Source: Addis Ababa City Administration.

These spacing requirements provide measurable criteria that can subsequently be used to evaluate existing façade lighting installations within the study corridor. In particular, they allow the study to examine whether excessive spacing produces discontinuous illumination, whether closely positioned fittings create excessive

brightness or visual clutter, and whether the selected lighting technique is appropriate for the architectural characteristics of the building.

The regulation also establishes considerations concerning the colour characteristics of façade illumination and the relationship between lighting and architectural material**.** For historically significant buildings and façades characterized by natural or traditional materials, the use of warmer and relatively low-intensity illumination is intended to maintain the visual character and texture of the architectural surface. The use of approximately 2000–3000 K warm-white lighting can therefore be considered as a criterion for assessing the compatibility of façade illumination with heritage and material expression. Contemporary buildings may accommodate a wider range of lighting effects, including dynamic or coloured lighting, subject to the applicable regulatory and control requirements.

Beyond individual fixtures, façade lighting regulation is significant because it establishes a relationship between lighting technology and architectural expression**.** Façade illumination can either reveal the form, rhythm, material, and identity of a building or obscure these characteristics through excessive brightness, inappropriate colour, irregular spacing, and poorly coordinated installations. Consequently, the local regulatory framework can be interpreted not only as a technical lighting requirement but also as an instrument for maintaining architectural coherence within the nighttime urban environment.

For this study, the local façade lighting regulation is therefore operationalized through five analytical dimensions: fixture spacing, fixture positioning, lighting technique, colour temperature, and architectural integration**.** These dimensions provide observable criteria for evaluating existing façade lighting practices. Fixture spacing can be compared with the prescribed maximum intervals; positioning can be assessed in relation to the façade and pedestrian environment; lighting technique can be examined according to its suitability for the building surface; colour temperature can be evaluated in relation to architectural material and character; and architectural integration can be assessed according to whether the lighting reinforces or conflicts with the building's form and identity.

The regulatory framework consequently serves as a local benchmark rather than an assumption of compliance**.** The existence of regulations does not necessarily demonstrate that façade lighting practices in the inner-city corridor conform to them. The distinction between the prescribed requirements and actual physical conditions is therefore central to this research. Chapter Four uses the identified regulatory criteria to assess existing façade lighting practices and determine areas of conformity and non-conformity. Chapter Five subsequently interprets these findings in relation to architectural expression, spatial quality, visual comfort, and energy-related concerns. Chapter Six then uses the identified regulatory and implementation gaps to formulate recommendations for improving façade lighting design, coordination, enforcement, and integration within the urban corridor.

Key Regulations of Façade Lighting

- **Lighting type:** Specifies requirements for appropriate façade lighting systems and technologies.
- **Fixture positioning:** Regulates the placement of lighting fixtures to ensure proper architectural integration.
- **Maximum fixture spacing:**
    - **2.4 m** for wall-washing systems.
    - **2.0 m** for up-lighting and grazing systems.
    - **4.0 m** for linear LED arrays.
    - **5.0 m** for floodlighting systems.
- **Lighting intensity:** Emphasizes the use of low-intensity illumination**,** particularly for historically significant buildings and sensitive architectural surfaces.
- **Colour temperature:** Recommends warm-white lighting of approximately 2000–3000 K for historically significant façades and façades using natural or traditional materials.
- **Architectural integration:** Requires façade lighting to complement the building's form, material, architectural character, and visual identity rather than dominate them.

Chapter Three

Methodology

3.1 Research Approach

This study employs a mixed-method research approach to assess urban illumination practices and their spatial, architectural, perceptual, and environmental implications in the inner-city corridors of Addis Ababa. The research was undertaken in the context of the city's corridor beautification and redevelopment initiatives, through which street, façade, landscape, and other forms of illumination have increasingly become part of the nighttime urban environment.

The methodology combines a case study approach with field observation, photographic documentation, GIS-based spatial analysis, technical and energy assessment, institutional interviews, documentary analysis, and structured questionnaires. These methods are used in combination because the study examines illumination as both a physical intervention and a product of formal design and management processes. Consequently, no single method is sufficient to examine the relationships among design intention, implementation, institutional responsibility, spatial configuration, public perception, and energy performance.

The methodological structure follows the four evaluation domains developed from the literature review: formal-process and regulatory consistency; spatial and visual integration; illumination as a medium of architectural and urban perception; and sustainability and operational management**.** These domains provide the analytical bridge between the literature reviewed in Chapter Two and the empirical investigation presented in the subsequent chapters.

Case Study Method

The case study method provides the principal organizing strategy of the research. It enables selected illuminated urban elements and their surrounding spatial contexts to be examined in detail, including how they were conceived, designed, implemented, managed, and experienced. The approach is appropriate because the research

investigates illumination within its real urban context rather than attempting to establish statistical generalizations for all lighting installations in Addis Ababa.

The case study approach also allows comparison between different management arrangements. Selected cases are first identified according to their relevance to the illuminated urban elements present in the study area and are subsequently classified as designer-managed or public-sector-managed according to the institutional and organizational arrangements through which their illumination was produced and managed. This distinction enables the study to examine not only physical outcomes but also differences in design responsibility, review, implementation, and corrective mechanisms.

Field Observation

Field observation provides direct evidence of the existing physical and visual condition of illuminated urban elements. Repeated daytime and nighttime visits were undertaken within the selected study corridors to document lighting installations, their relationship with streets and buildings, mounting arrangements, spatial distribution, façade conditions, landscape elements, pedestrian environments, and visible infrastructure.

Photographic documentation was used to record both the nighttime performance and daytime visual consequences of the installations. Particular attention was given to glare, excessive brightness, visual obstruction, fixture positioning, exposed cables, façade clutter, lighting uniformity, spatial enclosure, and the relationship between lighting equipment and surrounding architectural and urban elements.

GIS-Based Spatial Analysis

GIS-based spatial analysis was used to quantify the physical relationships between illumination infrastructure and the surrounding urban form. Spatial variables include street width, building height, building setback, pole location, pole spacing, and the relationship between pole height and the dimensions of the street corridor.

The GIS analysis provides a measurable basis for evaluating spatial integration rather than relying exclusively on visual judgement. It also supports comparison between the

observed physical configuration and the spatial relationships and dimensional criteria identified in the literature review.

Questionnaire and Institutional Interviews

A structured questionnaire was administered to professional and public respondents to obtain perceptual information on visual glare, visual comfort, spatial integration, architectural and aesthetic quality, and perceptions of energy utilisation. The questionnaire complemented the physical observations by capturing how the existing illumination environment is perceived and experienced by different groups of users and professionals.

Institutional interviews were conducted at the Addis Ababa City Administration Electric Service Administration Authority (ESAA) and the Mega Project Office, which are directly involved in the planning, implementation, coordination, and management of urban corridor development and illumination. The interviews focused on the illumination design and decision-making process, project objectives, technical and spatial considerations, institutional coordination, implementation procedures, monitoring, maintenance, energy utilisation, and approaches to addressing identified lighting deficiencies. The institutional interviews provided contextual and procedural information that could not be established through field observation and questionnaire responses alone, thereby supporting a more comprehensive assessment of existing urban illumination practice.

3.2 Description of the Study Area

The inner-city corridor system of Addis Ababa was selected as the primary study area because it contains a concentration of major corridor redevelopment and beautification interventions involving street lighting, façade lighting, landscape illumination, and other forms of urban illumination.

The study area includes the Bole Airport–Meskel Square axis, the Filwuha–National Palace corridor, and central corridors within Piassa, Churchill Avenue, and Mexico. These areas provide a range of urban conditions in which illumination interacts with streets, buildings, public spaces, vegetation, monuments, and other elements of the urban environment.

The selected corridors therefore provide an appropriate setting for examining the relationship between illumination practice and the physical, architectural, perceptual, and environmental characteristics of the inner-city public realm.

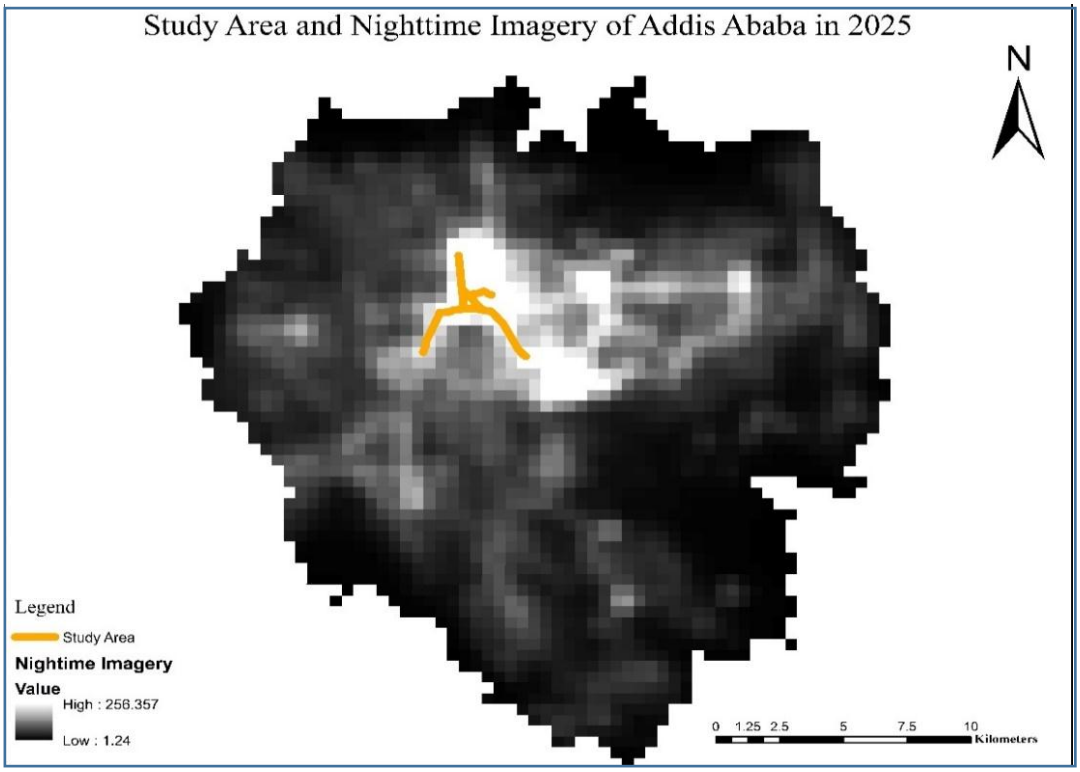


Figure 5. Study area location and night-time imagery of Addis Ababa.

Source. By the author using Arc Map 10.7

3.3 Research Design

The research design establishes the sequence through which the literature-derived evaluation framework is translated into empirical investigation. The process begins by identifying relevant illuminated urban elements and selecting representative cases within the study area. The cases are classified according to their management arrangements and examined through documentary, institutional, physical, spatial, technical, and perceptual evidence.

The investigation examines the relationship between the intended design and the implemented lighting environment. Institutional information from the Addis Ababa City Administration Electric Service Administration Authority (ESAA) and the Mega Project Office provides evidence on project objectives, design decisions, implementation, coordination, monitoring, maintenance, and technical requirements. Field observation and spatial assessment examine how these decisions are reflected in street dimensions, building form, setbacks, architectural character, lighting infrastructure, and public-space conditions, while questionnaire responses provide complementary evidence on visual comfort, glare, aesthetic quality, spatial integration, and energy utilisation.

The analysis proceeds from the design and management process to physical implementation and resulting impacts, enabling assessment of existing conditions, their underlying processes, conformity with established criteria, and mechanisms for addressing deficiencies. Evidence from different sources is then compared and synthesized to identify the principal spatial, architectural, perceptual, environmental, energy, and management implications of current illumination practice.

Overall analytical sequence:

Literature-derived criteria → illuminated urban element selection → case selection → management classification → design and management process → design concept and objectives → implementation → spatial and architectural/perceptual impacts → environmental and energy impacts → comparative synthesis → conclusions and recommendations.

3.4 Research Map

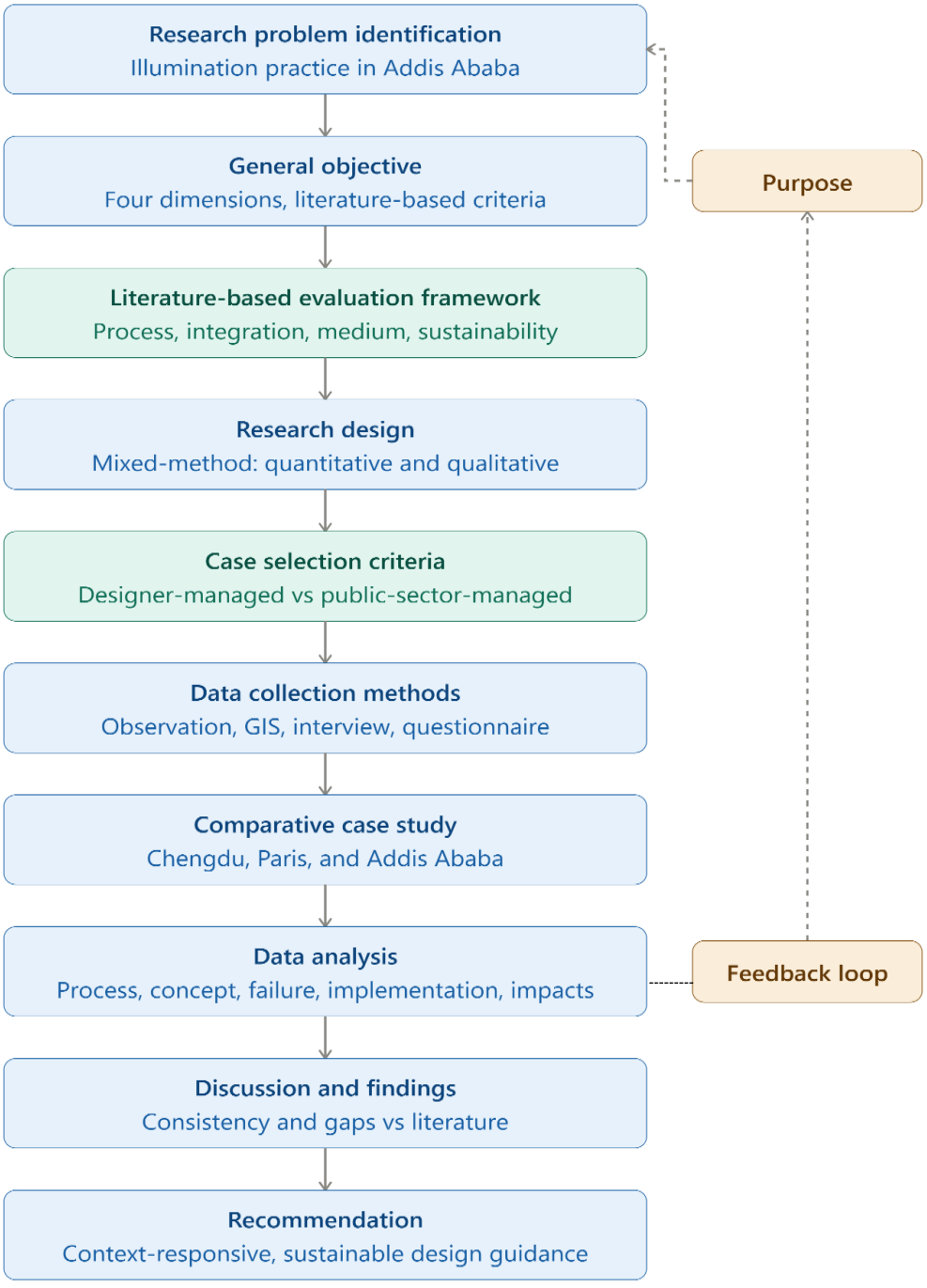


Figure 6: Illustrate research map of the thesis.

Source: Prepared by the author.

3.5 3.4 Types of Data

The study distinguishes the types of data according to the nature of evidence required for the evaluation. The principal data types are primary field data, primary perceptual data, institutional and documentary data, and spatial and technical data.

Primary Field Data

Primary field data comprise researcher-generated information obtained directly from the study area. This includes field observations, photographic documentation, identification and counting of lighting installations, and recording of physical relationships between illumination infrastructure and the surrounding urban environment.

The field data provide evidence concerning the actual implementation of illumination and its relationship with streets, buildings, landscape elements, pedestrian areas, and other components of the public realm.

Primary Perceptual Data

Primary perceptual data comprise responses obtained through the structured questionnaire. The questionnaire captures perceptions of glare, visual comfort, spatial integration, architectural and aesthetic quality, and energy utilization.

These data complement the physical observations by identifying how illumination is experienced and evaluated by people who use or interact with the illuminated urban environment.

Institutional and Documentary Data

Institutional and documentary data comprise official standards, manuals, project documents, technical specifications, energy records, and information obtained through institutional engagement.

These data establish the formal requirements, intended objectives, technical characteristics, institutional responsibilities, and operational conditions against which the observed cases can be evaluated.

Spatial and Technical Data

Spatial and technical data comprise measurements and information concerning street width, building height, building setback, pole height, pole spacing, fixture arrangement, luminous output, electrical power, and operating conditions.

Where sufficient information was available, technical and simulation-based assessment was used to examine illumination levels, distribution, and energy-related performance. These data provide quantitative evidence for evaluating spatial relationships and sustainability performance.

3.5 Data Sources

Three principal sources of empirical evidence were used in the study: **documents, people, and illuminated urban elements**. These sources correspond to the formal, human, and physical dimensions of urban illumination practice identified in the literature review.

Documents

Documentary sources include the Addis Ababa Façade Lighting Standard, AACRA street-lighting documentation and manuals, lighting specifications, energy-consumption records, project documentation, and relevant records obtained from the institutions involved in corridor development and lighting management.

These documents provide evidence of formal requirements, technical specifications, design intentions, institutional responsibilities, energy use, and implementation procedures. They therefore form an important basis for assessing formal-process and regulatory consistency and sustainability-related performance.

People

Human data sources comprise two principal groups.

The first group consists of institutional respondents involved in corridor development, lighting infrastructure, technical implementation, operation, or management. Interviews with relevant officials were used to establish how illumination projects

were initiated, designed, reviewed, coordinated, implemented, monitored, maintained, and, where applicable, corrected.

The second group consists of questionnaire respondents, including built-environment and technical professionals as well as users of the study corridors. Their responses provide evidence concerning the perceptual and experiential consequences of urban illumination.

Illuminated Urban Elements

The physical sources of evidence are the illuminated urban elements located within the selected study corridors. These include:

- Streets and mobility spaces;
- Buildings and façades;
- Walls and boundary elements;
- Trees and landscaped areas;
- Fountains and water features; and
- Monuments and other visually significant urban elements.

The selection of these categories follows the physical elements of the urban public realm identified in Chapter Two. Each element is evaluated according to the characteristics and lighting requirements relevant to its particular function and spatial context.

3.6 Selection of Illuminated Urban Elements and Cases

The selection process consists of two consecutive stages: selection of relevant illuminated urban elements and classification of selected cases according to their management arrangement. This distinction is important because the physical element being studied and the institutional arrangement through which its illumination was produced are separate methodological considerations.

Selection of Illuminated Urban Elements

An illuminated urban element was considered eligible for inclusion when it met the following criteria:

- it was located within the defined inner-city study corridors;

- it represented one of the urban-element categories identified in the literature review;
- it contained an identifiable artificial-lighting intervention;
- its physical and spatial relationship with the surrounding urban environment could be observed or measured;
- sufficient information was available to examine its design, implementation, or management; and
- the installation provided evidence relevant to at least one of the four evaluation domains established in Chapter Two.

These criteria ensured that the cases were selected because they were analytically relevant to the research questions rather than solely because they were visually prominent or easily accessible.

Classification of Cases by Management Arrangement

Following the selection of relevant illuminated urban elements, cases were classified according to the arrangement through which their illumination was designed and managed.

Designer-managed cases: Refer to installations for which the design and implementation were primarily directed by a professional design team working for a private property owner or developer. The Sheraton Addis Hotel façade illumination represents this category in the study.

Public-sector-managed cases: Refer to installations associated with public urban development, corridor redevelopment, or public infrastructure programmes in which public institutions have substantial responsibility for planning, technical approval, implementation, operation, maintenance, monitoring, or correction. Street and corridor lighting associated with public corridor redevelopment represents this category. The purpose of this classification is not to establish statistical representativeness but to enable an analytical comparison between different production and management arrangements. The two categories allow the research to examine whether differences in institutional responsibility, design review,

implementation, and corrective mechanisms are reflected in the resulting illumination conditions.

3.7 Institutional and Stakeholder Framework

The institutional dimension of the research examines the organizations involved in planning, technical implementation, operation, maintenance, and management of urban illumination. The institutional framework is considered in terms of management capacity, management instruments, management scope, and management strategy**.**

Addis Ababa City Administration Electric Service Administration Authority (AAESA)

AAESA was examined in relation to public lighting infrastructure, electrical services, operational responsibilities, technical requirements, and maintenance practices associated with the study cases. Its role is particularly relevant to understanding the operational and infrastructure dimensions of public-sector-managed illumination.

The institutional evidence collected from AAESA was used to examine the organization's capacity, available technical instruments, operational responsibilities, monitoring practices, and approaches to maintenance and correction.

Addis Ababa City Roads Authority (AACRA)

AACRA was considered in relation to road and corridor development, technical specifications, construction implementation, and coordination of lighting infrastructure associated with road projects. Its documentation provides evidence concerning the technical standards and construction requirements applicable to street-lighting interventions.

Where institutional responsibilities overlap, the research does not assume that one institution independently controls the entire lighting process. Instead, the institutional relationships identified through documentary evidence and interviews are used to establish how responsibility is distributed across planning, design, construction, operation, and maintenance.

Addis Ababa Mega Projects Office / Corridor Development Project Committee

The Mega Projects Office and relevant corridor-development bodies were examined in relation to corridor planning, urban design objectives, beautification programmes, project coordination, and implementation of large-scale inner-city interventions.

Their project documentation and interview responses provide evidence concerning the objectives and intended design outcomes of corridor redevelopment and the coordination between urban design, infrastructure, and lighting requirements.

Management Dimensions

The institutional investigation examines four management dimensions.

Management capacity concerns the institutional ability to plan, design, review, coordinate, implement, monitor, operate, maintain, and correct illumination systems.

Management instruments include plans, design guidelines, technical manuals, regulations, standards, approval procedures, technical specifications, inspection procedures, maintenance procedures, and other formal tools used to control illumination practice.

Management scope concerns the spatial and organizational level at which illumination is managed, ranging from individual properties and buildings to streets, public spaces, corridors, districts, and the wider city.

Management strategy concerns the broader approach used to achieve and maintain desired nighttime conditions, including lighting master planning, coordination between public and private lighting, energy management, maintenance, monitoring, operating schedules, and corrective action.

These four dimensions enable the institutional evidence to be connected directly to the formal-process and sustainability domains established in Chapter Two.

3.8 Sampling Design

Perceptual data were collected using a stratified purposive sampling approach with a total sample of 280 respondents (N = 280). Purposive sampling was used because the research required respondents with either professional knowledge of the built environment or lighting, or direct experience of the study corridors.

The respondent groups included academic youth, pedestrians, and technical professionals. Academic youth constituted 248 respondents (88.6%), pedestrians constituted 12 respondents (4.3%), and technical professionals constituted 20 respondents (7.1%).

The professional group included relevant built-environment and technical backgrounds such as architecture, urban design, planning, and electrical engineering. Public respondents were included to capture everyday perceptions of the illuminated environment.

The questionnaire results are therefore interpreted primarily as evidence of perceptual tendencies within the selected respondent groups, rather than as a statistically representative survey of the entire population of Addis Ababa.

3.9 Methods of Data Collection

Several complementary methods were employed to collect the required evidence. The methods were selected according to the type of information needed to evaluate each dimension of the research framework.

Structured Questionnaire

A structured questionnaire was administered to the selected sample of 280 respondents. A five-point Likert scale was used to assess perceptions of visual glare, visual comfort, spatial integration, architectural and aesthetic quality, and energy utilization.

The questionnaire provides perceptual evidence that complements physical observation and technical analysis. It was particularly important for evaluating the

extent to which the observed illumination conditions were experienced as visually comfortable, spatially integrated, aesthetically appropriate, or unnecessarily intensive.

Field Observation and Visual Documentation

Repeated daytime and nighttime field visits were undertaken across the selected corridors. Photographs were taken to document illumination conditions, fixture arrangements, relationships with buildings and streets, façade effects, landscape illumination, glare, visual clutter, exposed infrastructure, and other physical characteristics.

Daytime observations were particularly important because some consequences of illumination infrastructure, such as fixture clutter, cables, poles, brackets, and equipment attached to façades, remain visible even when the lighting system is not operating.

Spatial and Technical Measurement

Spatial measurements were undertaken using field information and GIS-based mapping. Street width, building height, building setback, pole height, pole spacing, and fixture location were recorded or derived where appropriate.

Technical information concerning fixture wattage, luminous output, lighting arrangement, and operating duration was also collected where available. These data were used to assess the relationship between installed lighting and the physical dimensions of the corridor and to examine energy-related implications.

Institutional Interviews

Structured and semi-structured interviews were conducted with relevant institutional representatives. The interviews focused on:

- how illumination projects were initiated;
- who participated in design and decision-making;
- the intended design concept and objectives;
- how technical requirements were established;

- how design proposals were reviewed or approved;
- how implementation was coordinated;
- how deficiencies were identified;
- whether corrective mechanisms existed;
- how operation and maintenance were undertaken; and
- what institutional or technical constraints affected implementation.

For public-sector-managed cases, particular attention was given to whether an identified design deficiency was recognized, reported, reviewed, corrected, or left unresolved.

Documentary and Secondary Data

Documentary evidence was collected from relevant institutions and supplemented by standards and academic literature. The documentary review included lighting standards, design manuals, project documentation, technical specifications, energy records, and relevant institutional records.

The documentary evidence was compared with interview responses and the observed physical condition to identify agreement or divergence between formal requirements, stated intentions, and actual implementation.

3.10 Data Analysis Framework

The data analysis framework translates the four evaluation domains developed in Chapter Two into specific analytical categories that can be examined through the collected evidence.

The analysis proceeds through seven interconnected categories.

Illumination Design Process

The first category examines how the illumination intervention was initiated and produced. It considers who initiated the project, who developed the design, who established the design requirements, who approved or reviewed the proposal, how

different institutions or stakeholders were coordinated, and who was responsible for implementation.

The principal evidence consists of institutional interviews, project documents, standards, and technical records. The analysis establishes the relationship between the formal development process and the resulting illumination intervention.

Illumination Design Concept

The second category examines the intended purpose and concept of the illumination. It considers whether the lighting was intended primarily for visibility, safety, architectural expression, beautification, identity, branding, commercial communication, landscape enhancement, or a combination of these objectives.

The intended concept is compared with the actual lighting arrangement and with the literature-based principles concerning illumination as a medium through which urban space and architecture are perceived and experienced.

Illumination Design-Failure Management

The third category examines how deficiencies in illumination design or implementation were identified and managed. This category is particularly relevant to public-sector-managed cases where formal institutions have responsibility for reviewing, monitoring, maintaining, or correcting public interventions.

The analysis considers whether deficiencies were identified, who was responsible for identifying them, whether complaints or technical observations were formally recorded, whether corrective action was undertaken, and whether identified problems remained unresolved.

This category distinguishes between a design problem**,** an implementation problem**,** and a management or corrective-action problem**,** rather than treating all observed deficiencies simply as design failures.

Illumination Design Implementation

The fourth category compares the intended design concept and applicable technical requirements with the actual as-built condition.

The analysis examines fixture type, location, mounting height, spacing, distribution, electrical power, luminous output, operating conditions, façade treatment, landscape illumination, and visible infrastructure. Photographs, field observations, GIS data, technical specifications, and simulation results are used where applicable.

This comparison identifies divergences between intended design**,** technical requirement**,** and implemented condition**.**

Spatial Impact

The fifth category evaluates the relationship between illumination infrastructure and the physical structure of the urban corridor. Indicators include street width, pole height, pole spacing, setback from building edges, building height, pedestrian space, spatial enclosure, and the relationship between lighting infrastructure and surrounding built form.

GIS measurements and field observations provide the principal evidence. The analysis determines whether illumination infrastructure is appropriately scaled and positioned within the spatial structure of the corridor.

Architectural and Perceptual Impact

The sixth category examines how illumination affects the visual and experiential qualities of buildings and public spaces. It considers architectural expression, visual hierarchy, façade coherence, identity, legibility, glare, visual comfort, clutter, contrast, and the relationship between individual illuminated elements and the wider nighttime environment.

Photographic observation and questionnaire responses are combined to compare physical visual conditions with user and professional perceptions.

Environmental and Energy Impact

The seventh category evaluates the environmental and operational implications of illumination. It considers electrical power demand, luminous output, operating duration, lighting intensity, targeting, control systems, energy utilization, maintenance requirements, and opportunities for adaptive or reduced-energy operation.

Institutional energy records, fixture specifications, technical calculations, simulation, and field observations are used to establish the relationship between installed lighting systems and energy performance.

Relationship between the Analysis Framework and the Four Evaluation Domains

The seven analytical categories are organized under the four broader evaluation domains developed in Chapter Two.

Evaluation domain	Main analytical categories	Principal Evidence
Formal-process and regulatory consistency	Design process; design-failure management; implementation	Documents, interviews, standards, project records, observation
Spatial and visual integration	Design concept; implementation; spatial impact	GIS, photographs, field observation, technical data
Illumination as a medium of architectural and urban perception	Design concept; architectural/perceptual impact	Photographs, observation, questionnaire, project intentions
Sustainability and operational management	Implementation; design-failure management; environmental/energy impact	Energy records, technical specifications, interviews, observation, simulation

Table 6. Relationship between the Analysis Framework and the Four Evaluation Domains

Source: Developed by the researcher based on the analytical framework established in Chapter Two

This framework ensures that the empirical analysis does not treat illumination simply as a technical lighting problem. Instead, each case is examined as the outcome of a relationship among design intention, formal process, physical implementation, spatial context, human perception, and operational management.

3.11 Data Validation, Triangulation and Reliability

Data validation was undertaken by comparing evidence obtained from different sources and methods. Documentary requirements and technical specifications were compared with institutional interview responses and the physical conditions observed in the study corridors. Similarly, perceptual questionnaire findings were compared with photographic evidence, field observations, spatial measurements, and technical information.

Triangulation was therefore used to establish convergence or divergence among three principal forms of evidence: what the documents require, what institutional actors report, and what is physically and perceptually observed**.**

For example, where excessive lighting was identified as a potential problem, the assessment was not based solely on visual impression. The observation was considered together with technical characteristics such as fixture wattage and luminous output, spatial conditions, operating duration, and questionnaire responses concerning glare or visual comfort.

The same principle was applied to spatial integration. Observed proximity between lighting fixtures and buildings was assessed using spatial measurements and photographic evidence, while questionnaire responses were used to determine whether the physical condition corresponded with perceived visual or spatial discomfort.

This cross-checking process strengthens the reliability of the findings by reducing dependence on a single source of evidence. It also enables the research to distinguish between discrepancies arising from design intention, implementation, institutional management, and user perception.

The final interpretation therefore results from the convergence of documentary, institutional, physical, spatial, technical, and perceptual evidence, consistent with the mixed-method and case study design of the research.

3.8 Data Validation and Reliability

Data Validation

The conduct of data validation through two methods which involved assessing technical standards and documented information from EAAS and comparing those standards to the actual implemented output of the study area. The researchers used respondent feedback to determine the differences which existed between the established lighting standards and the actual lighting conditions in the environment.

Data Reliability

Data reliability was confirmed by comparing and cross-checking responses obtained from both professionals and members of the general public. The use of multiple data collection methods, including questionnaires, interviews, and field observations, also helped improve the consistency and dependability of the study

Study reliability increased through multiple data collection methods, which included questionnaire surveys and field observations and photographic documentation and institutional reports and informal interviews. Research findings obtained from one method were continuously checked against information derived from other sources to confirm their accuracy and consistency. The observations of excessive brightness and façade lighting conditions and corridor spatial quality were verified through cross-checking with both respondent perceptions and technical lighting data collected from relevant institutions.

The observation process improved through multiple field observations which were conducted at various locations during nighttime conditions because this method established better observational consistency while reducing chances of making temporary or misleading interpretations. The research team utilized standardized questionnaires together with structured observation procedures to ensure consistent data collection methods throughout their fieldwork. The study achieved enhanced research credibility through triangulation because it established research consistency which resulted in more reliable research outcomes.

Chapter Four

4 Result

4.1 Overview of Empirical Findings

The empirical investigation identified a consistent difference between the intended role of urban illumination and the conditions observed in the inner-city corridors of Addis Ababa. The findings indicate that illumination has become an important component of corridor beautification, but its implementation is not consistently integrated with the spatial structure of the street, the architectural character of buildings, or the environmental and operational requirements of the nighttime city.

The evidence was obtained from field observation, spatial analysis, technical and energy assessment, institutional information, and questionnaire responses. Across these sources, four interconnected findings emerged. First, street-lighting infrastructure frequently operates at a scale and intensity that is not adequately related to street width, building height, setback, or the visual hierarchy of the corridor. Second, façade lighting is often added as a separate intervention rather than being integrated with the original architectural design, resulting in visual fragmentation and daytime infrastructure clutter. Third, high installed wattage, long operating periods, and limited adaptive control create significant energy and lifecycle concerns. Fourth, although public institutions have established responsibilities for design implementation, follow-up, maintenance, and monitoring, the evidence indicates a gap in independent design review and systematic corrective management.

The investigation also identified a contrasting building-supply-managed case, represented by Sheraton Addis, where façade illumination demonstrates a stronger relationship between architectural form, fixture placement, lighting control, operation, and maintenance. This case provides an important local reference for understanding the potential of a more integrated approach to façade illumination rather than treating it solely as a decorative addition. The results therefore show that the principal problem is not simply the presence of artificial illumination but the way illumination is conceived, positioned, implemented, reviewed, and operated within the urban environment.

4.2 The Concept of the Illumination Project

The illumination project in the inner-city corridors of Addis Ababa was conceived not simply as a technical lighting intervention, but as part of a broader urban development and beautification initiative intended to improve the city's nighttime image and experience. Institutional evidence indicates that the project was associated with corridor development and beautification, with ESAA/AAESA involved in the technical provision, implementation, monitoring, follow-up, and maintenance of lighting infrastructure. The project therefore pursued several interconnected objectives, including strengthening landmark identity, enhancing urban aesthetics, supporting safety and security, encouraging nighttime activity, and contributing to the image of Addis Ababa as a modern and increasingly smart city.

Landmark Identity and Urban Image

One important objective of the project was to strengthen the identity and recognition of major urban corridors and landmarks after dark. Illumination can emphasize important buildings, streets, public spaces, and urban nodes, contributing to a recognizable nighttime image. However, the findings indicate that identity cannot be achieved through brightness or repetitive decorative lighting alone. The extensive application of similar lighting forms and patterns can reduce the distinctiveness of individual places rather than strengthen it. Landmark identity therefore depends on contextual, place-specific, and architecturally responsive illumination**.**

Aesthetic Enhancement and Architectural Expression

A second objective was to improve the aesthetic quality and visual attractiveness of the inner-city environment through decorative street and façade lighting. The findings, however, reveal a distinction between achieving visual impact and achieving architectural integration. Several façade lighting installations were irregularly arranged or insufficiently related to windows, structural divisions, cornices, and other architectural elements. Similarly, large decorative street-lighting structures sometimes competed visually with surrounding buildings. The project consequently produced a strong nighttime visual presence, but this did not consistently result in architectural coherence and streetscape quality**.**

Safety and Security

Safety and security represent another major justification for nighttime illumination. Appropriate lighting can improve visibility for pedestrians, vehicles, entrances, and public spaces and support safer nighttime movement. The findings, however, demonstrate that safety is not achieved simply through increased brightness. Excessive intensity, glare, inappropriate positioning, and strong contrasts can reduce visual comfort and interfere with pedestrian and vehicular visibility. Lighting positioned close to building edges and pedestrian areas was observed to create glare and visual obstruction. Effective safety lighting therefore requires controlled, appropriate, and context-sensitive illumination rather than maximum brightness**.**

Nighttime Economy and Urban Activity

The project can also be understood in relation to nighttime economic and social activity. Improved visibility and attractiveness can encourage people to remain active in commercial corridors and extend the functional use of urban spaces beyond daylight hours. However, continuous illumination throughout the night does not necessarily correspond to actual patterns of activity. Observations of manually operated façade lighting remaining active for extended periods indicate the need to match lighting operation with nighttime activity levels. Effective nighttime illumination should therefore incorporate appropriate scheduling, dimming, and adaptive operation rather than maintaining maximum illumination throughout the entire night.

Smart-City Integration and Lighting Management

The illumination project also reflects Addis Ababa's broader ambition toward technologically supported urban management. ESAA/AAESA's use of IoT-based monitoring and a Situation Room to identify non-functional decorative street lights demonstrates a transition toward digitally supported lighting management. This provides a mechanism for monitoring infrastructure and initiating maintenance interventions. However, smart lighting can extend beyond fault detection to include adaptive control, energy management, dimming, and performance monitoring. The findings therefore suggest that technological capacity exists, but its integration with energy management and context-responsive urban lighting remains limited**.**

Overall Project Concept and Implementation Gap

Taken together, the illumination project was intended to improve Addis Ababa's nighttime image, strengthen landmark identity, enhance aesthetics, support safety, encourage nighttime activity, and contribute to the city's modernization. The key analytical issue is therefore not the validity of these objectives, but how effectively they were translated into design, implementation, and management practices**.** The findings indicate that responsibilities for implementation, maintenance, monitoring, and technical management are identifiable, while stronger mechanisms are still needed to evaluate whether illumination achieves its intended objectives without compromising spatial quality, architectural identity, visual comfort, environmental performance, and energy efficiency**.**

4.2.1 Institutional Roles in Illumination Design

The illumination process is connected to the broader street and corridor development process. The Addis Ababa Design and Construction Works Bureau provides the designed street or corridor, establishing the physical framework within which the lighting system is subsequently arranged. ESAA/AAESA then undertakes the street-light layout based on the provided street design, including decisions concerning the arrangement, form, and height of lighting poles. This demonstrates that illumination is institutionally connected to the physical development of the corridor rather than being implemented independently from the street-development process.

At the same time, the sequence indicates an important distinction between **street design** followed by lighting layout **and** lighting as an integrated component of urban and street design from the beginning**.** The distinction becomes significant because the physical characteristics of the corridor—including street width, building height, building setback, pedestrian movement, landscape elements, and architectural form—directly influence the appropriate scale, position, intensity, and visual character of lighting infrastructure. The subsequent spatial analysis therefore examines whether the technical lighting layout adequately responds to these contextual conditions.

4.2.2 Illumination Design and Technical Layout

Following the provision of the street design, ESAA/AAESA is involved in determining the arrangement of the street-lighting system. This includes the positioning and form of decorative poles and consideration of pole height. These technical decisions have direct consequences for the relationship between lighting infrastructure and the surrounding street volume, building edges, pedestrian areas, and architectural environment.

The field investigation assessed these relationships through the physical characteristics of the implemented corridor. The results demonstrate that the existence of a technical lighting layout does not necessarily ensure contextual integration. In particular, the subsequent analysis identifies relationships between street width, pole height, building height, pole setback, visual dominance, and glare. These findings demonstrate the difference between technical provision of illumination and urban-design integration of illumination**.**

4.2.3 Implementation and Follow-Up

The institutional evidence confirms that ESAA/AAESA is involved not only in the technical arrangement of decorative street lighting but also in its implementation and subsequent follow-up. This indicates the existence of an operational management responsibility extending beyond the initial installation of the lighting infrastructure.

The finding is important because it changes the interpretation of the management problem. The study does not identify a complete absence of institutional involvement or operational responsibility. Rather, the existing system demonstrates stronger evidence of implementation and operational follow-up than of systematic review of the design quality of illumination in relation to the wider urban environment

4.2.4 Maintenance and IoT-Based Monitoring

Maintenance forms an established component of the illumination management process. ESAA/AAESA undertakes maintenance of decorative street-lighting infrastructure following implementation. In addition, the authority uses IoT-based monitoring and a Situation Room to identify non-functional decorative street lights.

This creates a mechanism for detecting operational failures and supporting maintenance responses.

The presence of this system demonstrates an important operational capacity within the existing illumination-management structure. Lighting management therefore extends from installation into the operational stage through follow-up, maintenance, and technological monitoring. However, operational monitoring primarily addresses whether lighting infrastructure is functioning. It does not necessarily establish whether a functioning lighting system is appropriately positioned, proportioned, shielded, energy efficient, architecturally integrated, or compatible with the surrounding urban environment.

4.2.5 Design Review and Corrective-Management Gap

The principal gap identified from the institutional and field evidence concerns the design-review and corrective-management stage. The available evidence establishes responsibilities for street design, lighting layout, implementation, follow-up, maintenance, and operational monitoring. However, it does not sufficiently demonstrate a distinct and independently structured stage through which the completed illumination design is systematically evaluated against spatial, architectural, visual, environmental, safety, and energy criteria before or during implementation.

This distinction is particularly important because many of the problems identified in the study are not equipment failures. A lighting pole may operate correctly while being too close to a building edge; a luminaire may function correctly while producing excessive glare; a façade lighting system may remain fully operational while failing to reveal the architectural form; and a lighting system may operate continuously while consuming more energy than necessary. Such conditions cannot be adequately addressed through maintenance alone.

The resulting gap is therefore better understood as a design and design-review separation problem rather than as an absence of management. The existing system provides operational management, but the design-quality dimension requires a stronger mechanism for independent review, identification of deficiencies, and

corrective action. This distinction is consistent with the field findings, which show conflicts between lighting infrastructure and building form, excessive visual dominance, façade clutter, and high lighting intensity despite the existence of institutional implementation and maintenance responsibilities.

4.2.6 Overall Sequence of the Illumination Design and Management Process

Based on the institutional evidence, the illumination process can therefore be represented as:

City/corridor development concept → street and corridor design → illumination project objectives → lighting layout and technical design → implementation → follow-up → maintenance → IoT/Situation-Room monitoring

The analysis identifies a missing or insufficiently formalized link between technical design and implementation:

Design → Independent design review → Correction/modification → Implementation

The strengthened process emerging from the findings can therefore be expressed as:

City/corridor development concept → street design → illumination concept and objectives → lighting design → independent design review → corrective action → implementation → performance monitoring → maintenance and continuous improvement.

This sequence provides the basis for interpreting the subsequent findings. It shows that the central issue is not whether Addis Ababa has an illumination-management system, but whether the existing system sufficiently connects the **conceptual objectives of** beautification, identity, safety, nighttime activity, and smart-city development **with the** spatial, architectural, environmental, energy, and operational performance of the implemented lighting**.**

4.3 Comparative Analysis of Street Lighting and Corridor Spatial Relationships: Addis Ababa, Chengdu Tianfu, and Paris Montaigne

The spatial relationship between street lighting and the surrounding built environment was comparatively examined in the Chengdu Tianfu, Paris Montaigne, and Addis Ababa inner-city corridor case studies. The comparison focused on the relationship between **street-light heights, building height, setback from the building edge, and the overall volume of the street corridor**. These factors were considered important in determining whether street lighting functions as an integrated element of the streetscape or becomes visually dominant and intrusive. The comparison therefore provides a contextual basis for assessing the spatial compatibility, visual comfort, and architectural relationship of the lighting systems within different urban corridor settings.

Chengdu Tianfu Corridor

The Chengdu Tianfu Corridor demonstrates a relatively coordinated relationship between street-lighting elements and the surrounding corridor volume. The height and positioning of the street lights are combined with appropriate setback and green-buffer spaces, allowing the lighting elements to remain visually integrated with the surrounding buildings and landscape. The relationship between pole height, building mass, and street width creates a relatively balanced streetscape proportion. The separation between the luminaires and building edges also helps reduce direct visual intrusion and potential glare, allowing the architectural form and corridor landscape to remain visually legible at night.

Paris Montaigne Avenue

Paris Montaigne Avenue provides another example of a relatively proportional relationship between street lighting and the existing streetscape. The placement and scale of the lighting elements are coordinated with the corridor's architectural character, building frontage, and street-space dimensions. The appropriate setback from building edges prevents the lighting infrastructure from becoming excessively dominant within the pedestrian field of view. Consequently, the street-lighting

elements contribute to the nighttime character of the avenue while maintaining a clear visual relationship with the surrounding architectural and urban elements.

Addis Ababa Inner-City Corridor

In contrast, the placement of street lighting within the Addis Ababa inner-city corridor demonstrates a weaker spatial relationship with the surrounding built environment. The lighting infrastructure was generally positioned close to building edges without sufficient consideration of the relationship between pole height, building height, building setback, and corridor width. As a result, the lighting elements become visually prominent within the street scene rather than functioning as coordinated components of the overall spatial structure.

Glare and visual discomfort: The close positioning of high-intensity street lights to building edges increases the exposure of pedestrians and other users to direct and reflected light. This condition contributes to excessive glare and reduces visual comfort within the corridor.

Visual obstruction: The high brightness and close positioning of lighting elements can obstruct views of surrounding architectural features and reduce the visual clarity of building façades and other streetscape elements. Instead of supporting the perception of the architectural environment, the lighting infrastructure can become a dominant foreground element.

Contextual height mismatch: The height of the street-lighting elements was not consistently coordinated with the height and mass of surrounding buildings. Where tall or highly illuminated poles are positioned close to building edges, they can visually compete with the building mass and create a sense of dominance within the corridor scene.

Spatial relationship: Unlike the Chengdu Tianfu and Paris Montaigne examples, where lighting placement demonstrates greater consideration of setback, scale, and corridor volume, the Addis Ababa case indicates a weaker integration between lighting infrastructure and the existing spatial structure. This suggests that the lighting system was implemented primarily as an illumination and beautification intervention

rather than as an integrated component of the corridor's urban and architectural design.

Spatial criterion	**Chengdu Tianfu**	**Paris Montaigne**	**Addis Ababa Inner-City**
Pole height vs. building height	Relatively coordinated	Proportionally integrated	Contextual mismatch
Setback from building edge	Adequate	Appropriate	Very close/insufficient
Relationship with corridor volume	Balanced	Well integrated	Visually dominant
Green/landscape buffer	Present	Limited/controlled	Limited
Visual obstruction	Low	Low	High
Glare potential	Controlled	Controlled	High
Architectural visibility	Maintained	Maintained	Partially obstructed
Overall spatial integration	High	High	Low

Table 7. Street lighting comparison in Chengdu, Paris and Addis Ababa

Source. Author analysis based on the comparison result

4.4 Spatial Context Mismatch and Conflict between Public Infrastructure and Private Architecture

The comparative spatial analysis of Chengdu Tianfu, Paris Montaigne, and the Addis Ababa inner-city corridor demonstrates that the effectiveness of urban illumination is not determined only by lighting intensity or fixture performance, but also by how lighting infrastructure is positioned within the existing spatial structure of the corridor. In the Chengdu Tianfu and Paris Montaigne cases, the relationship between street-light height, building height, setback, street width, and surrounding landscape contributes to a relatively balanced corridor volume. In contrast, the Addis Ababa case demonstrates a weaker spatial relationship, where lighting infrastructure is frequently positioned close to building edges and becomes visually dominant within the corridor.

This condition indicates a structural mismatch between public infrastructure requirements and private architectural boundaries. Instead of coordinating street-lighting infrastructure with building setbacks, property boundaries, building heights, pedestrian space, and the overall corridor volume, the lighting system has been inserted into an already constrained spatial environment. The resulting condition produces physical and visual competition between municipal infrastructure and private architecture, compromising the volumetric order and visual coherence of the streetscape.

The problem is therefore not simply the presence of street lighting, but the absence of an integrated spatial framework for determining where lighting should be located, how high it should be, how far it should be from building edges, and how its scale should relate to the surrounding built form. This represents a planning and design gap in which illumination has been treated primarily as an infrastructure and beautification intervention rather than as an integrated component of urban spatial design.

4.7.1 Spatial Context Mismatch: Setback, Height, and Streetlight Proportion

The geometric relationship between street-light infrastructure and the surrounding built envelope is a critical determinant of corridor spatial quality. The comparative

analysis shows that appropriate setback and proportional height allow lighting elements to remain visually subordinate to, or appropriately coordinated with, the surrounding architectural and landscape structure. Conversely, inadequate setback combined with excessive fixture height or brightness can transform lighting infrastructure into a dominant foreground element.

In the Addis Ababa inner-city corridor, the close positioning of high-intensity lighting structures to building edges creates a compressed relationship between the public right-of-way and the private architectural envelope. This reduces the visual separation normally required between infrastructure and buildings and contributes to a fragmented streetscape. The condition is particularly problematic where building setbacks are already limited, because the introduction of large lighting structures further reduces the effective visual and physical width of the corridor.

From an urban design perspective, adequate spatial separation between infrastructure and building façades is necessary to maintain pedestrian movement, visual openness, access, maintenance, and a coherent relationship between public and private space (Carmona et al., 2010). Lighting design principles similarly require consideration of the relationship between luminaires, surrounding buildings, viewing angles, and light distribution to minimize glare, unwanted illumination, and visual intrusion (Boyce, 2014).



Figure 7. Illustrate the Base map location of the building where street pole spatially in conflict with context of the building boundary

Source. Author base map extraction and photographed.

4.4.1 Empirical Evidence of Spatial Context Mismatch

The field evidence shown in Figure X demonstrates a clear spatial mismatch between the municipal street-lighting infrastructure and the adjacent building envelope. The street-light pole is positioned extremely close to the building frontage, with little or no visible setback between the pole structure and the private architectural boundary. The upper multi-globed luminaire is also positioned approximately at the level of the building's balcony zone rather than being visually separated from the façade. This condition creates a direct visual relationship between the lighting infrastructure and the residential building envelope, making the pole appear as part of the building frontage rather than as an independent element of the public right-of-way.

The image further demonstrates a mismatch between pole height, building height, setback, and corridor volume**.** Although the adjacent building is a relatively low-rise urban block, the decorative pole and its multiple high-output luminaires occupy a prominent position within the foreground of the building façade. The lighting structure therefore becomes visually dominant rather than functioning as a background infrastructure element. Its close proximity to balconies and windows also increases the potential for direct glare, reflected light, and unwanted illumination within private residential areas.

From the perspective of the ESAA implementation approach, the critical issue is not simply that the pole is located near a property boundary. Street-lighting implementation must respond to roadway illumination requirements, available right-of-way, pole spacing, luminaire position, illumination level, and uniformity. However, the observed condition indicates that the implementation does not adequately translate these technical considerations into a three-dimensional relationship with the surrounding built environment**.** In particular, the relationship between pole height, building height, façade setback, balcony projection, and visual field has not been sufficiently integrated into the installation decision.

This distinction is important: the spatial problem should not be interpreted as a failure of ESAA to provide a street-lighting standard, but as a gap between technical street-lighting implementation and context-sensitive urban design coordination. The existing implementation can satisfy the functional objective of placing and operating street

lighting while simultaneously producing an undesirable spatial relationship with adjacent architecture.

4.4.2 The Implementation Gap

The evidence identifies a spatial coordination gap in the application of street-lighting infrastructure**.** The gap occurs at the point where the technical requirements for street illumination are translated into the physical location and scale of the pole within the built environment.

The implementation can therefore be understood at three levels:

1. Technical implementation: The ESAA approach addresses street illumination through considerations such as roadway function, illumination requirements, pole spacing, luminaire position, light distribution, and available right-of-way.

2. Spatial implementation: The observed installation shows insufficient coordination between these requirements and the physical characteristics of the adjacent building, particularly façade setback, balcony projection, building height, and pedestrian visual space.

3. Urban design integration: There is a missing intermediate design-management layer that evaluates whether the technically feasible pole location is also spatially compatible with the architectural envelope and overall corridor volume**.**

4.4.3 Spatial Infrastructure Mismatch

The empirical evidence demonstrates that the problem is not merely the physical presence of street-lighting infrastructure, but the **lack of spatial integration between public infrastructure and private architecture**. As shown in Figure X, the street-light pole is positioned very close to the building edge, creating an almost continuous relationship between the public infrastructure and the private building envelope. The intermediate height of the multi-globed luminaire also places the lighting element directly within the visual field of the building façade and balconies.

This condition creates three interconnected forms of spatial conflict:

- **Physical conflict:** The pole occupies space immediately adjacent to the building envelope, reducing the spatial separation between public infrastructure and private property.
- **Visual conflict:** The scale and decorative form of the luminaire compete with the architectural façade and become a visually dominant element within the streetscape.
- **Spatial and lighting conflict:** The close positioning of the luminaire to balconies, windows, and façades increases the potential for visual intrusion, glare, reflected brightness, and unwanted illumination of private spaces.

The observed condition therefore indicates a mismatch between the **scale and placement of municipal infrastructure and the spatial characteristics of the surrounding built environment**. The street-lighting element does not sufficiently respond to the building height, façade setback, balcony projection, or the overall volumetric character of the corridor. Rather than functioning as a coordinated component of the public streetscape, it becomes an intrusive element within the architectural foreground.

4.4.4 Design and Management Gap

The spatial mismatch indicates a gap between technical infrastructure installation and context-sensitive urban design management. The existing implementation approach needs to move beyond determining whether a location is technically available for pole installation and consider whether the proposed position is spatially compatible with the surrounding built environment.

A context-sensitive management process should therefore assess the proposed lighting location against the building envelope, building height, pole height, façade setback, balcony projection, street width, pedestrian movement, and visual field before installation.

This provides the basis for a BIM-integrated illumination management approach, in which the existing corridor and proposed lighting infrastructure are modelled together

before construction. Such a process would allow potential spatial conflicts to be identified at the design and approval stage, particularly where a pole is positioned too close to a façade, where its height becomes disproportionate to the adjacent building, or where the luminaire directly overlaps the visual field of balconies and windows.

The management process can consequently shift from:

Available roadside space → pole installation to **Existing urban-form assessment → BIM-based spatial modelling → setback and height assessment → visual conflict assessment → coordinated approval → installation.**

This approach would help establish a more integrated relationship between municipal lighting infrastructure, architectural form, and public right-of-way, reducing the spatial conflict identified in the Addis Ababa inner-city corridor.

Such a process would strengthen coordination between municipal lighting infrastructure, architectural form, and the public right-of-way**,** while reducing the spatial and visual conflicts identified along the Addis Ababa inner-city corridors. It would also move lighting management from a predominantly installation-oriented approach toward an integrated design, assessment, and approval process, ensuring that lighting infrastructure contributes to corridor quality rather than becoming an additional source of spatial conflict.

4.5 Building Setback Mismatch: Light Trespass, Glare, and Visual Conflict

The spatial relationship illustrated in Figure 21 demonstrates a significant mismatch between the location of street-lighting infrastructure and the setback of the adjacent building envelope. The GIS base map establishes the spatial location of the building and roadway, while the corresponding nighttime photograph demonstrates the resulting relationship between the street-lighting installation and the building façade. The lighting source is positioned very close to the building frontage and directly within the visual field of the building openings. This limited spatial separation weakens the distinction between the public right-of-way and the private indoor environment.

The condition demonstrates that building setback is not only a physical planning consideration but also an important factor in nighttime visual comfort and lighting management. Where lighting infrastructure is positioned too close to building façades, the distance available for light distribution and visual separation is reduced. The façade and windows consequently become directly exposed to the lighting source, increasing the potential for glare, reflected brightness, and unwanted illumination within private spaces.

Light Trespass into Private Spaces: The close relationship between the street luminaire and the building openings creates a direct pathway for outdoor light to enter the interior environment. Rather than remaining primarily within the intended public right-of-way, light can extend toward windows and occupied spaces. This weakens the spatial boundary between the public nighttime environment and private indoor areas and may interfere with the normal use and visual comfort of the interior spaces.

Glare and Visual Discomfort: The photograph also demonstrates a strong concentrated brightness around the luminaire. Because the source is positioned close to the façade and within the field of view of building occupants, the bright source can create excessive contrast between the illuminated area and its darker surroundings. This condition can produce visual discomfort and make it difficult for occupants to maintain a comfortable visual connection with the exterior.

Indoor-Outdoor Visual Screening: The relationship between the bright exterior source and the glazed façade can also affect visibility through the windows. Strong exterior brightness and reflections on glass can reduce the clarity of views from inside the building toward the street. In this condition, the window no longer functions effectively as a visual connection between the indoor and outdoor environments. Instead, reflected brightness can dominate the visual field and create a blinding or mirror-like effect, particularly when the observer is looking toward the illuminated façade or street.

The evidence therefore demonstrates that inadequate coordination between building setback and street-lighting placement can produce consequences beyond the physical occupation of the streetscape. It can affect the visual relationship between public and private space, the visibility of architectural façades, and the comfort of occupants within adjacent buildings

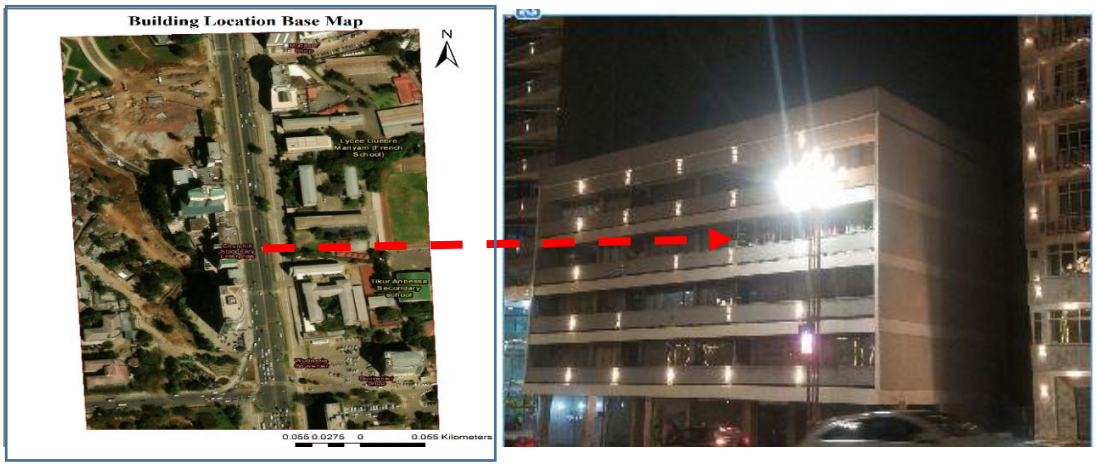


Figure 8. Illustrate street light setback challenge of occupants disconferties

Source. Author Gis basemap generation and photographed

Design and Management Gap

The observed condition identifies a building-setback and lighting-coordination gap in the implementation of street-lighting infrastructure. The problem occurs when the location of the lighting installation is determined primarily from the perspective of the roadway or available public space without sufficiently evaluating the relationship with adjacent building façades, windows, balconies, and private interior environments.

The gap can therefore be understood as a missing spatial coordination stage between street-lighting implementation and building-envelope assessment. A technically feasible location for a street-light pole may still be inappropriate when its relationship with an adjacent building creates excessive visual exposure or intrusion into private spaces.

To address this gap, the lighting design and management process should evaluate the proposed pole location in relation to the existing building envelope before installation. The assessment should consider:

Building setback → façade and window location → pole position → pole height → luminaire orientation → viewing angle → potential glare and light trespass.

This process can be incorporated into a BIM-integrated illumination management framework, allowing the proposed lighting infrastructure and surrounding buildings to be assessed together before installation. The model can identify locations where luminaires are positioned directly in front of windows, where inadequate setback creates excessive visual exposure, or where the lighting structure conflicts with the architectural envelope.

The management approach should therefore shift from:

Roadside space available → install street light to: **Assess building and street relationship → identify suitable lighting zone → establish setback → coordinate pole height and luminaire orientation → assess façade and window exposure → approve installation.**

This approach would help maintain a clear spatial distinction between public lighting infrastructure and private architectural space**,** while allowing street lighting to perform its functional role without becoming a source of visual intrusion. The finding consequently reinforces the need for integrated spatial planning and design management of urban illumination**,** rather than treating street-lighting installation as an independent utility intervention.

4.6 Aesthetic Visual Competition between Street Lighting and the Building Background

The visual character of a corridor can be influenced by the relationship between street-lighting infrastructure and the surrounding architectural background. A well-integrated streetscape requires lighting elements to support the spatial character of the corridor without competing with its architectural form. As Lynch argues in *The Image of the City*, the legibility and imageability of an urban environment depend on the clarity and visual coherence of its paths and the elements that define them. In this context, street lighting should contribute to the identity of the corridor while maintaining an appropriate visual hierarchy with the buildings behind it.



Figure 9. Illustrate structural conflict of street light and background building bole corridor

Source. Fana Broadcasting Agency X page

The case shown in the figure demonstrates a contrasting condition. The highly ornate, multi-globed street-light poles form strong vertical and decorative elements against contemporary high-rise buildings with relatively simple and minimalist façades. Because the lighting structures are repeated continuously along the corridor and occupy a prominent position within the foreground, they compete visually with the architectural background rather than simply complementing it. The contrast between the elaborate lighting elements and the restrained architectural forms becomes particularly evident during daytime, when the decorative fixtures are visible as physical objects rather than primarily as sources of nighttime illumination.

The main design problem is therefore not the use of decorative lighting itself, but the absence of sufficient visual coordination between the lighting elements and the architectural context. The repeated poles establish a strong foreground pattern that can interrupt views toward building façades and reduce the clarity of the corridor's architectural composition. Their complex geometry also introduces additional visual information into an already dense urban scene.

This finding indicates a streetscape design and management gap. Street-lighting infrastructure appears to have been treated as an independent decorative element rather than as part of a coordinated visual hierarchy involving the roadway, landscape, pedestrian space, and architectural background. A context-sensitive approach should therefore establish criteria for the scale, form, spacing, setback, and visual prominence of street-lighting elements in relation to surrounding buildings.

The design-management approach should shift from standardised decorative installations toward context-responsive streetscape design, in which lighting elements are selected and positioned according to the character and visual composition of each corridor. This would allow street lighting to contribute to urban identity without obscuring or competing with the architectural character of the city.

The design-management approach should shift from standardised decorative installations toward context-responsive streetscape design, where lighting elements are selected and positioned according to the character, scale, and visual composition of each corridor. This requires coordinating fixture form, pole height, spacing, colour, and setback with surrounding buildings so that lighting contributes to urban identity while maintaining architectural visibility and a clear visual hierarchy. The identified gap is therefore the lack of contextual design criteria for integrating public lighting infrastructure with existing architectural form, resulting in repeated decorative elements that can dominate the streetscape rather than complement it.

4.6.1 Chromatic and Tectonic Visual Dominance of Golden Street-Light Elements

From an urban design perspective, the colour, material finish, and physical form of street-lighting infrastructure contribute directly to the visual hierarchy of a corridor. As Albers explains through the principle of colour interaction, the perception and visual weight of a colour depend on its surrounding context. In the study area, the strong golden-yellow finish and warm illumination of the decorative street-light elements contrast sharply with the predominantly neutral grey and muted façades. This contrast increases the visual prominence of the lighting infrastructure, causing it to compete with rather than complement the architectural background. The resulting **design and management gap** is the absence of contextual criteria for coordinating the colour, material, form, and visual intensity of street-lighting elements with surrounding architecture. An urban design approach should therefore treat lighting infrastructure as part of the overall streetscape composition, selecting finishes and forms that reinforce the character of the corridor while reserving stronger decorative colours for strategic locations such as gateways, landmarks, and focal spaces



Figure 10. Illustrate the golden chromatic dominance& visual competition of the street light along bole corridor

Source. Fana Broadcasting X page

4.6.5 Structural Form, Scaling, and Linear Perspective Enclosure

From an urban design perspective, the physical form, height, and repetition of street-lighting elements influence how the spatial structure of an urban corridor is perceived. As Lynch emphasizes in *The Image of the City*, the legibility and imageability of a street depend on the clarity of its path and the coherence of the elements that define it. The two views in Figure below illustrate how changes in the relationship between the lighting structure and the architectural background can alter the perceived scale and visual enclosure of the corridor.



Figure 11. Demonstrate Side-by-Side Analysis of Streetscape Scaling and Structural Profile Shifts.

Source. Author capture photograph 2025

In the left image**,** the street-lighting elements remain relatively subordinate to the surrounding building mass and the broad street space. Their scale and position allow the buildings, roadway, landscape, and pedestrian environment to remain visually dominant. In the right image**,** the closer alignment of the decorative pole with the building façade makes its structural form and vertical scale much more apparent. The pole visually intersects the building mass and becomes part of the foreground framework through which the corridor is perceived. This creates a stronger sense of visual enclosure and introduces an additional vertical rhythm that competes with the architectural structure.

The difference demonstrates that street-lighting form cannot be assessed independently from viewing distance, building scale, street width, and the linear perspective of the corridor**.** Heavy ornamentation, multiple luminaire arms, and oversized structural profiles increase the visual mass of the infrastructure and can make it appear disproportionately prominent, particularly when positioned directly in

front of large building façades. Conversely, simpler and more proportionate forms can support the continuity of the street without unnecessarily interrupting the architectural background.

The resulting urban design and management gap is the lack of criteria for coordinating the structural form and scale of street-lighting elements with the surrounding built environment. Lighting infrastructure should therefore be managed as part of the corridor's spatial composition, with pole height, structural profile, luminaire size, spacing, setback, and repetition assessed against building height, street width, and the desired visual perspective. A context-responsive approach would allow lighting elements to establish rhythm and identity while maintaining the legibility, openness, and architectural continuity of the urban corridor.

The empirical comparative field evidence presented provides a clear material manifestation of the change in the visual and spatial character of the National Theatre corridor before and after renewal. The pre-renewal condition shows slender, clean-profiled, and relatively unornamented street-light poles that functioned as subordinate infrastructure, allowing the surrounding mid-rise and high-rise buildings to remain visually dominant and preserving the vertical and horizontal rhythms of the corridor (Baker, 2012; Forty, 2000). In contrast, the post-renewal installation introduces heavier, multi-tiered poles with expansive multi-armed decorative crowns, increasing the physical and visual mass of the infrastructure. This condition reflects the concept of decorative inflation, where excessive detailing transforms a functional element into a visually dominant foreground structure (Forty, 2000). Their repeated placement along both sides of the corridor creates a strong vertical rhythm that intersects the linear perspective of the avenue and forms a dense visual layer against the architectural background. As noted by Narboni (2016) and Salingaros (2005), such increased visual mass can interrupt the continuity of building façades and weaken the legibility of the corridor. From an urban design perspective, the comparison therefore demonstrates a shift from subordinate and context-responsive infrastructure toward visually dominant decorative infrastructure**,** creating a design-management gap in the control of pole scale, structural complexity, spacing, and relationship with the surrounding building envelope.

4.7 Façade Lighting and Architectural Expression: Design Coordination and Implementation Gap

Field observations revealed that façade lighting along the inner-city corridor is largely determined by individual building owners and property managers, resulting in considerable variation in fixture type, placement, colour, intensity, and lighting composition. Although façade lighting can enhance nighttime visibility and contribute to building identity, its effectiveness depends on how well the lighting responds to the architectural composition of the building. In several observed cases, lighting was applied directly to building surfaces or edges without sufficient coordination with windows, structural divisions, façade proportions, and other architectural features.



Figure 12. Illustrate the façade lighting practice observed in the study area

Source. Author photographs captured in 2025

As illustrated in Figure 12, some buildings use continuous linear lighting to emphasize vertical and horizontal architectural edges, while others illuminate large portions of the façade without clearly relating the lighting pattern to the building's

structural composition. These different approaches demonstrate that façade lighting is not simply an electrical installation but also a component of architectural expression and the nighttime visual character of the corridor. Where lighting is excessively continuous, fragmented, or poorly coordinated with the building form, the lighting itself can become more visually prominent than the architectural features it is intended to reveal.

The finding therefore indicates a façade-lighting design and implimentation gap rather than simply an infrastructure problem. Unlike public street lighting, façade lighting is primarily initiated and controlled by building owners, developers, and property managers. Consequently, its integration with the wider urban environment depends on the availability and application of appropriate design guidance and coordination during building design and approval. From an urban design perspective, façade illumination should be considered as part of the architectural composition, with fixture location, colour, intensity, and lighting pattern coordinated with the building's structural form and its relationship to the surrounding streetscape.

The implimentation approach should therefore move from individual building-based lighting decisions toward context-responsive façade-lighting design**,** where building owners, architects, and relevant municipal authorities coordinate the treatment of façades with the character of the corridor. This would allow façade lighting to strengthen architectural identity and nighttime legibility while avoiding fragmented or visually excessive illumination.

The results indicate that the location, spacing, and arrangement of façade lighting fixtures strongly influence the nighttime perception of buildings. Although effective façade lighting should enhance architectural form, proportions, rhythm, and character, many observed buildings showed discontinuous and poorly coordinated lighting, resulting in fragmented illumination, visual clutter, and reduced aesthetic quality. The observations also revealed low compliance with the façade lighting requirements of the Addis Ababa City Administration Building Permit and Control Authority, which emphasize integrating lighting with architectural design. Overall, the findings indicate that façade lighting is often treated as an independent element rather than part of the architectural design process, limiting its contribution to a coherent and visually pleasing nighttime urban environment.

4.7.1 Empirical Field Analysis: Gap between Façade Lighting Guidance and Physical Implementation

Field observation of the selected building demonstrates a clear gap between the principles established in the Addis Ababa façade-lighting regulatory framework and their physical implementation. The regulatory framework emphasizes the coordinated placement and spacing of façade luminaires according to the selected lighting technique, with the objective of achieving an appropriate and continuous illumination of the building surface while maintaining architectural expression. However, the observed installation presents a predominantly fixture-oriented approach in which individual luminaires appear to have been added to the façade without sufficient integration with the building's structural and architectural composition.

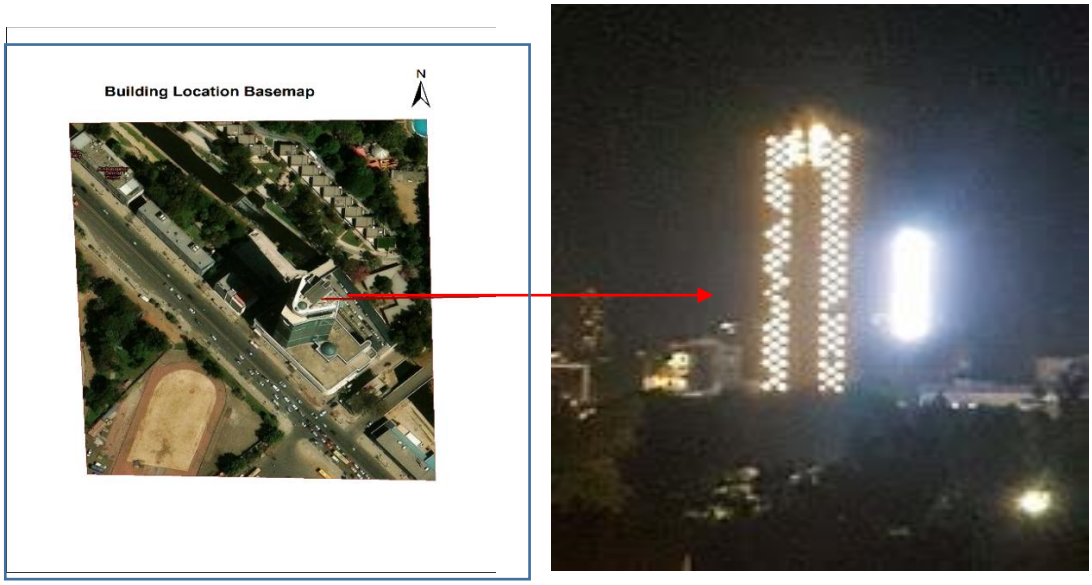


Figure 13. Demonstrate grid wall-mounted lighting on the (Nani) building facade

Source. Autore basemap generation and photography

The façade is characterized by a dense and repetitive arrangement of point-source luminaires forming a visible grid across the tower. While the local regulatory framework provides maximum spacing requirements for different façade-lighting techniques, the observed installation appears to prioritize the repetition of individual light sources rather than the controlled revelation of the building's architectural form. The fixtures do not clearly correspond with the tower's major structural divisions, vertical bays, or façade articulation. As a result, the lighting pattern becomes visually independent from the building's underlying geometry. This represents an

implementation gap between fixture placement and architectural integration**,** where the lighting system functions primarily as a decorative layer rather than as an integrated component of the façade design.

A second issue is the lack of visual hierarchy between the different lighting elements. The dense point-source lighting on the tower is accompanied by an intensely luminous vertical element on the adjacent façade. The substantially higher apparent brightness of this element draws immediate visual attention and competes with the illuminated tower, making the overall façade composition difficult to read as a unified architectural image. Rather than establishing a coordinated hierarchy in which lighting reinforces the building's principal architectural features, the different lighting elements appear to operate independently. This condition is important in relation to the regulatory principle of coordinated façade illumination. The local framework identifies fixture spacing and lighting technique as important parameters for achieving controlled façade illumination. In the observed case, however, the visual prominence of the individual fixtures remains greater than the architectural effect produced by the lighting **system**. The building is therefore perceived partly through a pattern of luminous points rather than through the deliberate revelation of its mass, structural rhythm, verticality, and façade articulation.

The field observation also indicates that compliance with a spacing requirement alone would not necessarily guarantee good architectural lighting**.** Even where individual fixtures may fall within an allowable physical interval, their arrangement, orientation, intensity, colour, and relationship to the building's architectural elements need to be considered collectively. The observed façade illustrates this distinction: the lighting is continuous and highly visible, but continuity of fixtures does not automatically produce continuity of architectural expression. Effective façade lighting should instead establish a relationship between the location of the luminaire and the architectural feature that it is intended to reveal.

This condition indicates an implementation and design-coordination gap between the regulatory framework and existing practice. Although the framework provides guidance on fixture spacing and lighting treatment, the installation shows limited architectural integration and does not sufficiently respond to the building’s structural and architectural composition. Consequently, individual fixtures become more visually prominent than the architectural form itself, creating visual fragmentation and an unclear nighttime hierarchy across the façade.

4.7.2 Excessive Brightness and Loss of Architectural Depth

Architectural lighting is most effective when it establishes a deliberate balance between light and shadow, allowing building form, depth, texture, and material characteristics to remain visually legible (Boyce, 2014). In contrast, excessive and continuously distributed illumination can suppress these qualities by creating an almost uniform luminous surface. This principle is particularly relevant to the observed façade along Churchill Avenue, where the extensive use of linear LED strips and closely spaced wall-mounted luminaires produces a high and relatively continuous level of brightness across the building envelope. Rather than selectively revealing architectural elements, the lighting becomes the dominant visual feature of the building, reducing the distinction between projecting and recessed surfaces and weakening the perception of façade depth.

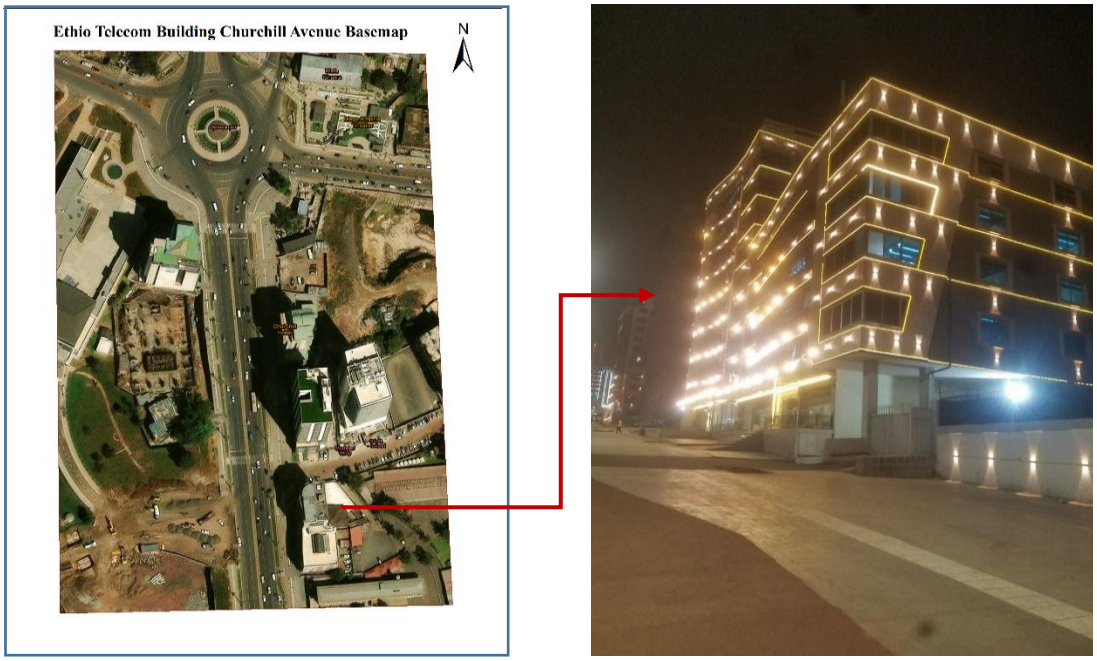


Figure 14. Excessive Façade Illumination and Its Impact on Architectural Expression
Source: Author's basemap generation and field photograph

Empirical Field Analysis

The field observation illustrates a common tendency in façade illumination in which increased brightness is treated as an improvement in nighttime appearance. In the observed building, the façade is illuminated through a dense combination of continuous linear LED strips along the building edges and multiple bidirectional wall-mounted luminaires. The close spacing and repetition of these elements create overlapping zones of illumination, producing a relatively uniform luminous

appearance across several façade levels. Consequently, the lighting gives greater visual prominence to the light fittings themselves than to the architectural features they are intended to reveal.

The resulting condition can be described as an over-brightness flattening effect. The strong and repetitive illumination reduces the contrast between illuminated and shaded surfaces, making balcony projections, wall planes, recesses, and other changes in façade geometry less visually distinct. Instead of using shadow to articulate the three-dimensional character of the building, the lighting visually compresses these elements into a predominantly luminous surface. This weakens the perception of depth and reduces the ability of nighttime lighting to communicate the building's architectural hierarchy.

A further concern is the loss of material and surface expression**.** The concentration of luminous elements and their reflections across the façade produce areas of intense brightness that compete with the underlying colour, texture, and finish of the building materials. As a result, the façade is perceived primarily through its emitted and reflected light rather than through the architectural qualities of its surfaces. The lighting therefore functions more as a continuous visual outline than as a controlled system for revealing architectural form.

This condition is particularly significant within the inner-city corridor because individual buildings contribute collectively to the nighttime visual character of the street. When façade lighting is excessively bright and continuously applied, it can compete with neighbouring buildings and street-level lighting, increasing visual clutter and reducing the distinction between architectural elements. The observed case therefore demonstrates that façade illumination does not necessarily improve architectural expression through increased brightness**.** Without appropriate control of intensity, spacing, distribution, and contrast, excessive illumination can instead obscure architectural depth, diminish material legibility, and reduce nighttime visual comfort.

4.7.3 Empirical Field Evidence: Structural Linear Distortion via Over-Glow

A key tenet of architectural lighting is that a lighting system should reveal and support the structure of a building, underlining its volumes, the articulation of its façades, its window rhythms, and its tectonic depth. Municipal design codes similarly encourage the use of vertical and horizontal lighting features to "enhance" architectural form rather than "overpower" it. The field evidence shown in Figure 14, however, departs significantly from these principles, resulting in a marked alteration of architectural form.

This architectural flattening is characterized by an uncalibrated application of linear perimeter lighting that erases the façade's true geometry. Instead of modeling three-dimensional form through strategic shadow, continuous over-glow strips away recessed window rhythms and structural columns. The immense luminance emitted by unshielded LED strips creates an aggressive optical frame that dominates the viewer's field of perception, washing out the building envelope's authentic material expression and tectonic depth under a uniform, unyielding layer of glare.



Figure 15. Demonstrate over glow linear LED strip light distorting architectural features

Source. Author photograph in 2025.

- **Structural highlighting is replaced by perimeter outlining:** linear lighting is applied continuously around the outer edges of the building envelope rather than emphasizing key architectural elements.

- **High-power LED strips are installed with excessive luminance:** producing brightness levels that exceed the visual requirements for architectural accentuation.
- **Tectonic and material expression is suppressed:** the overwhelming light output obscures façade materials, depth variation, and architectural detailing.

The field evidence further demonstrates that installing linear LED systems without adequate design control or regulatory oversight contributes to structural distortion. In both examples in Figure 14, high-intensity light strips are wrapped directly around the exterior boundaries of the buildings, creating a luminous frame that visually overwhelms the architecture. Because these luminaires lack appropriate shielding and emit excessive, uncalibrated light, they generate significant over-glow that blurs the visual boundaries of the façades — concealing recessed windows, structural columns, and surface textures rather than revealing them.

As a result, the buildings lose their perceived depth and material richness, while their architectural identity is reduced to a simplified geometric outline. This produces a tectonic collapse in visual perception, transforming three-dimensional architectural forms into flat, two-dimensional sources of glare and undermining the intended relationship between lighting and architecture.

4.7.4 Regulatory Deviations in Architectural Lighting: The Gap between Statutory Mandates and Field Practice

The structural and photometric consistency of a city's nightscape relies on the uniform enforcement of municipal design standards. When private developers install lighting systems without strict regulatory supervision or long-term follow-up, the corridor's visual order breaks down, turning what should be a coordinated architectural presentation into an unmapped series of structural distortions.

This statutory enforcement failure is clearly visible where unmonitored private installations undermine municipal spatial planning. Instead of following standardized guidelines, individual building envelopes become sites of uncalibrated photometric experimentation. This lack of oversight allows conflicting lumen intensities and unshielded fixtures to disrupt the physical clarity of the streetscape, exposing a major gap between the city's written design rules and actual field conditions along the corridor.

This policy-to-practice divide is evident when analyzing the specific building façades documented below:

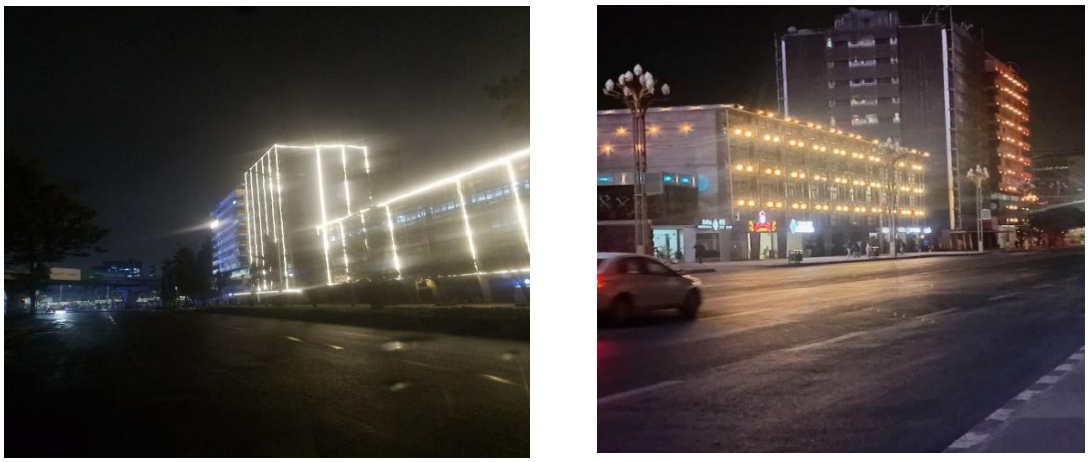


Figure 16. Lighting compliance gap between regulation and field practice

Source: Author photograph, inner-city corridor, 2025.

The empirical data collected across the study corridors reveals a systemic failure to implement the city lighting manual's core directives. Instead of coordinated architectural lighting, private developments operate independently, producing fragmented night-time visual conditions. This gap between regulation and practice can be summarized into four key categories:

- **Regulatory vs. Practical Divergence:** Lighting regulations call for coordinated architectural accent lighting, glare control, and a form-sensitive illumination strategy, while field practice shows isolated decision-making that departs from these principles.
- **Uncontrolled Lighting Application:** Field observation indicates widespread use of ad-hoc LED strips, excessive lumen outputs, and façade-washing techniques that ignore architectural form and design intent.
- **Lack of Standardization and Context Awareness:** As shown in the figure applied façade lighting varies significantly in lumen intensity and installation method across buildings, without regard for the structure of the building.
- **Urban Visual Outcome and Spatial Impact:** The inconsistent practice produces a chaotic visual image, undermines corridor legibility, and directly conflicts with the city's goal of a unified, readable, and sustainable nighttime identity. Collectively, these conditions result in photometric disorder, where buildings function in isolation rather than as part of a coherent urban lighting system.

The structural breakdown detailed across these four dimensions highlights a profound disconnect between statutory design intent and empirical field execution along the urban corridor. When private architectural developments bypass formalized municipal guidelines, the resulting unplanned deployment of LED strips, uncalibrated lumen outputs, and uncoordinated façade washing transforms a shared public nightscape into an array of isolated, competing structures. This regulatory enforcement deficit strips the corridor of its visual legibility and structural cohesion. Resolving this persistent policy-to-practice divide requires transitioning away from isolated private developer decision-making and toward a strictly monitored, unified municipal lighting framework that treats individual building envelopes as interconnected components of a sustainable, cohesive urban identity.

4.7.5 Sustainability and Lifecycle Challenges Replacement of Façade Lighting Fixtures

Sustainable urban design requires that building infrastructure operate under strict circular-economy and life-cycle management principles, minimizing technological waste and structural maintenance costs (design-for-deconstruction principles). The Addis Ababa City Administration explicitly ties modern façade lighting mandates to resource conservation and operational longevity, expecting lighting systems to remain stable and sustainable over time.

A major hidden challenge to sustainability identified during field audits is the architectural shift toward sealed LED fixtures. In legacy lighting systems, a burnt-out component simply required a quick, low-cost bulb replacement. The contemporary installations documented across the study sites, however, are manufactured as sealed fixture modules: once an internal diode, driver, or lens fails, the entire physical fixture must be detached and discarded.

This engineering limitation creates a heavy financial and operational burden for property owners along the corridors. It causes premature system abandonment, generates excessive electronic waste, and directly undermines the municipal goal of establishing sustainable, energy-conscious, long-lasting nighttime infrastructure.



Figure 17. Demonstrate unsustainable burnout lighting fixture requires a complete replacement

Source. Author photograph in 2026

4.7.6 Maintenance Accessibility and Façade Degradation

Architectural technology literature indicates that any building utility added to an exterior envelope must feature a clear lifecycle maintenance strategy, taking into account safe physical accessibility, architectural preservation, and ease of technical repair without defacing the primary building skin.



Figure 18. Illustrate unsustainable lighting fixtures placed on the entire surface, challenging for maintenance or replacement for disfunctioning lighting.

Source. Author photograph in 2026

The field configurations shown in the above figure reveal significant spatial and logistical difficulties in maintaining fixtures over time. These modular lighting arrays are added to high vertical surfaces as an architectural afterthought, with no built-in maintenance paths, integrated utility catwalks, access-panel openings, or recessed structural tracks.

- **The Accessibility Bottleneck:** When a high-rise fixture fails on the façade, as shown in Figure 17, changing it is disruptive and costly: it requires aftermarket equipment capable of reaching the height, which obstructs active pedestrian walkways and corridor traffic lanes.

Façade Degradation during Repair: Because maintenance is difficult to execute safely, building owners either allow broken fixtures to remain dark indefinitely creating fragmented patches of unlit exterior skin or workers are forced to make uncoordinated, unsafe alterations directly on the exterior finish. This lack of a structured lifecycle plan turns maintenance into an ongoing threat to the building's safety, economic value, and architectural appearance

4.7.7 Daytime Visual Impact of Exposed Façade Lighting Infrastructure

Architectural theory emphasizes that the building envelope must maintain formal purity and tectonic order during the day, ensuring that any integrated utility system remains visually secondary to the primary architectural expression. The Addis Ababa City Administration Building Permit and Control Authority establishes that professional lighting interventions must preserve a clean façade surface, avoid structural cluttering, and align with the visual integrity and "truth of material" of the building substrate. When lighting components are added as an uncoordinated retrofit, they violate these guidelines and introduce visual noise that degrades the image ability of urban corridors during daylight hours.



Figure 19. Demonstrate unintegrated façade lighting on the exterior surface

Source. The author photographed in 2026.

The physical reality captured in Figure 18 demonstrates how unregulated aftermarket installations permanently degrade the architectural skin during the day. Instead of hiding wiring infrastructure within structural reveals or internal conduits, standard field practice relies on pinning heavy, uncoordinated electrical networks directly onto the outer building finish.

- **Façade Fragmentation and Grid Distortion:** As documented in Figure the installation of a matrix-style exterior lighting system has forced a dense web of exposed wiring conduits and structural anchors onto a textured natural finish. This industrial clutter disrupts the vertical rhythm and curved geometry of the large arched windows, replacing a clean architectural composition with a chaotic, overlapping network of black utility lines that act as permanent visual noise under daytime sunlight.

- **Surface Cluttering and Substrate Damage:** The right panel of Figure highlights a similar issue on a modern painted surface, where arbitrary vertical and horizontal loops of exposed surface conduit fracture the solid wall plane and are pinned insecurely with repetitive plastic anchor clips. This creates severe daytime visual pollution and long-term physical vulnerabilities: drill holes and mechanical penetrations slice through the weather barrier, leading to water retention, paint peeling, and localized substrate staining.
- The structural omission of recessed internal conduits introduces severe municipal safety hazards along the public right-of-way, substantially increasing the vulnerability to accidental electrical shorts, fire outbreaks, and mechanical snagging. Because these electrical networks are pinned externally along lower building envelopes and adjacent pedestrian property lines, they are directly exposed to weathering, unauthorized tampering, and accidental physical impact.

- Over time, environmental degradation breaks down the insulation of these surface-mounted utility lines, while loose, sagging conduit loops present an immediate tripping hazard for pedestrians and a snagging risk for passing maintenance equipment. By leaving live, unprotected wiring runs easily reachable within high-density corridor zones, these non-standard field installations transform decorative architectural systems into significant public safety liabilities that threaten both the structural integrity of the property and the physical well-being of the public.

This empirical evidence demonstrates that when façade lighting is installed without structural integration, it creates a severe aesthetic conflict — a utility system designed to enhance the urban nightscape ends up defacing, cluttering, and physically degrading the building's architectural identity throughout the day.

4.8 Energy Implications of Urban Illumination Practice

The energy implications of urban illumination in the inner-city corridor are examined by relating the installed lighting infrastructure, its luminous performance, operating duration, and management practices to the functional requirements of the street environment. The analysis considers both the publicly implemented street-lighting system and privately operated architectural façade lighting, since these two components collectively contribute to the nighttime energy demand of the corridor. Rather than treating energy consumption as an isolated technical issue, the analysis considers how lighting capacity, spatial requirements, fixture configuration, operating schedules, and management practices interact to influence the efficiency of urban illumination.

For the public street-lighting system, the prescribed illuminance requirement and implementation of street lighting are undertaken through the Addis Ababa City Administration Electric Service Administration Authority (ESAA). Therefore, the observed energy implication should not be interpreted simply as a failure to comply with the prescribed lux requirement. Instead, the analysis examines the relationship between the prescribed functional requirement and the capacity and configuration of the installed lighting system. This distinction is important because compliance with an illuminance requirement does not necessarily guarantee energy-efficient lighting if the installed electrical capacity, luminous distribution, fixture configuration, or operating regime is excessive relative to the spatial function of the corridor. In parallel, façade lighting is largely influenced by individual building owners and therefore presents a different institutional and management condition.

4.8.1 Structural Energy Efficiency Gap between Installed Capacity and Optimized Benchmark

To quantify the structural energy-efficiency gap across the wider study area, the total connected load of the 968 implemented street-lighting poles (*P* actual) was compared with an IES-based optimized baseline (*P*IES) of 180 W per pole. This comparison does not imply that ESAA's prescribed lux requirement is itself excessive. Rather, it demonstrates the extent to which the installed electrical capacity and fixture configuration exceed the capacity represented by an optimized lighting benchmark**.**

To quantify the structural energy efficiency gap across the wider study area that the total actual connected load (P_{actual}) of the 968 street light poles is mathematically balanced against the optimized IES-compliant base line wattages (P_{IES}):

- Actual connected system load (P_{actual}):

  P_{actual} = 968 poles × 770 W = 745,360 W= 745.36kw

- Targeted IES baseline connected load (P_{IES}):

  P_{IES}= 968 poles ×180W= 174,240 W=174.240kw

- Absolut Structural Power Surplus:

  $\Delta P = P_{actual} - P_{IES=}$ 745.36 kW- 174.240 kW= 571.12 kw

The initial calculation reveals a structural power of 571.12 kW. This indicates that 76.6%of the total electric capacity is tied up in the corridor's street lighting infrastructure, which directly exceeds international engineering benchmarks for safe arterial illumination.

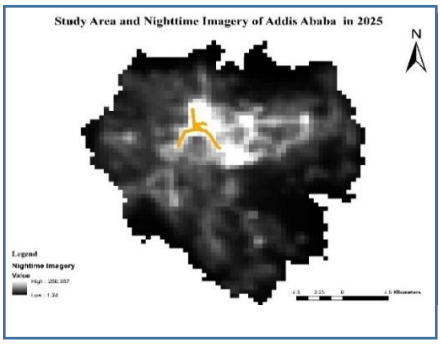




Figure 20. Demonstrate the inner-city corridor where decorative street light

Source. Author GIs processing and photograph

Empirical Operational Energy Overutilization Analysis

By cross-referencing the recorded monthly billing data provided by the municipal electric utility against the theoretical energy footprint required by IES guidelines, we can isolate the exact volume of monthly and annual energy waste:

- Actual Recorded Monthly Consumption ($E_{actual\ monthly}$).

  334,334 Kw/month

  $$\Delta t_{nightly} = \frac{334{,}334\ \text{Kw/month}}{745.36\text{kW} \times 30 days} \approx 14.91\ \text{hours/night}$$

  This extended operational baseline indicates a significant daylight burn cycle or a complete lack of photocell shutoff controls across the grid.

- Target IES-compliant Monthly Consumption($E_{IES_monthly}$)

  $E_{IES_monthly}$= 174.24kW× 14.91 hours/night× 30 days= 77,933.1kWh/month

Systemic Waste Metrics and Municipal Impact

Comparing these two operational footprints exposes a severe drain on the municipal energy source.

- Monthly overutilization Surplus:

  $\Delta E_{\text{monthly}} = 333{,}334\text{kW} - 77{,}933.1\text{kWh/month} = 255{,}400.9\text{kWh/month}$

- Projected Annual Environmental and Grid Waste:

  $E_{wasted_annual} = 255{,}400.9\text{kWh/month} \times 12 \text{ months} = 3{,}064{,}810.8\text{kWh/year}$

Summary for the analysis Fixture wattage Vs. IES Standards

The macro-scale empirical calculations expose a profound energy and structural conflict within the corridor's lighting infrastructure. The key driver of this overutilization is the uncalibrated dual-distribution design of the implemented street poles. Rather than directing light exclusively onto the roadway, each luminaire draws a massive **770 Watts**, which is internally split into:

- **A 500-Watt Downward Component:** Intended for pavement illumination.
- **A 500-Watt Downward Component:** Intended for pavement illumination.

When evaluated against the IES RP-8-21 performance standard for Primary Arterial Streets (PAS) with high pedestrian conflict, this configuration presents a severe technical mismatch. An IES-compliant, optimized system utilizing high-efficacy LED luminaires requires an average of only **180 Watts** per pole to achieve safe, uniform horizontal ground illuminance.

By comparing the actual system deployment of **968 street poles** and the verified monthly municipal consumption of **333,334 kWh** against the IES benchmark, the following systemic impacts are quantified:

- Systemic Power Overshoot: The total connected load of the study area reaches 745.36 kW, outstripping the optimized international benchmark of 174.24 kW by an absolute surplus of 571.12 kW. This means 76.6% of the grid capacity allocated to these streetlights directly exceeds international engineering recommendations.
- The Upward Energy Burden: Across the 968 poles, the 270-Watt upward-facing component alone draws a continuous 261.36 kW of power. This means

35.1% of the total municipal energy consumption is strictly dedicated to throwing unshielded light upward into the atmosphere and against building facades, rather than illuminating the driving or walking planes.

- Macro-Level Resource Waste: This layout forces a monthly excess consumption of 255,400.9 kWh, translating to an annual grid waste of 3,064,810.8 kWh/year.

In conclusion, the data demonstrates that the corridor's street lighting network operates at **4.27 times** the energy volume required by international safety standards. Instead of translating this massive power draw into useful roadway visibility, the structural split of the fixture misallocates **261.36 kW** of continuous power into the upper vision line.

The component does not contribute to traffic safety; instead, it converts public electricity into ambient light pollution, severe disability glare, and destructive visual competition that washes out the architectural facades lining

4.8.2 Energy Performance of the Implemented Street-Lighting System

Implemented street-lighting system is influenced not only by the prescribed illuminance requirement but also by the capacity, configuration, distribution, and operation of the installed luminaires. Although ESAA establishes and implements the technical lighting requirement for public streets, the analysis indicates a visible variance between this requirement and the energy capacity embodied in the implemented decorative lighting system. The following analysis therefore examines this relationship by considering the installed load, lighting configuration, and operational practice of the street-lighting system. From a design and management perspective, the energy performance of the

4.8.2.1 Overutilization of Lighting Power Relative to Street Hierarchy Requirements

Evaluating the quantitative relationship between installed electrical capacity and functional illumination thresholds reveals a significant systemic misalignment along the studied corridor. To establish an empirical baseline for this inner-city corridor, the spatial parameters and inventory data are mathematically cross-examined against international benchmarks and localized administrative requirements.

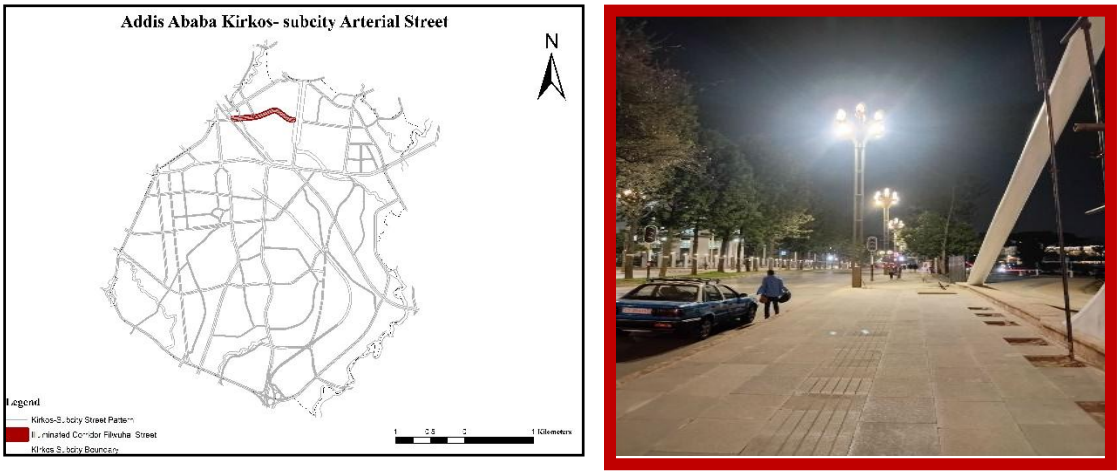


Figure 21. Shows area map and street lighting condition of the Secondary Arterial Street (SAS) corridor from Ambassador to National Palace, Addis Ababa

Source. The author's GIS analysis and photographs

As spatially mapped and delineated by the red corridor buffer, the study area encompasses a total streetscape surface area of 29,756.019 m². Based on the standard illuminance requirement of 10 lux (lumens per square meter) for a Secondary Arterial Street (SAS), the corridor serves as the spatial boundary for evaluating lighting performance. Within this designated area, a dedicated street lighting infrastructure consisting of 58 lighting poles is installed. Each pole operates with an electrical load of 770 W LED luminaires, according to data obtained from the Addis Ababa City Administration Electric Service Administration Authority.

The analyzed corridor extends from the Ambassador area to the National Palace segment. This existing lighting arrangement establishes the baseline operational condition for assessing energy utilization and lighting performance. Accordingly, the system can be evaluated through two analytical dimensions: (1) compliance with illuminance requirements based on the prescribed 10-lux standard, and (2) electrical power demand in relation to the installed wattage load, thereby enabling the identification of potential overutilization in both lighting output and energy consumption.

4.8.2.2 Iluminance Performance Analysis (Lux Level Discrepancy)

The standard illuminating metric assigned for this specific street classification by the Addis Ababa Administration Electric Service Administration Authority is explicitly set at a baseline target value of **10 Lux**. In comparison, international guidelines

provided by the Illuminating Engineering Society (IES) for Major/Arterial Street Classifications specify a functional target range of **10 to 20 Lux** depending on pedestrian activity levels.

To evaluate the extreme parameters of the existing infrastructure, this analysis applies the maximum recommended IES standard benchmark (**20 Lux**) against the localized administrative mandate (**10 Lux**).

The value of the area and number of street poles along the SAS of Filwuha				Lumen Value Per Pole
Street Type	Area in (m^2)	No street Pole along the Corridor	Standard Lux value by ESAA	Up Bulb = 45000 lm Down Bulb= 40000 lm
SAS	29756.019	58	10 Lux	85000 lm

Table 8. Shows SAS of the study area and designated value of Lux by ESAA

Empirical Illuminance Calculation Steps:

To calculate the actual average illuminance ($E_{average}$ in Lux) produced across the corridor's surface area, the standard Lumen Method formula is applied:

$$E_{avg} = \frac{N \times \Phi \times CU \times LLF}{A}$$

Where:

- N = Total Number of Street Poles =58 poles
- Φ = Luminous flux per pole = 85,000 lumens
- A= Total spatial surface area of the = 29756.019m^2
- CU = Coefficient of Utilization (standard structural efficiency factor for public street arm geometry) = 0.45
- LLF = Light Loss Factor (accounting for dirt accumulation and lamp depreciation over time) = 0.80

Step 1: Calculation of Total Generated Lumen

Total Lumens= 58 ×85,000lm= 4,930,000 lumens

The user performed a technical project where he quantified and mapped the 58 street poles along the "Ambassador to National Palace" road using ArcGIS under the

"technical specification of street lighting" of Addis Ababa, after which he set 770 watts (LED) and then 85,000 lm (luminous flux per pole).

Step 2: Calculate Effective Luminous Flux Striking the Road Surface

Effective = 4, 930,000 lumens×0.45×0.85= 1,774,800 lumens

Step 3: Compute the Estimated Actual Average Illuminance (E_{avg})

$$E=\frac{1{,}774{,}800\ \text{lm}}{29756.019\text{m}2} \approx 59.64\text{Lux}$$

Variance of Implemented

$$\text{Illumination} = \left(\frac{\text{Actual Value}-\text{Targeted Value}}{\text{Target Value}}\right)$$

Where:

- Actual Estimated Level 59.64 Lux
- Targeted Value(Addis Ababa Authority Mandate)= 10 Lux

Absolute difference (the surplus illumination)

- Surplus Lux= 59.64 Lux−10 Lux = 49.64 Lux

Divide the Surplus by the Original Targeted Base Line

$$Ratio\ Over\ Targeted = \frac{59.64\ Lux-10\ Lux}{10\ Lux} = 4.964$$

The ratio of the percentage Variance = 4.964×100= 496.4%

Interpretation: This means the actual lighting level is nearly 6 times higher 596.4% than what the local authority requires, resulting in a net energy and light pollution surplus of 496.4% over the mandatory baseline. This is because of the unguided standard of the electric service authority of the city administration manual.

Variance of Implemented

$$\text{Illumination} = \left(\frac{\text{Actual Value}-\text{Targeted Value}}{\text{Target Value}}\right)$$

Where:

- Actual Estimated Level 59.64 Lux
- Targeted Value IES(International Engineering Society) = 20 Lux

Absolute difference (the surplus illumination)

- Surplus Lux= 59.64 Lux−20 Lux = 39.64 Lux

Divide the Surplus by the Original Targeted Base Line

$$Ratio\ Over\ Targeted = \frac{59.64\ Lux - 20\ Lux}{20\ Lux} = 1.982$$

The ratio of the percentage Variance = 1.982×100= 198.2%

Interpretation: This demonstrates that even when compared to the maximum limits recommended by international engineering standards 20, the corridor's actual lighting output is nearly 3 times higher, 298.2 %, resulting in a net illuminance surplus of 198.2% above the highest recommended international benchmark.

Analysis of Variance

Standard Reference	Targeted Threshold	Actual Estimated Level	Percentage over illumination
Addis Ababa Authority Mandate	10 Lux	59.64 Lux	+496.4%
IES Maximum Guideline (Arterial)	20 Lux	59.64 Lux	+198.2%

Table 9. Illustrate the targeted and the actual practiced level and over illumination percentage of implemented street light

Source. IES and ESAA and analysis result by the author

Electrical Load and Wattage Analysis (Energy Utilization Matrix)

The electrical overutilization within the **29,756.019 m^2** spatial boundary can be quantified by calculating the Lighting Power Density (LPD). The IES standard recommends a maximum sustainable power capacity range of **50W to 100W** per pole for arterial paths. Applying the upper boundary of the standard framework (100W) yields a clear picture of the structural energy deficit:

- Total Installed Corridor Load:

  Total Wattages= 58 Streetlight Poles ×770W= 44,660 watts (44.66kW)

- Maximum IES Recommended Capacity Target (100W/ per pole)
  Targeted Wattage = 58 poles × 100W= 5,800W
- Net Surplus Power Consumption:
  Surplus Load = 44, 660W− 5,860W= 38,850 Watts (38.86kW)

Analayzing the Power Density Relative to the Georeferenced Area of the Street

Current LPD=$\frac{44{,}660\text{W}}{\mathbf{29{,}756.019\ m2}} \approx 1.501 W/m2$

Maximum IES Compliant LPD = $\frac{5{,}800W}{\mathbf{29{,}756.019\ m2}} \approx 0.195 W/m2$

The existing layout draws **more than seven times ≈770%** the electrical power required to satisfy the maximum threshold of international engineering recommendations. When evaluated against the localized 10 Lux standard mandated by the Addis Ababa Electric Service Authority, this surplus energy load represents a profound operational waste. The data confirms that the corridor's lighting configuration operates as an uncalibrated utility load, over-consuming electrical energy to generate unnecessary lumen levels that conflict directly with both municipal standards and sustainable streetscape practices.

4.8.3 Energy Implications of on the Façade Lighting

From a design and management perspective, private façade lighting presents a distinct energy-utilization condition within the inner-city corridor. Although ESAA provides technical instructions and guidance for the implementation of building façade lighting, the actual selection, arrangement, operating schedule, and control of façade-lighting fixtures are largely reflected at the individual building level. The field observations indicate a gap between this intended implementation framework and the observed operational practice, particularly in relation to fixture density, continuous operation, and the limited application of automated control measures. Consequently, façade lighting that is primarily intended to enhance architectural expression and nighttime identity can also create an additional and largely unmanaged electrical load. The following analysis therefore examines this design and management gap through the observed operating pattern of façade lighting and the resulting energy demand.

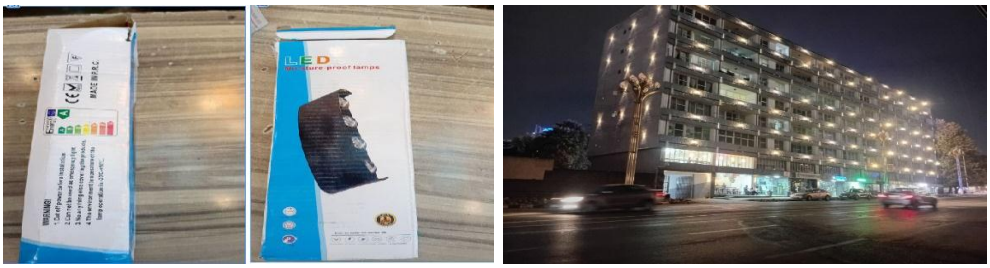


Figure 22. Illustrate an example wall mounted light fixture applied on the building façade along the study area corridor.

Source. Author photograph on the actual building site

Field observations indicate that many of the façade-lighting installations operate as fixed loads, with individual fixtures remaining at full output throughout the observed nighttime period rather than responding to changes in pedestrian activity or nighttime demand. In contemporary architectural lighting practice, façade illumination can be managed through scheduled operation, astronomical timers, photoelectric controls, dimming, or other programmable systems that reduce output during periods of low activity. In contrast, the observed corridor condition was characterized by an approximately 11-hour operating period, with no evident evidence of systematic dimming or late-night reduction in output. This represents a management gap because the energy demand of the decorative lighting is determined not only by the wattage of

individual fixtures but also by the number of fixtures operating simultaneously and the duration for which they remain at full output.

The energy implication becomes more evident when the observed façade-lighting configuration is examined at building level. A representative apartment building within the study corridor was selected to quantify the electrical and economic burden associated with this practice. The façade was configured with 159 point-source luminaires, each rated at 10 W. At an assumed operating duration of 11 hours per night, the total installed lighting load is 1.59 kW. The resulting energy demand was calculated as follows:

Daily energy consumption

E daily = $N \times P \times T$

= 159 × 0.01 kW × 11 hours

= **17.49 kWh/night**

Using the study tariff of 4.00 ETB/kWh, the corresponding nightly operating cost is:

C daily = 17.49 kWh × 4.00 ETB/kWh

= **69.96 ETB/night**

The annual energy demand is therefore:

E annual = 17.49 kWh/night × 365 days

= **6,383.85 kWh/year**

And the corresponding annual operating cost is:

C annual = 69.96 ETB/night × 365 days

= **25,535.40 ETB/year**

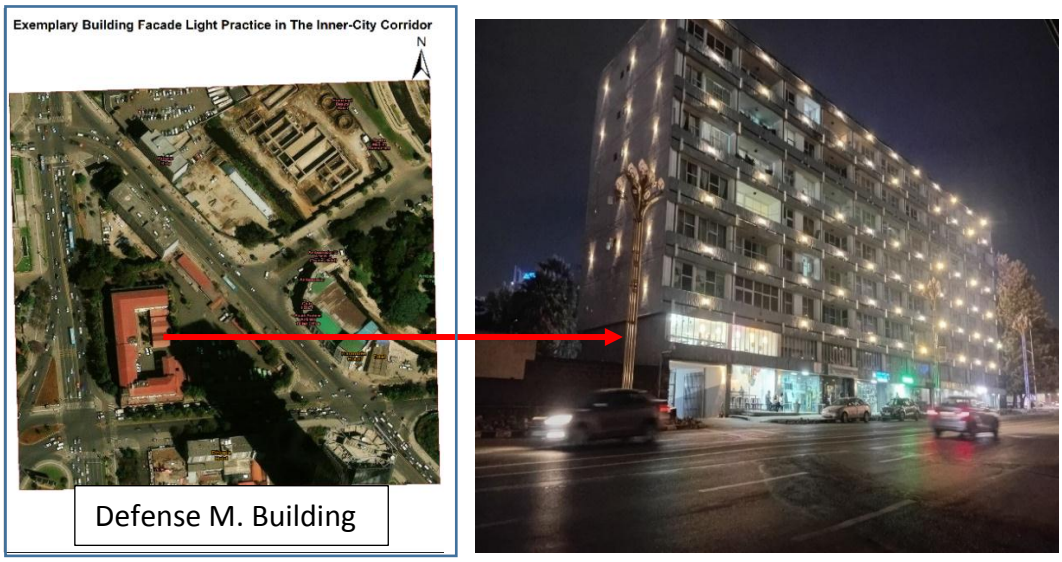


Figure 23. Demonstrate the base map and a building façade lighting practice of energy concern.

Source. Author baseman creation and photographed

These calculations demonstrate that the energy implication is not attributable simply to the use of façade lighting, but to the combination of **fixture quantity, installed wattage, operating duration, and control practice**. A 10 W individual fixture may appear to represent a relatively small electrical demand; however, when 159 fixtures operate simultaneously for approximately 11 hours each night, the cumulative load becomes significant at building level. When similar installations are repeated across multiple commercial, institutional, and residential buildings along the corridor, their combined demand can become an important component of nighttime electricity consumption.

Operational Hour Block	Real World Existing Condition	Smart Control Automation	Structural Impact
Peak Hour(18:00-22:00)	100% Output (1.59 kW)	100% Output(1.59kW)	Necessary Aesthetical Lighting
Off-Peak(22:00-05:00)	100% Output(1.59kW)	50% Dimmer or Cutoff(0.795/0 kW	100% pure energy wastage

Table. 10. Comparative Grid Analysis of Existing Corridor Operations vs. Smart Control Automation

The observed operating condition indicates that façade lighting remains at approximately full output throughout the 11-hour nighttime period**,** resulting in a continuous electrical demand during the entire period of operation. For the representative building, the 159 façade fixtures, each rated at 10 W, produce an installed load of 1.59 kW and a calculated energy demand of 17.49 kWh per night when operated for 11 hours. The absence or limited use of scheduled dimming, automatic switching, or other adaptive control measures means that the installed lighting capacity is maintained throughout the full operating period, irrespective of variations in nighttime activity. Thus, the energy implication is associated not only with the individual fixture wattage but also with the cumulative number of fixtures and the extended duration of their operation.

The observed condition consequently demonstrates a combined design and management gap in private façade lighting. At the design level, the extensive use of multiple point-source fixtures across individual façades increases the cumulative installed lighting load, while at the management level, the continued operation of these fixtures for approximately 11 hours without evident adaptive control increases the associated energy demand. Although ESAA provides technical instructions for façade-lighting implementation, the observed building-level practices indicate that the translation of such guidance into energy-conscious fixture selection, lighting density, operating duration, and control mechanisms remains limited. The result is a façade-lighting system that fulfils an architectural and visual function but operates with a relatively fixed energy demand, raising concerns regarding the efficiency and management of nighttime electricity use across the corridor.

4.8.3.1 Cumulative Energy Implications across Some the Corridor Buildings

To examine the cumulative implication of the observed façade-lighting practice, six representative buildings were assessed according to their approximate number of point-source fixtures and the associated energy demand. Each fixture was considered at the observed rating of 10 W (0.01 kW), with an assumed operating duration of 11 hours per night. The resulting calculations provide a common basis for comparing the energy demand of the selected buildings and demonstrate how relatively small individual fixture loads become significant when multiplied across a building façade and subsequently across several properties.

Exemplary Building Typology	Façade Profile	Approximate Estimated Point Fixture(N)	Nightly Draw 11 hours 10W (0.01kW)	Annual Consumption
Medin Ensurance Building	Solid wall and glass facade	216	23.76kWh/day	8,672.4kWh/year
Nile Insurance Company	Horizontal Glass and solid wall	288	31.68kWh/day	11,563.2kWh/year
Construction Bank	Glass and panel finish	216	23.76kWh/day	8,672.4kWh/year
Apartment Building	Glass and solid wall	241	26.51kWh/day	9,676.15kWh/year
Nani building near the Gion hotel	Glass and wall	170	18.7kWh/day	6,825.5kWh/year
Ethio Telcome Building at Churchill Road	Glass and a solid wall	192	21.12kWh/day	7708.8kWh/year
Total Aggregated Cluster Sample	Combined Baseline Impact	1,323 units	145.53kWh / day	53,118.45kWh/year

Table 11. Typological matrix of cumulative façade-lighting energy performance across selected corridor buildings.

Source: Author's onsite investigation and infrastructure audit, 2026.

The results show considerable variation in the number of façade fixtures among the selected buildings, ranging from approximately 170 to 288 point-source luminaires. Collectively, the six buildings contain an estimated **1,323 fixtures**, producing a combined nightly energy demand of approximately **145.53 kWh** when operated for

11 hours. On an annual basis, this represents approximately **53,118.45 kWh/year**. The variation between buildings demonstrates that façade geometry, building scale, architectural treatment, and the intensity of decorative illumination influence the resulting energy demand. Thus, the energy implication is not determined by fixture wattage alone but by the relationship between the architectural design of the façade and the number and distribution of luminaires used to illuminate it.

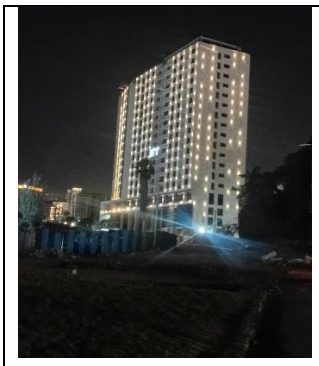
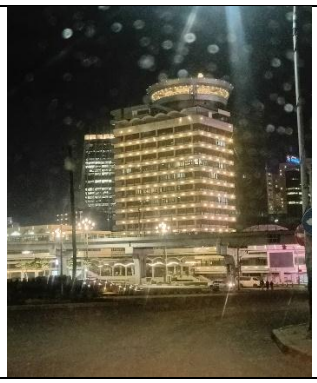
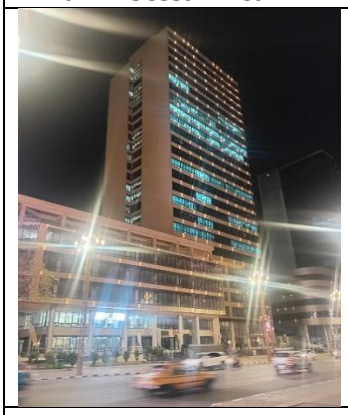
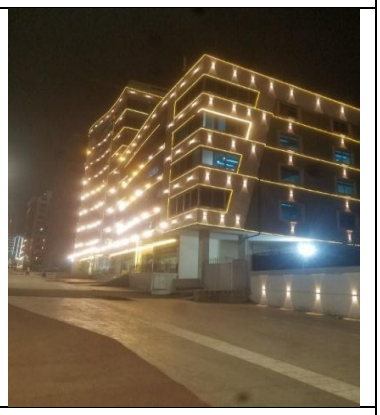
		
A new apartment building around TikurAnbessa Area	Construction and Business Bank in front of Commercial College	Medin Insurance building, Leghar area
		
Nile Insurance building near the National Theatre	Nani building at Giyon hotel	Tele building at Churchill road

Figure 24. Photographic matrix illustrating point-source façade-lighting practices observed in selected buildings along the inner-city corridor.

Source: Field photographs captured by the author, 2026.

The photographic evidence further demonstrates the repeated use of dense point-source lighting across different architectural typologies. Similar lighting approaches can be observed on glass-and-solid-wall façades, panelled façades, and mixed architectural envelopes. This indicates that the observed practice is not restricted to one particular building type but forms part of a broader pattern of private façade

illumination within the corridor. From an energy-management perspective, repeated application of similar high-density lighting arrangements increases the cumulative demand associated with private architectural illumination.

Power Source of the six building clusters $\frac{53{,}118.45\ \text{kWh / year}}{4{,}000{,}008\ \text{kWh / year}} \times 100 \approx 1.33\%$

The six-building sample can also be considered in relation to the recorded public street-lighting energy consumption used in this study. The annual façade-lighting demand of **53,118.45 kWh** represents approximately **1.33%** of the reported annual public street-lighting consumption of **4,000,008 kWh/year**. Although this comparison should not be interpreted as representing the total energy consumption of all private façade lighting in Addis Ababa, it demonstrates that a relatively small sample of privately operated façade-lighting systems can constitute a measurable additional energy demand when compared with the city's public street-lighting system.

The observed condition therefore identifies a management gap rather than simply a fixture-efficiency problem**.** ESAA's involvement in establishing the technical direction for façade-lighting implementation provides a framework for lighting practice; however, the field evidence indicates that the application of this framework at building level does not consistently demonstrate energy-responsive operation. The cumulative energy demand is influenced by decisions concerning the number of fixtures, their spatial distribution, operating duration, and the provision of control mechanisms. Where these decisions are not coordinated with energy-management objectives, façade lighting can remain at a relatively fixed electrical load throughout the 11-hour nighttime period.

Consequently, the energy implication of private façade lighting should be understood as a combined outcome of **design intensity and operational management**. The design determines how much lighting capacity is installed on the building envelope, while management determines how that capacity is operated over time. The six-building assessment demonstrates that these decisions accumulate into a measurable energy demand, highlighting the need for stronger coordination between ESAA's technical direction, building-level lighting design, and the operational management of privately installed façade-lighting systems.

4.8.4 Comparative Benchmark of Façade Lighting Energy Management and Control Systems

The energy implications identified in the observed private façade-lighting practices can be further understood by examining how façade illumination is controlled and managed in an established local building application. For this purpose, the Sheraton Addis façade-lighting system is considered as an empirical benchmark, not as a direct numerical comparison of energy consumption, but as a reference for the **systematic management of architectural lighting**. The comparison focuses on how lighting control, operating schedules, fixture organization, electrical protection, and system responsiveness can influence the efficient use of energy while maintaining the intended architectural and nighttime visual function. In contrast to the predominantly fixed and manually operated façade-lighting arrangements observed along the study corridor, the Sheraton case demonstrates an approach in which façade illumination is integrated into a programmable control system.

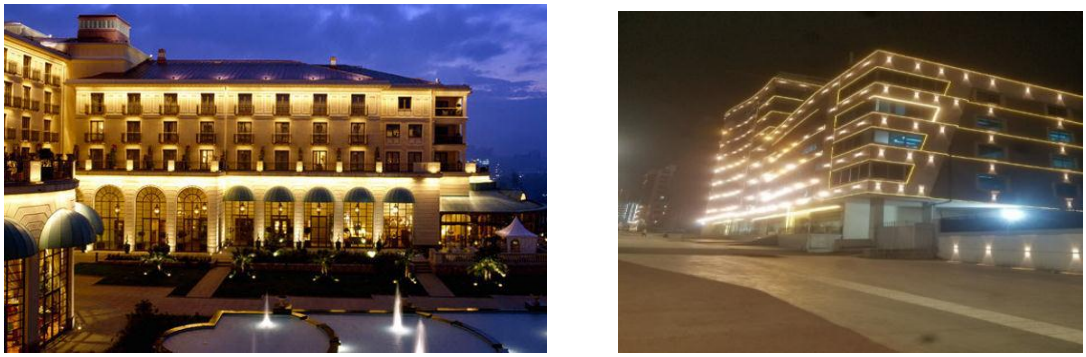


Figure 25. Comparative illustration of programmed façade-lighting control and the unmodulated façade-lighting practice observed along the study corridor.

Source: Author's field documentation and comparative analysis; Sheraton Addis reference image.

The significance of the Sheraton case lies particularly in its **control methodology**. The use of a Digital Addressable Lighting Interface (DALI)-based system provides a communication layer through which lighting components can be controlled and managed rather than relying solely on manual switching. Such an arrangement allows the lighting system to be programmed according to the operational requirements of the building and the changing conditions of the nighttime environment. From an energy-management perspective, this provides the possibility of adjusting lighting output, scheduling operation, and selectively managing lighting zones rather than maintaining all façade fixtures at a fixed operating condition throughout the night.

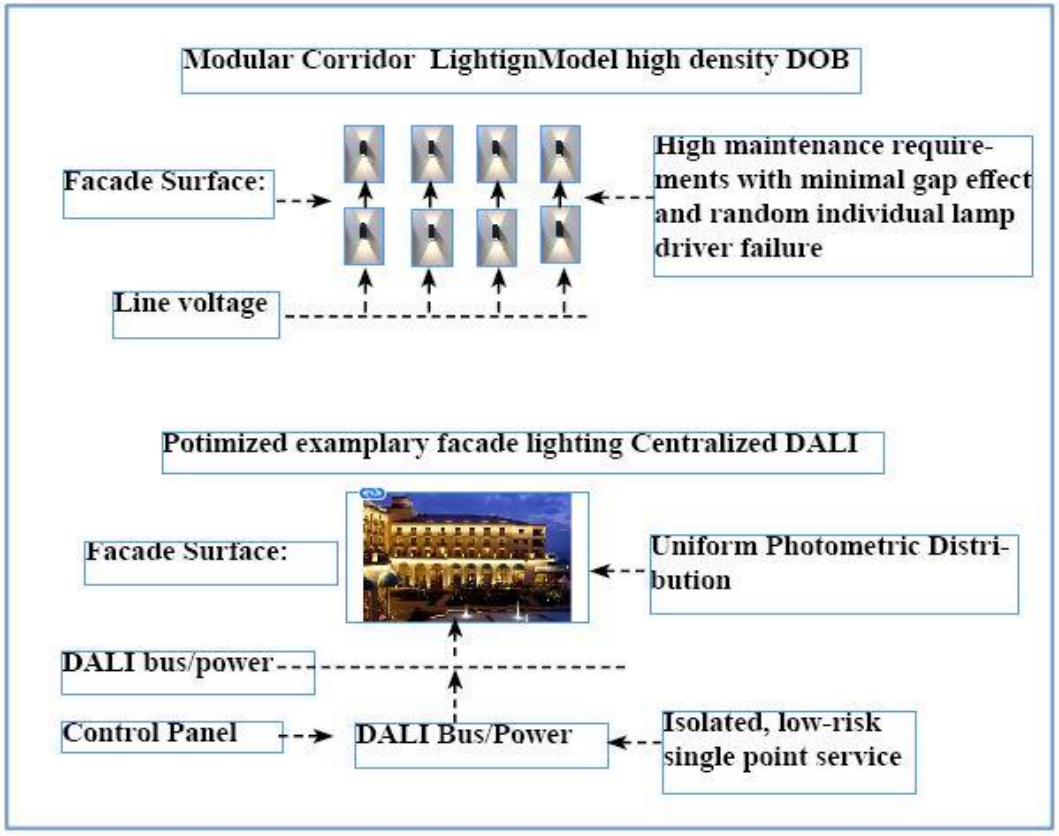


Figure 26. Schematic representation of the difference between a programmed façade-lighting control system and an unmodulated lighting arrangement.
Source: Author's schematic representation.

The comparison indicates that energy efficiency in façade lighting is therefore strongly related to the **organization and management of the lighting system**, rather than being determined solely by the wattage of individual luminaires. The observed corridor practice is characterized by dense point-source installations that are operated for an extended nighttime period with limited evidence of adaptive control. The benchmark case, in contrast, demonstrates the value of integrating façade lighting with a control architecture capable of regulating operation according to programmed schedules and lighting requirements. This distinction is important because a façade-lighting system can provide the same architectural function through different levels of operational control, with significant implications for the duration and intensity of electricity use.

The benchmark also demonstrates the importance of **system integration and maintainability**. A coordinated control architecture can allow lighting components to

be organized into manageable circuits or zones, facilitate selective operation, and provide a more systematic approach to maintenance and fault management. This contrasts with fragmented installations in which numerous individual fixtures are manually switched and operated as a single fixed load. The latter arrangement limits the ability to respond to changing nighttime conditions and makes energy management dependent primarily on manual intervention.

From the perspective of the present study, the Sheraton case therefore provides an important local reference for understanding how façade lighting can be managed as an **energy-responsive architectural system**. Its relevance is not that it represents a universal model to be replicated identically across all buildings, but that it demonstrates the principle of integrating lighting design with programmable control, operational scheduling, zoning, and system management. These principles provide a useful benchmark against which the observed façade-lighting practices of the inner-city corridor can be interpreted.

Engineering Parameter	**Audited Corridor Façade Practice (Current Field Reality)**	**Sheraton Addis Envelope Model (Empirical Benchmark)**	**Structural Systemic Deficit/ Operational Gap**
Control Architecture	Manual binary switching networks; total absence of smart envelope automation.	Network-addressable master controller running local static IP via DALI protocol.	Complete absence of digital communication layer prevents localized fixture monitoring.
Duty Cycle & Regulation	Static, unmodulated 11-hour all-night burning at 100% capacity.	Automated two-phase schedule (100% peak dusk-midnight; 40%–50% off-peak curfew).	50%–60% off-peak energy waste due to the lack of automated facade dimming.
Optical Distribution	Unshielded, perimeter-wrapped linear output throwing light directly into the sky.	Recessed down-lighting units tucked organically under structural slab edges.	Severe macro-scale light pollution; loss of facade tectonic depth via over-glow.

Electrical Protection	Monolithic circuit lines; vulnerable to cascading failures from localized water ingress.	Localized fault containment via isolated sub-circuit breakers and soft-start dimming.	High maintenance burden and premature component blowout from facade inrush current.
Inrush Surge Mitigation	Unbuffered; high cumulative transient currents overstress manual switches and circuits.	Soft-start phase-cut ramp-ups and staggered circuit sequencing via master control.	Accelerated degradation of switching gear; localized voltage sags and recurrent circuit breaker tripping.
Thermal & Lifespan Continuity	High thermal coupling on single substrate; high failure rate leading to the "teeth-gap" effect.	Thermally isolated components; remote drivers housed in climate-controlled panel enclosures.	Premature fixture burnout within short operational lifecycles; high maintenance overhead and broken visual continuity.
Luminous Efficacy Degradation	High thermal saturation drops output over hours of continuous use, wasting energy as heat.	Stable electro-thermal profile maintains high efficacy (lm/W) through programmed dimming.	Financial waste where power input remains fixed but physical lumens output depreciates continuously.

Table 12. Comparative assessment of façade-lighting design, control, and energy-management approaches.

Source: Author's physical auditing and system comparative analysis, 2026.

The comparative assessment consequently identifies the principal gap as one of energy-management integration. The issue is not simply the presence of façade lighting or the use of decorative fixtures, but the extent to which the lighting system is designed and managed as an integrated component of building operation. ESAA's technical direction establishes an important basis for façade-lighting implementation; however, the observed cases indicate that the translation of this direction into building-level control, scheduling, and energy-responsive operation remains inconsistent.

The Sheraton benchmark demonstrates that façade lighting can be treated as a programmable building system in which architectural expression and energy management are considered together.

Accordingly, the comparison supports the interpretation that the energy implications identified in Section 4.8.3 arise from the interaction between lighting design decisions and operational management**.**

Greater attention to programmable control, scheduled operation, zoning, dimming capability, and coordinated system management can reduce unnecessary operation while preserving the intended nighttime architectural identity. The Sheraton case therefore serves as an empirical local benchmark for the type of integrated energy-management approach that could inform the improvement of private façade-lighting practice within the inner-city corridor.

4.8.5 Macro-Scale Validation of Energy Implications through Nighttime-Light Imagery

The energy implications identified through the assessment of the street- and façade-lighting systems can be further examined at the city scale using nighttime-light imagery. While ground-based calculations demonstrate the installed capacity, operating duration, and energy demand of individual lighting systems, nighttime-light imagery provides a broader spatial indication of how changes in artificial illumination are reflected in the overall brightness of the urban nightscape. The satellite analysis therefore serves as a **macro-scale spatial validation** of the increasing intensity of artificial nighttime illumination associated with the development of the inner-city corridor. It does not represent a direct measurement of electricity consumption; rather, the observed change in nighttime radiance provides complementary evidence of the increasing intensity and spatial concentration of artificial lighting.

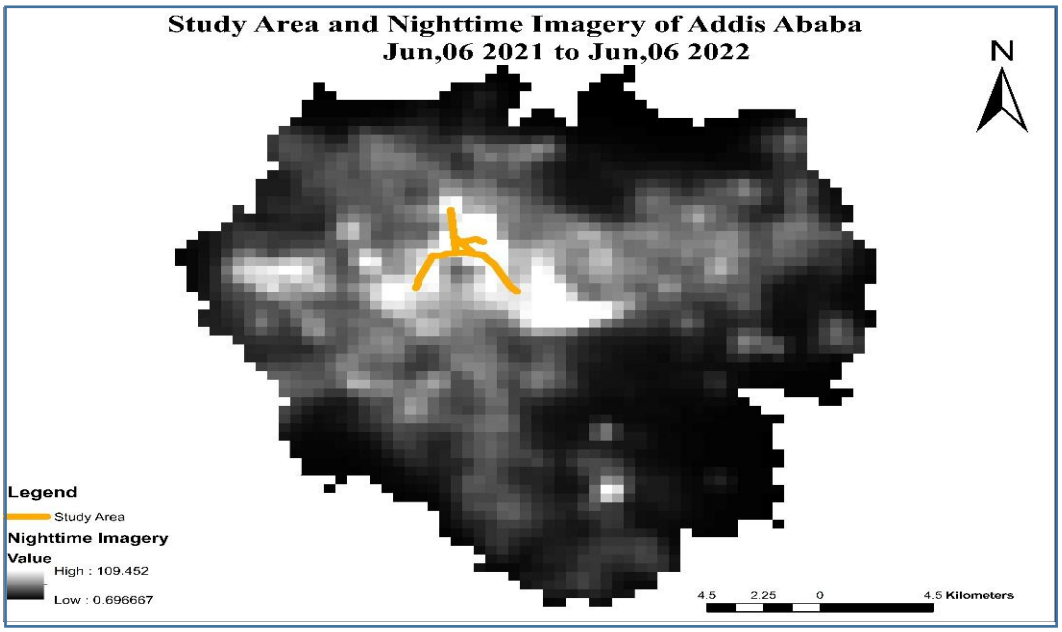


Figure 27. Nighttime-light imagery showing the urban brightness condition during the 2021–2022 baseline period.

Source: Author's GIS and nighttime-light spatial analysis

The 2021–2022 imagery provides the baseline condition against which the subsequent nighttime environment can be assessed. During this period, the inner-city area exhibited a comparatively moderate and spatially blended nighttime-light pattern, with the study corridor embedded within the wider urban brightness field. The baseline establishes an important reference for evaluating the changes that occurred

following the subsequent illumination and corridor-development interventions. The spatial pattern indicates that nighttime brightness was present across the urban area but was less strongly concentrated along the study corridor.

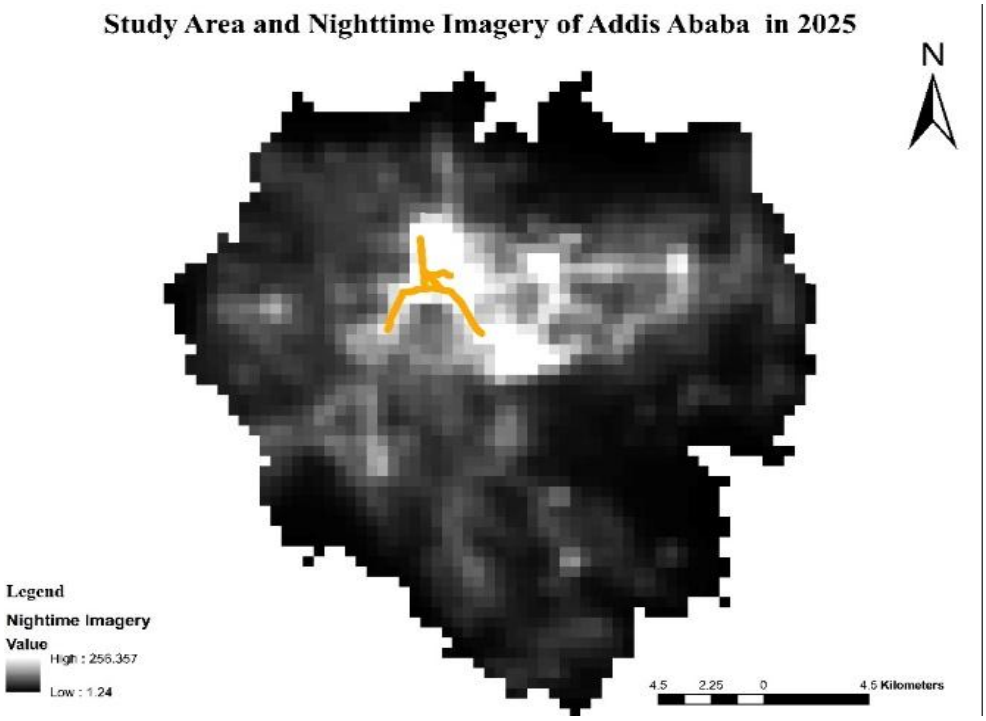


Figure 28. Nighttime-light imagery showing the increased concentration of urban brightness along the inner-city corridor in 2025.
Source: Author's GIS and nighttime-light spatial analysis.

The 2025 imagery demonstrates a substantially more pronounced concentration of nighttime brightness within the study area. The maximum pixel value reported in the analysis increased from **109.452 in the 2021–2022 baseline to 256.357 in 2025**, representing an increase of approximately **134.2%** in the observed radiometric value. This change provides macro-scale spatial evidence that the nighttime visual environment has become considerably brighter following the implementation of the corridor illumination and the expansion of façade-lighting practices.

The significance of this increase, however, should not be interpreted simply as evidence of improved urban quality. Brightness is sometimes regarded by urban decision-makers and stakeholders as an indicator of beautification, attractiveness, modernization, or nighttime vitality. While increased illumination can contribute positively to visibility and nighttime identity, treating greater brightness as an

aesthetic objective in itself can overlook the energy required to produce and maintain that brightness. The findings of this study indicate that the visual increase in nighttime illumination needs to be considered together with the capacity, distribution, operating duration, and control of artificial lighting**.** In this sense, the question is not whether the city should be brighter, but whether the additional brightness is appropriately directed, functionally justified, and proportionate to the energy resources required to sustain it.

The observed increase in nighttime brightness also reflects the combined influence of design and management decisions**.** At the design level, the use of high-capacity decorative street-lighting systems, upward-directed light components, and dense private façade-lighting arrangements increases the amount of artificial light introduced into the nighttime environment. At the management level, extended operating periods and limited evidence of adaptive control allow these systems to remain active for long periods without sufficient adjustment to changing nighttime conditions. The satellite evidence therefore complements the preceding technical analysis by showing that the implications of these decisions are not confined to individual fixtures or buildings but become spatially visible at the urban scale. The uploaded analysis similarly identifies the relationship between unshielded street-lighting components, private façade lighting, and increased nighttime brightness.

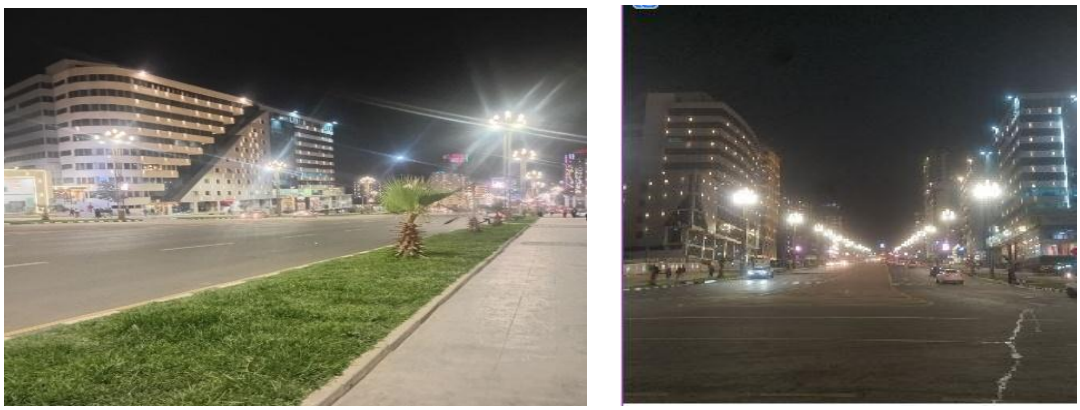


Figure 29. Corridor exclusion analysis showing the spatial concentration of nighttime brightness along the upgraded street network.
Source: Author's photograph, 2026.

The corridor exclusion analysis provides further spatial evidence for interpreting this change. When the upgraded corridor is excluded from the 2025 nighttime-light raster, the surrounding urban areas exhibit comparatively lower and more gradual brightness

patterns, while the strongest concentration remains associated with the developed lighting corridor. This spatial contrast strengthens the interpretation that the observed increase in brightness is closely associated with the illuminated corridor rather than representing a uniform change across the entire urban area.

Taken together, the nighttime-light analysis provides a broader spatial dimension to the energy findings established through the preceding street- and façade-lighting assessments. The increased nighttime radiance does not, by itself, quantify electricity consumption; however, when considered alongside the documented high-capacity street-lighting infrastructure, prolonged façade-lighting operation, and limited adaptive control, it provides complementary evidence of an increasingly intensive artificial-lighting environment.

The implication is therefore one of energy-conscious lighting management rather than brightness maximization**.** Urban illumination should be evaluated according to the relationship between visual benefit, functional need, spatial distribution, and energy demand, with design and management decisions working together to achieve an appropriate nighttime environment without unnecessarily increasing the city's lighting load

4.9 Respondent Data Analysis

The study used Stratified Random Sampling to make sure that the opinions of both experts and people who use the Addis Ababa inner-city corridor every day were heard equally.

4.9.1 Experiential Stratification of Respondents' Academic Background

To capture a diverse range of perspectives on the inner-city corridor developments, the target population (N = 280) was stratified based on their academic backgrounds. This stratification is critical because an individual's educational level often shapes their spatial awareness, professional intersection with urban design, and daily experiential usage of city streets.

Academic Level	Respondents Count(N)	Percentage
High School	60	21.4%
Diploma	40	14.3%
Degree	152	54.3%
Master Degree	28	10.0%
Others	0	0. 0%
Total	280	100%

Table 13. Stratified respondents categories, percentage and count

4.9.2 Spatial and Experiential Relationship with the Corridor

Mode of Experience	Respondent Count(N)	Percentage (%)
Residential (Live in the inner city)	150	53.6%
Occupational(Work place area)	50	17.9%
Transient(pass by transport or walk on foot)	80	28.6%
Total	280	100.0%

Table 14. Illustrate the respondent experience of the inner-city corridor

4.9.3 Technical and Aesthetic Familiarity with Urban Lighting Typologies

Level of Familiarity	Respondents Count(N)	Percentage (%)
Very Familiar	45	16.1%
Familiar	30	10.7%
Neutral	140	50.0%
Slightly Familiar	40	14.3%
Not Familiar	25	8.9%
Total	280	100%

Table 15. Respondents' Level of Familiarity with Urban Lighting Applications

The survey assessed respondents' familiarity with functional, decorative, and architectural lighting to contextualize public perceptions of the nighttime urban environment. Half of the respondents (50.0%, n = 140) reported a neutral level of familiarity, indicating that most users perceive urban lighting as a general environmental condition rather than distinct lighting categories. A combined 26.8% demonstrated familiarity or strong familiarity with urban lighting design, providing informed perspectives on technical lighting issues. Meanwhile, 23.2% reported limited or no familiarity, contributing valuable insights based on everyday experiences of safety, brightness, and visual comfort

4.9.4 Analysis of Street Lighting Quality and Impact

Section 2: The results of the empirical study obtained from the research questionnaire are presented in this section. This part of the instrument assessed public and professional opinions on the qualitative, physiological and environmental effects of the current street lighting system along Addis Ababa's inner city corridors.

4.9.5 Unshielded Street Light Glare and Visual Comfort

Respondents were asked to react to the question of ″Unshielded street lighting causes glare that reduces visual comfort at night″ to determine the immediate sensory impact of current luminaire designs

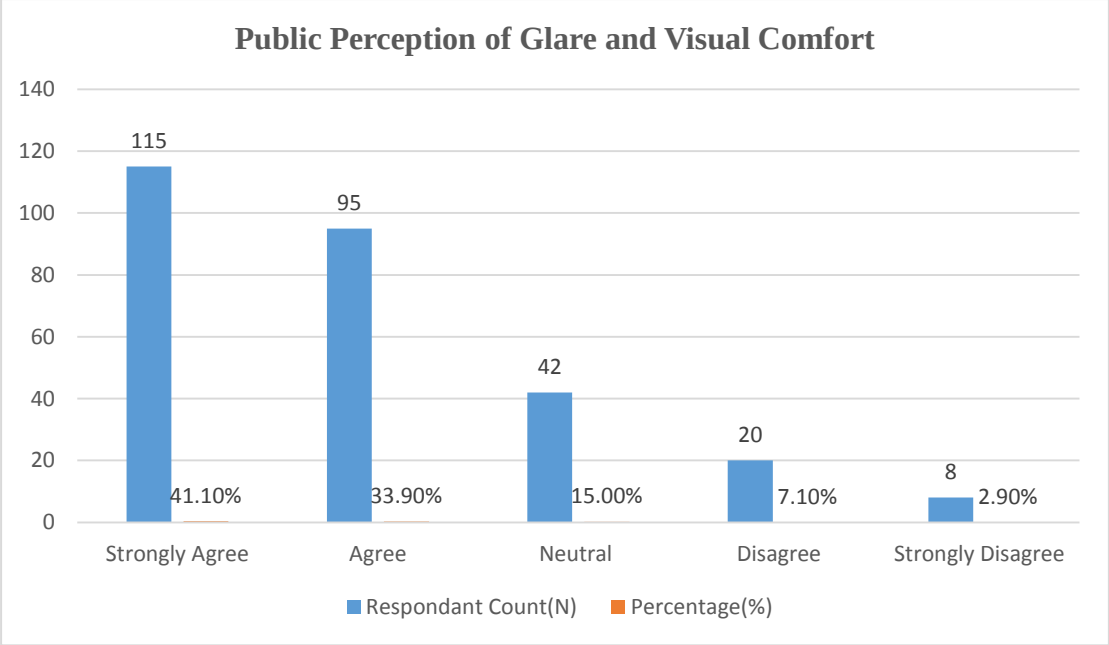


Figure 30. Demonstrate public perception of the glare and visual comfort

4.9.6 Perception of Upward Light Spill and Sky Glow

The environmental consequence of poorly directed artificial light was evaluated through the statement: "Street lights that allow light to spill upward contribute to sky glow and light pollution

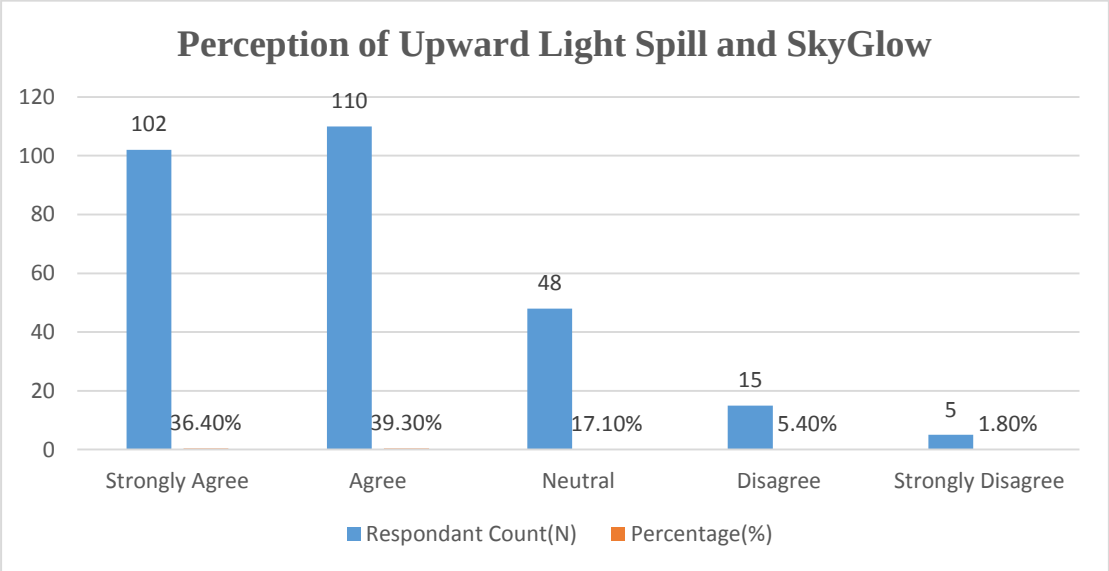


Figure 31. Demonstrate the respondent's perception of upward light spill & sky glow

4.9.7 Impact of Poorly Controlled Lighting on Urban Night Quality

To assess the holistic atmospheric quality of the cityscape at night, respondents evaluated the statement: “Poorly controlled street lighting negatively affects the quality of the urban night environment."

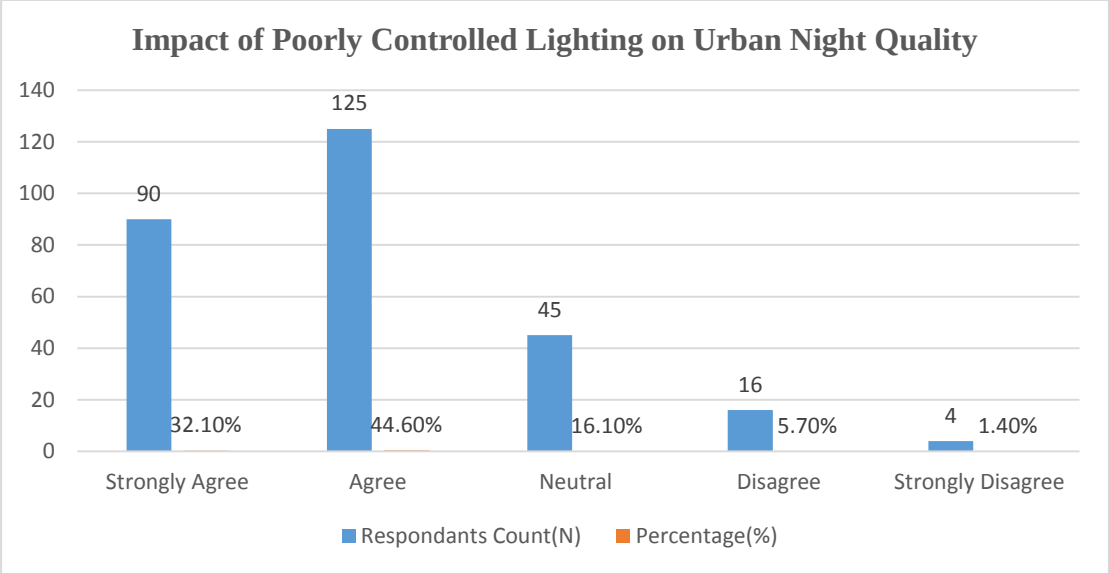


Figure 32. Illustrate the impact of poorly controlled lighting on urban night quality

4.9.8 Perceived Effectiveness of Shielded Luminaire Fixtures

To evaluate public support for technical mitigation strategies, respondents rated their agreement on whether: "Shielded street lights provide adequate illumination while reducing unnecessary light spill."

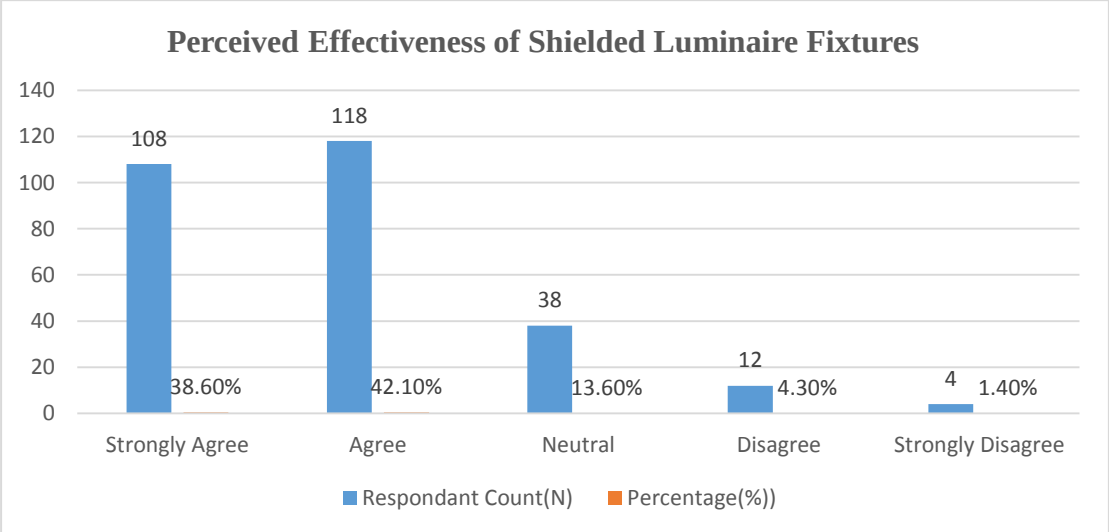


Figure 33. Demonstrate the respondent’s perception on effective shielded luminaire fixture

4.9.9 Public Support for Infrastructural Shielding Replacements

Shifting from a theoretical understanding of shielding to an actionable policy preference, respondents evaluated whether: "Replacing unshielded street lights with shielded fixtures improves Overall Street lighting performance."

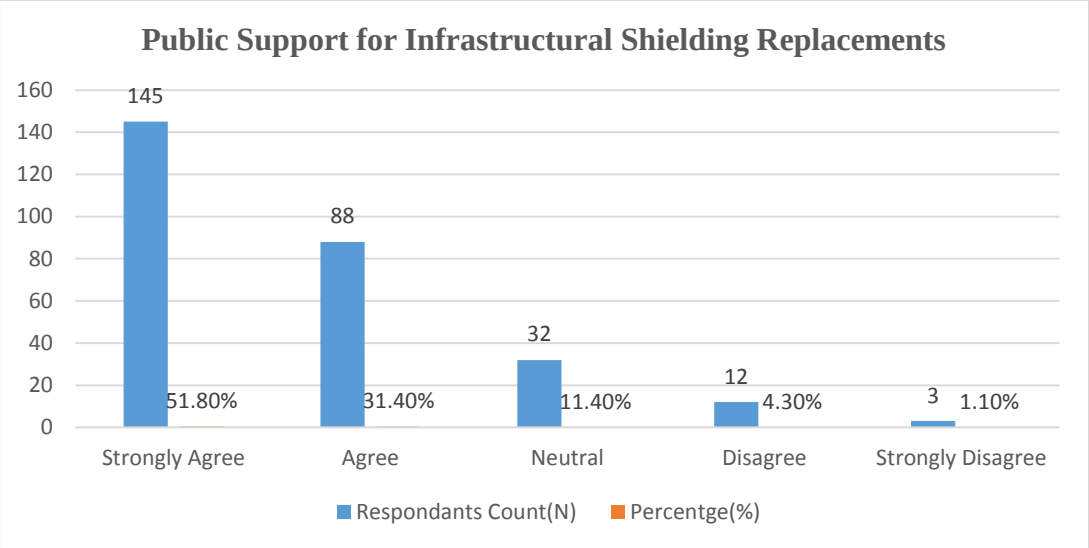


Figure 34. Illustrate the respondents' supporting replacement infrastructural

4.9.10 Harmonization of Safety and Environmental Quality

The final variable in this section interrogated the core philosophy of modern urban design: "Street lighting should balance safety needs with environmental and visual quality considerations."

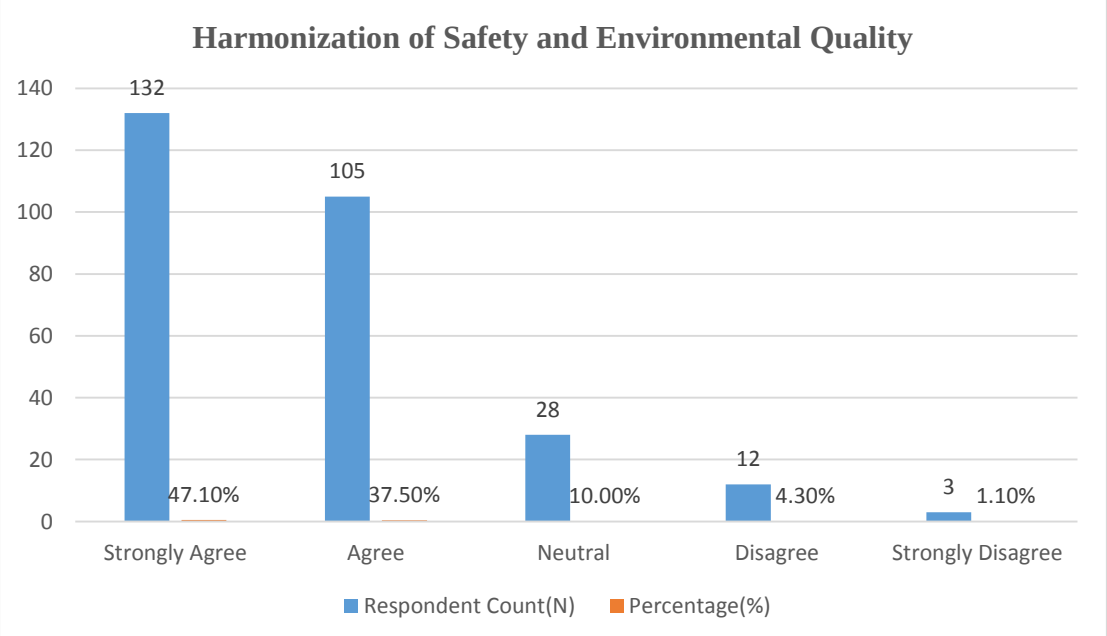


Figure 35. Illustrate the balancing bar chart, balancing safety with quality

4.9.11 Analysis of Street Lighting and Urban Spatial Context

Section 3: This section examines the structural and spatial interplay between street lighting placement and the physical parameters of the inner-city corridor, assessing building setbacks, architectural proportions, and structural dominance.

Adequacy of Equipment Setback from Property Boundaries

Respondents evaluated the statement: "Street lights in my area are positioned with adequate setback from buildings and property boundaries."

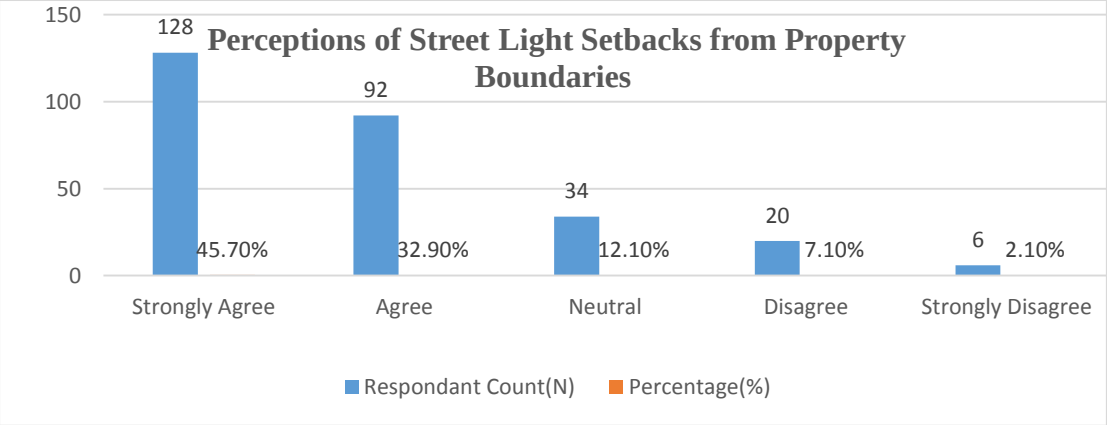


Figure 36. Illustrate the respondents' perceptions of Street Light Setbacks

4.9.12 Alignment with Building Heights and Proportions

Respondents evaluated whether: "The placement of street lights responds well to the height and proportion of surrounding buildings."

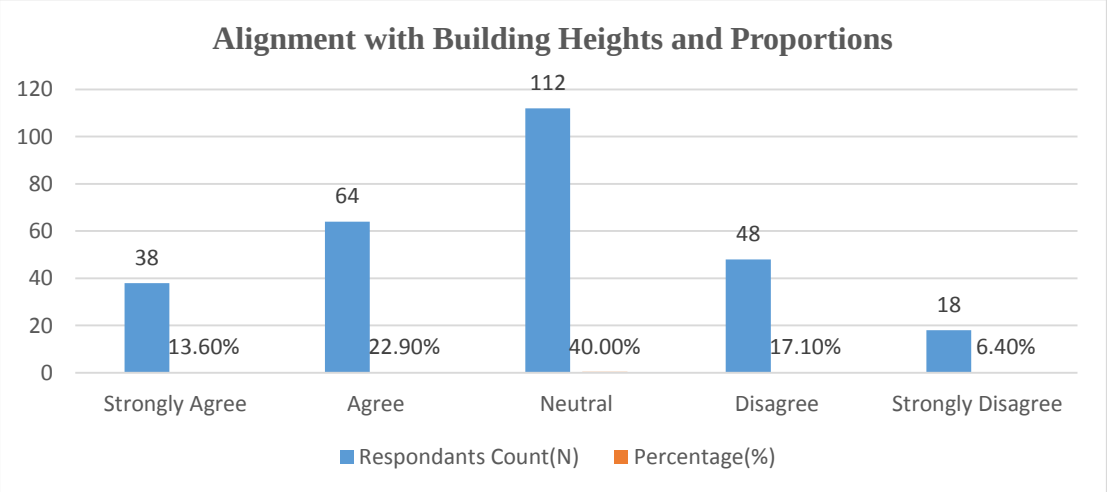


Figure 37. Illustrate Street Light Response to Building Height and Proportions

4.9.13 Visual Dominance Due to Inadequate Setbacks

Respondents evaluated the statement: "Inadequate setback between street lights and buildings makes the lighting feel visually dominant in the street."

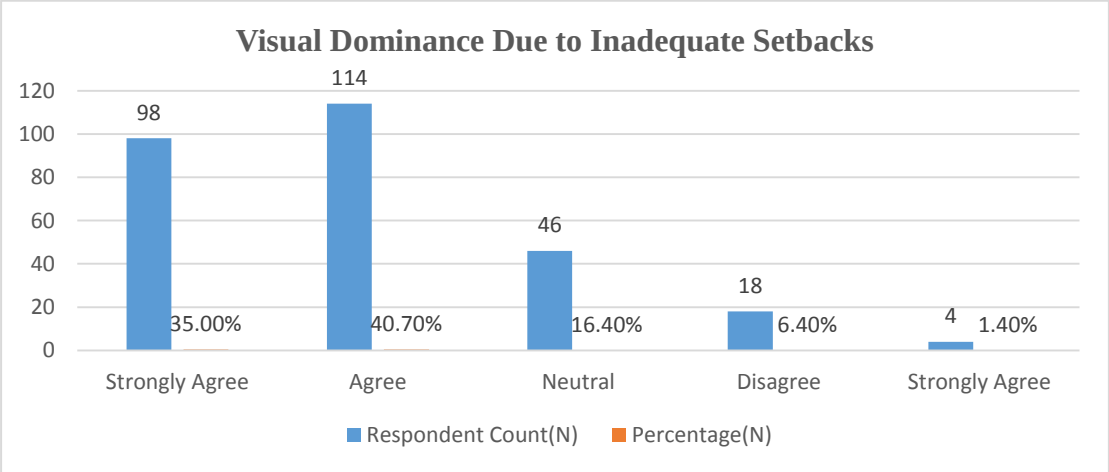


Figure 38. Illustrate respondents' Perception of Lighting Visual Dominance

4.10. Street Lighting and Spatial Volume Integration

Section 4: This section probes how illumination strategies accentuate or disrupt the overall volume of the street corridor and its broader urban context.

4.9.14 Nighttime Disruption via Contextual Misalignment

Respondents evaluated the statement: "Poor alignment between street light placement and urban context disrupts the night-time streetscape."

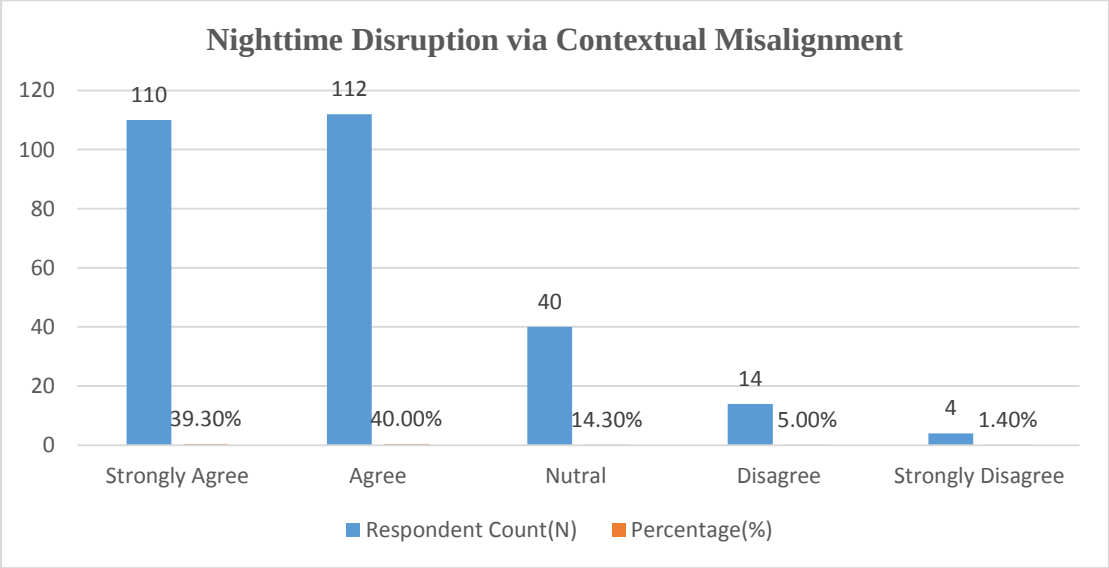


Figure 39. Illustrate Impact of Contextual Misalignment on Night-Time Streetscape

4.9.15 Holistic Street Space Design vs. Isolated Elements

Respondents reacted to the premise: "Street lights should be designed as part of the overall street space rather than as isolated elements."

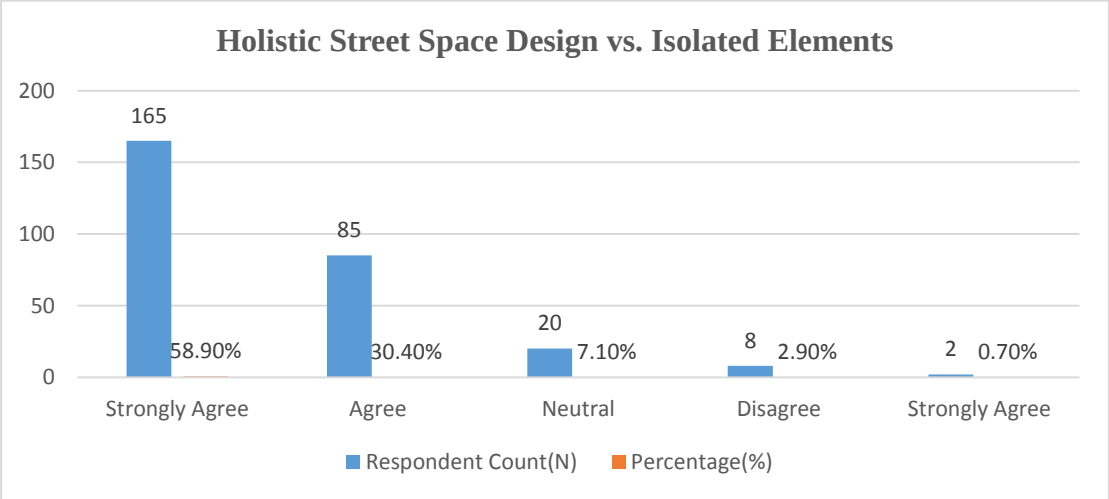


Figure 40. Illustrate the respondents' support for Integrated Street Space Lighting Design

4.9.16 Balancing City-Wide Identity with Individual Building Expression

Respondents evaluated the statement: "Façade lighting should balance city-wide identity with the expression of individual buildings."

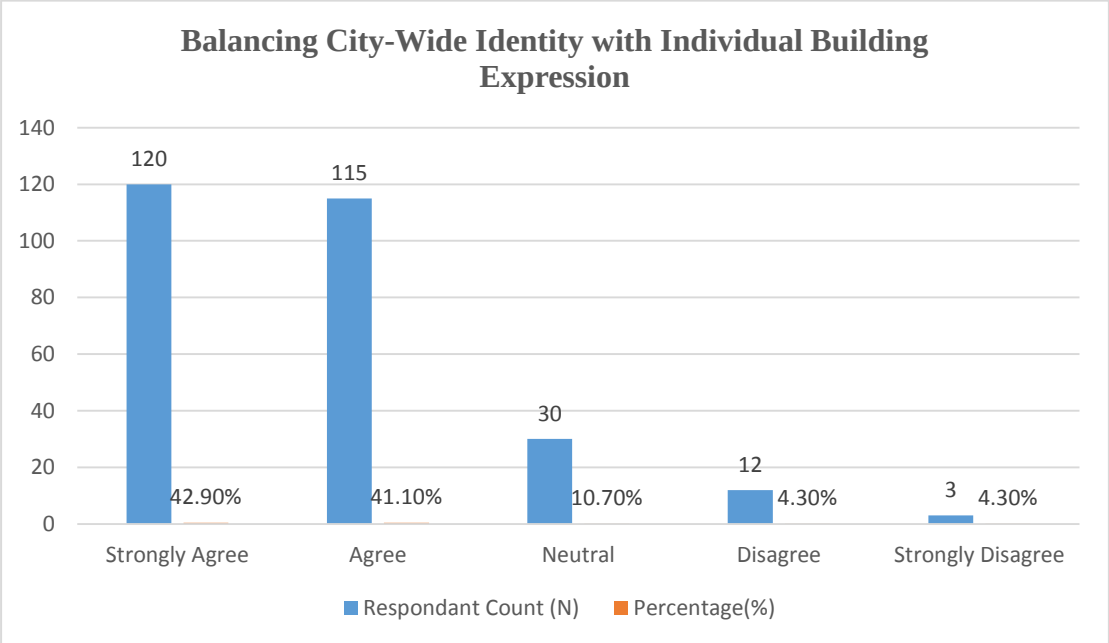


Figure 41. Demonstrate respondents Balancing City-Wide Identity with Individual Facade Expression

4.9.17 Excessive Brightness on Secondary Arterial Streets

Respondents evaluated the statement: "The use of decorative lighting on secondary arterial streets sometimes leads to excessive brightness compared to the street's functional role."

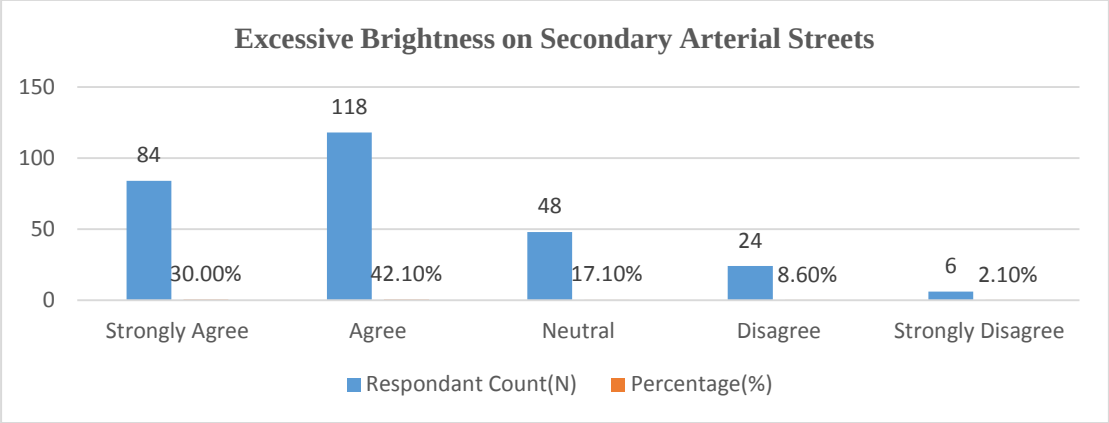


Figure 42. Illustrate the respondents Perceptions of Excessive Brightness on Secondary Streets

4.9.18 Balance between Aesthetics and Energy Efficiency

Respondents evaluated whether: "Decorative street lights are designed in a way that balances aesthetic appeal with energy efficiency."

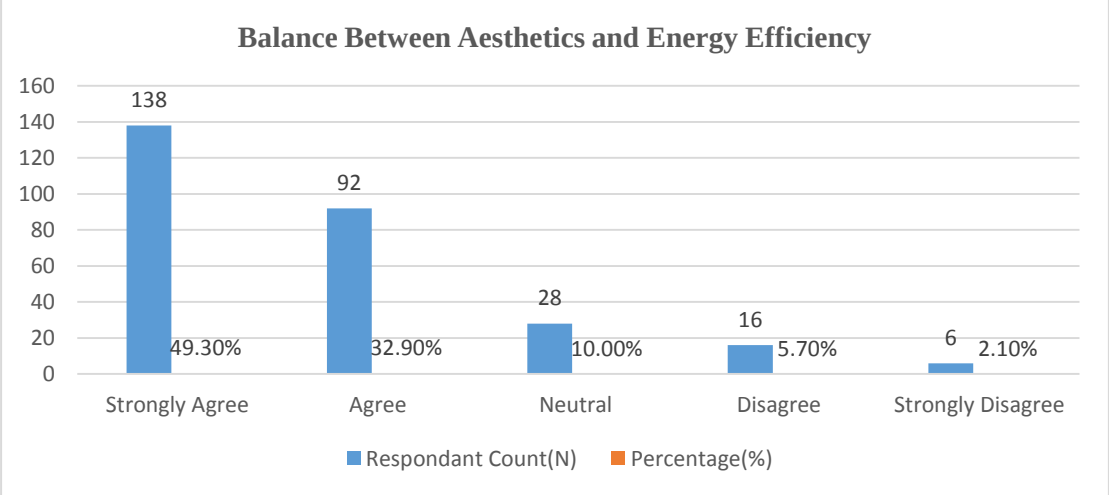


Figure 43. Illustrate the respondents' perceived balance between aesthetics and energy Efficiency

4.9.19 Impact of Hierarchical Misalignment on Functional Clarity

Respondents evaluated the statement: "Misalignment between street hierarchy and decorative lighting reduces the functional clarity of urban streets."

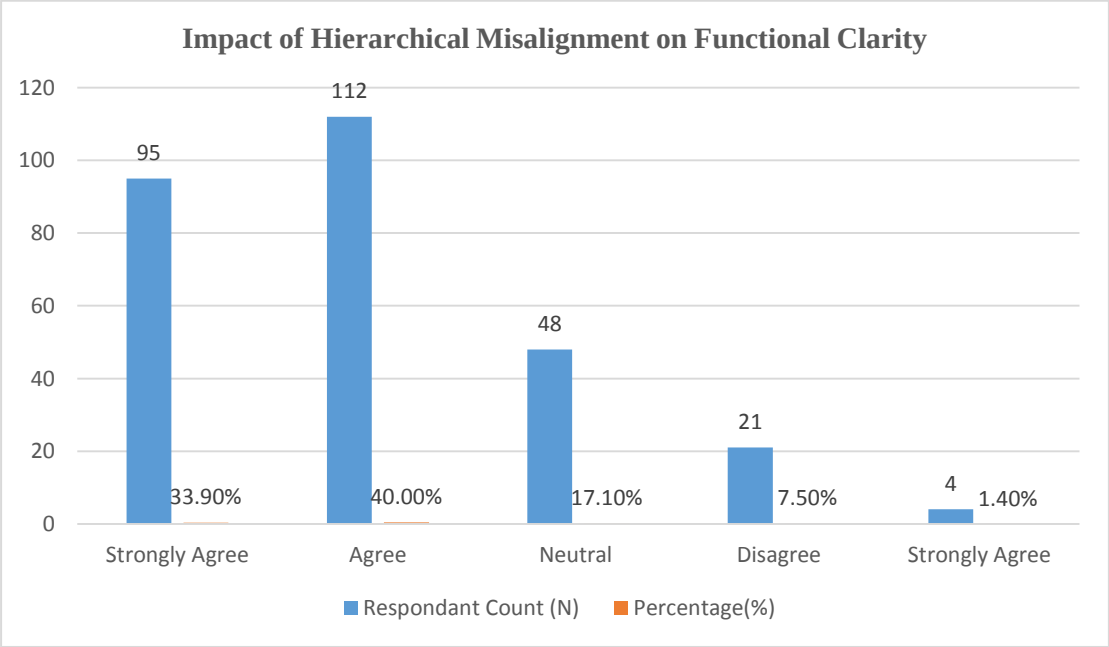


Figure 44. Illustrate the respondent's Impact of Hierarchical Misalignment on Functional Clarity

4.9.20 Adaptation of Lighting to Street Type for Optimization

Respondents evaluated whether: "Decorative street lighting should be adapted to street type (primary vs. Secondary) to optimize energy use and visual impact."

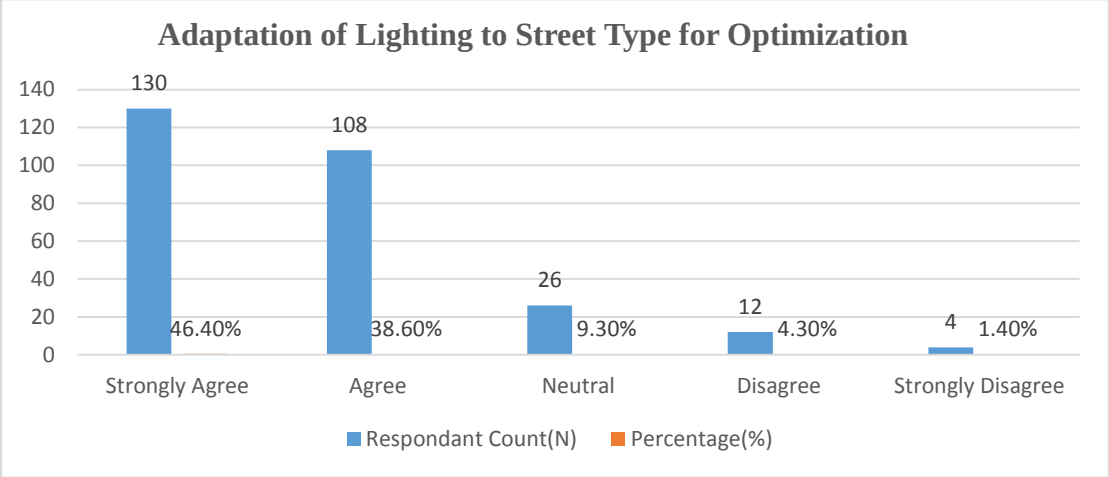


Figure 45. Illustrate the respondents' Support for Adapting Lighting

4.9.21 Energy Drain via Poorly Placed Decorative Lighting

Respondents evaluated the statement: "Excessive or poorly placed decorative lighting increases unnecessary energy consumption."

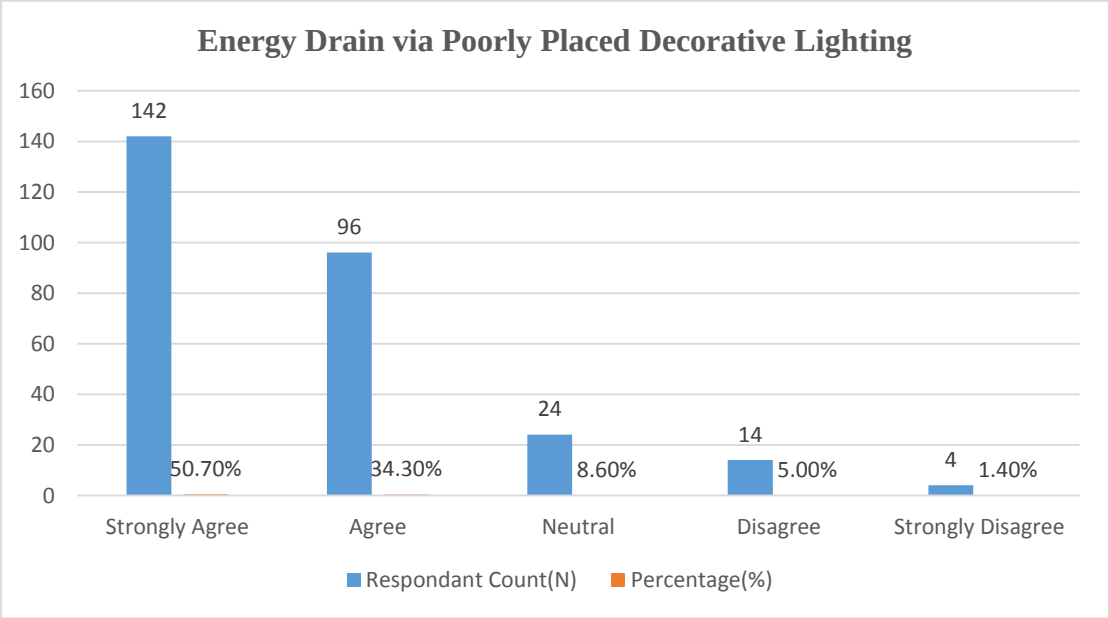


Figure 46. Illustrate the respondent's decorative placement and energy waste

4.9.22 Modular-Based Façade Lighting as a Non-Sustainable Practice

Section 6: This section critiques the technical execution of grid and modular facade installations, focusing on their structural sustainability, energy profiles, and long-term maintenance burdens.

Excessive Energy Consumption of Modular Grid Systems

Respondents evaluated the statement: "Modular-based façade lighting systems consume excessive energy due to the large number of fixtures."

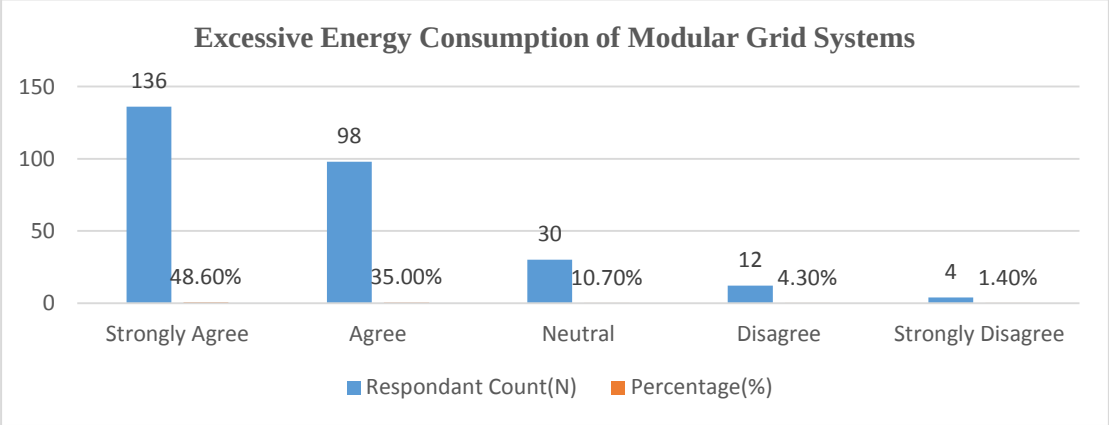


Figure 47. Demonstrate the respondents' Energy Demands of Modular Systems

4.9.23 Impact of Un-Dimmable and Un-Controlled Systems

Respondents evaluated the statement: "Façade lighting that cannot be controlled or dimmed contributes to unnecessary night-time energy use."

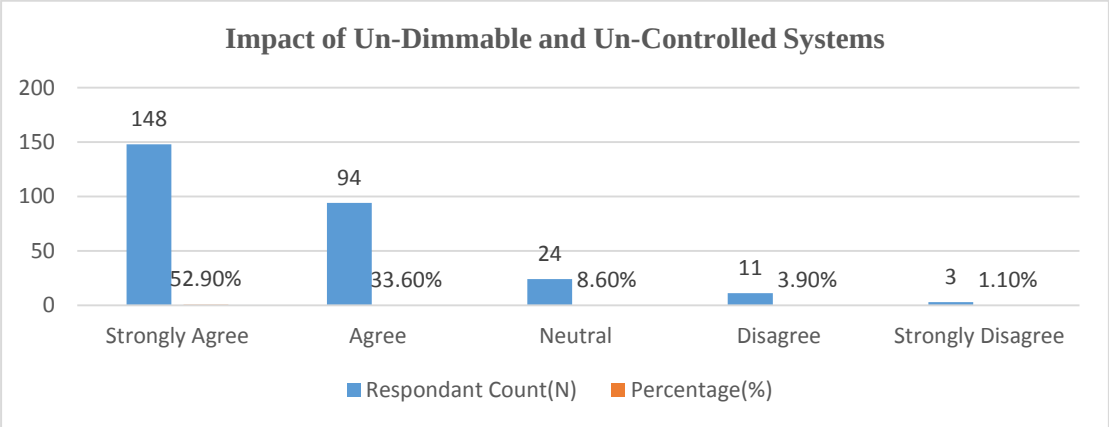


Figure 48. Illustrate the respondent's energy impacts of non-dimmable systems

4.9.24 Maintenance Deficits of Grid-Based Architectures

Respondents evaluated whether: "Maintenance of grid-based façade lighting is difficult, leading to inefficient replacement or repair of fixtures."

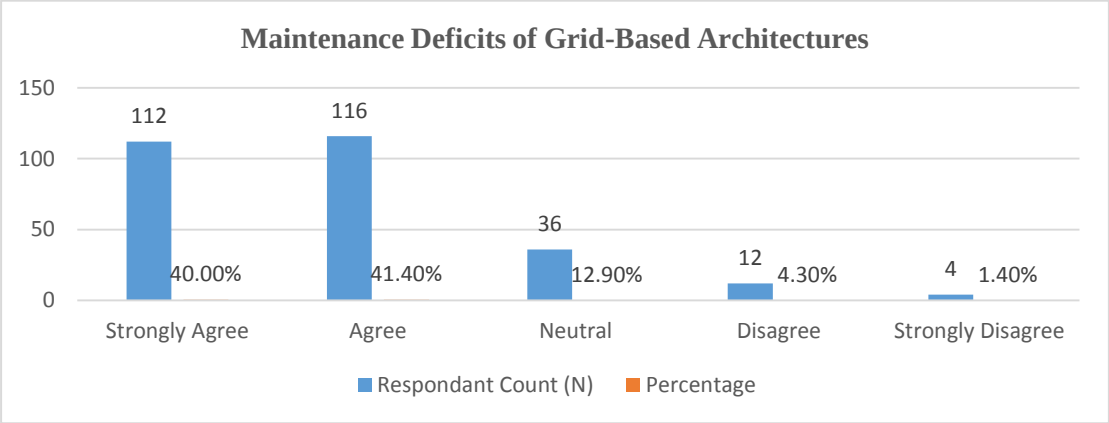


Figure 49. Illustrate the respondents' maintenance challenges of grid-based systems

4.9.25 Sustainability Profile of Current Facade Practices

Respondents evaluated the statement: "The current practice of grid-based façade lighting does not promote sustainable use of energy in urban buildings."

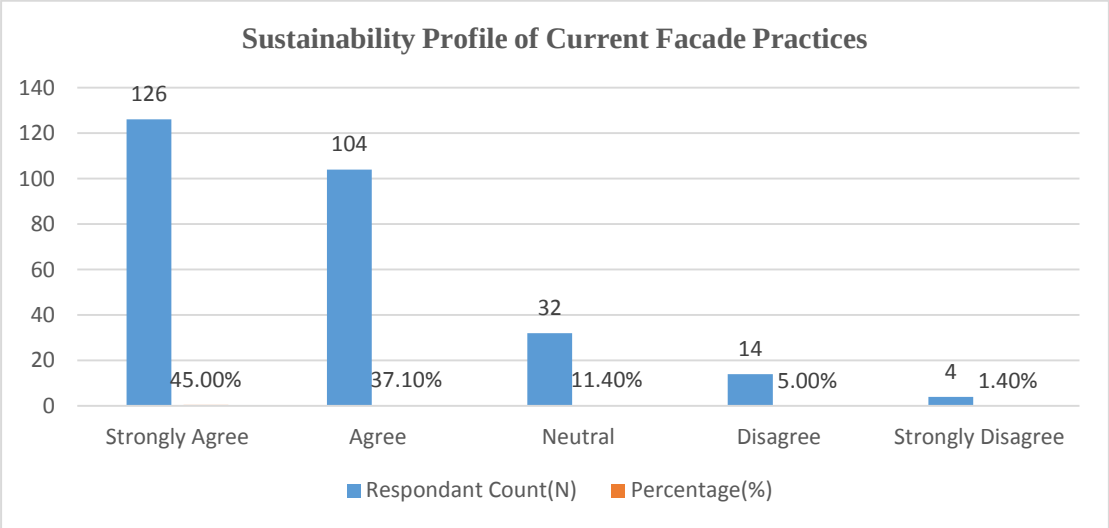


Figure 50. Illustrate the respondents Sustainability Evaluation of Current Facade Practices

As shown in Figure 4.25, 82.1% of participants agreed that contemporary grid installations violate basic sustainability criteria. The data exposes an uncoordinated design trend where decorative flashiness is prioritized over environmental stewardship, challenging developers to realign lighting aesthetics with green building frameworks.

4.9.26 Minimizing Energy Consumption While Safeguarding Visual Impact

Respondents evaluated the statement: "Façade lighting should be designed to minimize energy consumption while maintaining visual impact."

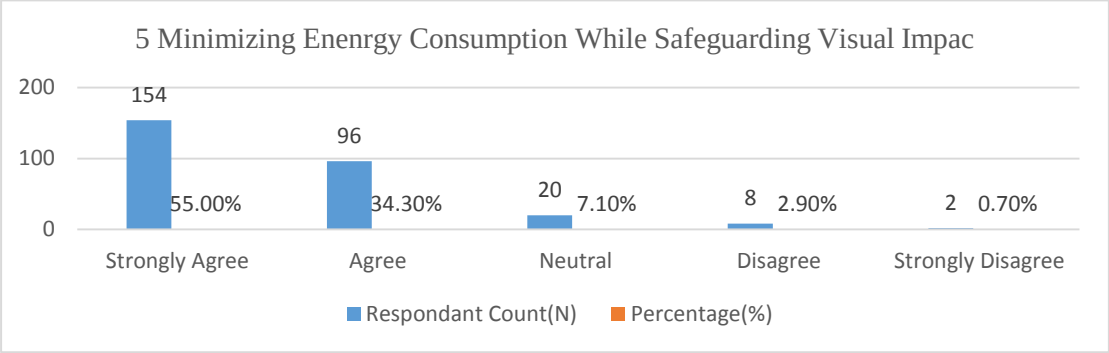


Figure 51. Illustrate the respondents' balancing energy Impact and consumption

A substantial 89.3% consensus the above figure backs the demand for hyper-efficient design methodologies. Stakeholders are advocating for a smart balance where

techniques like washing, grazing, or dark-sky safe grazing emphasize form without drawing excessive energy.

4.9.27 Impact of Unsustainable Practices on the Urban Nightscape

Respondents evaluated whether: "Non-sustainable façade lighting practices negatively affect the environmental quality of the urban nightscape."

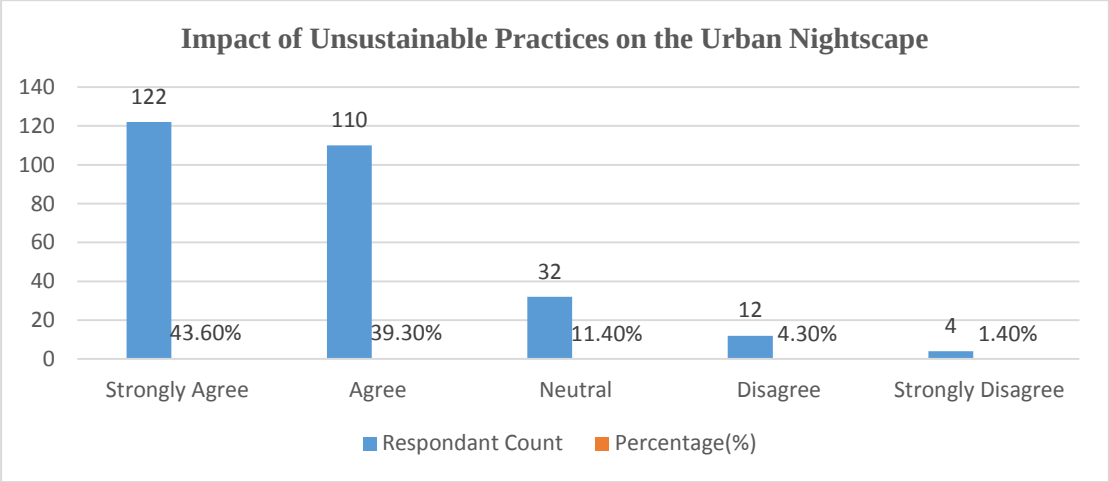


Figure 52. Illustrate the respondents Urban Nightscape Degradation via Non-Sustainable Lighting

4.10 Daytime Influence of Façade Lighting Fixtures

Section 8: This final section explores the daytime visual clutter generated by poorly concealed or integrated lighting infrastructure.

4.10.1 Exposed Cabling and Equipment Clutter

Respondents evaluated the statement: "Exposed cables and poorly positioned lighting fixtures create visual clutter on building façades."

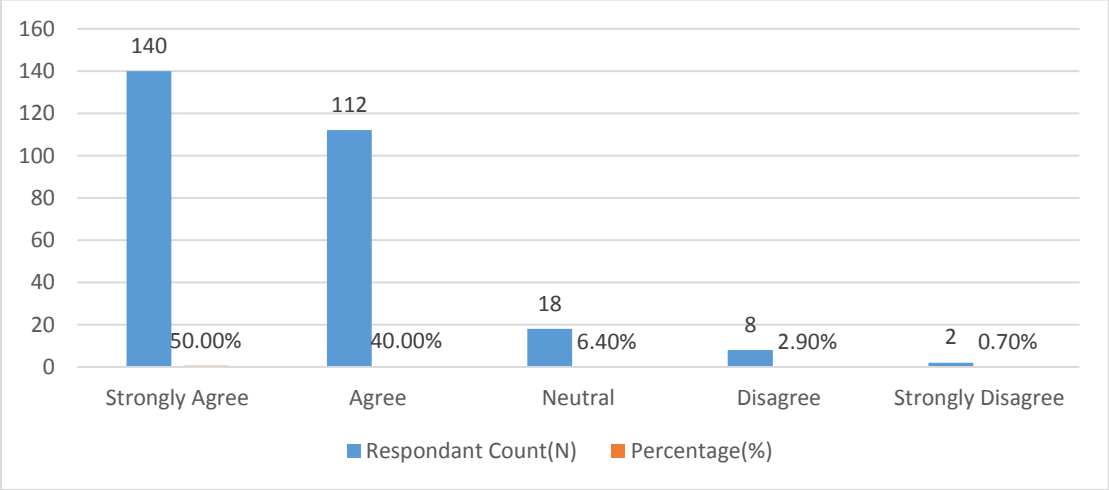


Figure 53. Illustrate the respondent Daytime Visual Clutter

4.10.2 Dual-Temporal Consideration in Design

Respondents evaluated whether: "Façade lighting design should consider the building's appearance during the day, not just at night."

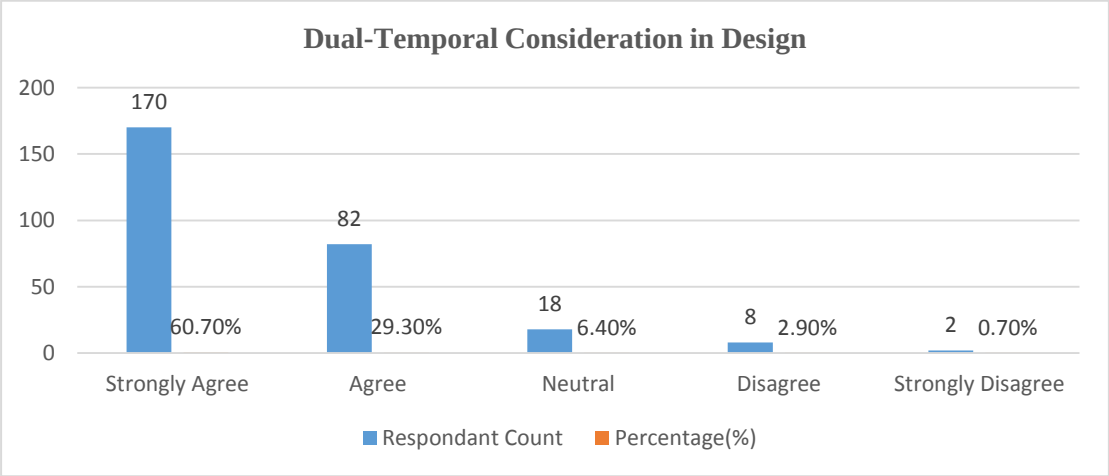


Figure 54. Illustrate the respondent Support for Dual-Temporal Architectural Design

4.10.3 Architectural Degradation via Disorganized Fixtures

Respondents evaluated the statement: "Visible and disorganized fixtures reduce the architectural quality of the building façade."

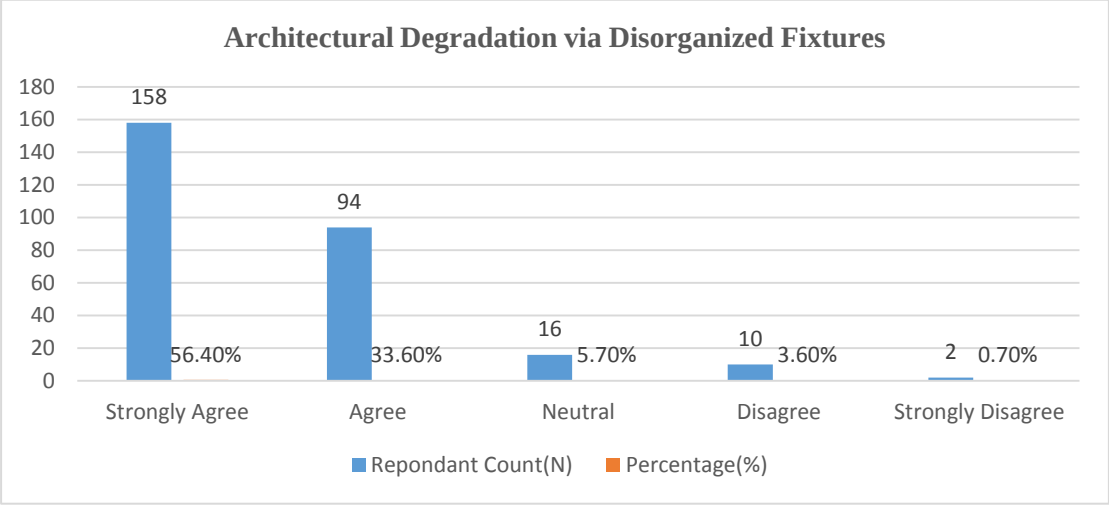


Figure 55. Illustrate the respondent Architectural Quality Degradation

The figure shows an emphatic 90.0% cumulative agreement (56.4%strongly agreeing). Disorganized fixture placement behaves as an unwanted architectural parasite on building surfaces. By breaking up surface rhythm, shadow plays, and systemic detailing, sloppy installation techniques actively undo the premium craftsmanship of the corridor's newly minted or preserved street-facing envelopes.

4.11 Respondent Data Analysis

The study used Stratified Random Sampling to make sure that the opinions of both experts and people who use the Addis Ababa inner-city corridor every day were heard equally.

4. 11.1 Experiential Stratification of Respondents

The 280 people who answered the questions were divided into four groups based on what they studied and how they use the streets:

Stratum	Category	Percentage	Respondents (Count)
Technical Expert	Master's Degree Holders	10%	28
Professional	Bachelor Degree Holders	30%	84
Academic/Student	University & College Students	10%	28
Daily user	Pedestrians(High School/Other)	50%	140
Total		100%	280

Table 16. Stratified respondents categories, percentage and count

Discussion: It is clear that half of the people who answered the questions, whish's 140 people look at the corridor from the point of view of a pedestrian. This is very important for figuring out if the lighting is good for people. The other half of the people who answered the questions, whish's also 140 people are technical experts and professionals who give a critique of the lighting from a technical point of view making sure that the findings are based on both what architects think and what people who use the city think.

4.11.2 Input Analysis: Street Lighting Quality & Impact

When we look at what the different groups say we can see how they feel about the lighting. The people who walk on the streets, which is 50% of the people who answered the questions or 140 people say that the lights are too harsh and hurt their eyes. Since these people are closest to the lights it is a problem that 90% of them agree that the lights are not shielded properly. The technical experts, which is 40% of the people who answered the questions or the people with Masters Degrees think that the lights should be changed to fixtures. They say that the current lights are not just ugly but waste energy and make the city look bad at night.

4.11.3 Spatial Context and Architectural Alignment

Proportion: The 84 professionals and 28 technical experts say that the lighting does not match the height of the buildings. The data shows that as the buildings in the inner-city corridor get taller the lighting has not changed and it does not look good.

Setback Analysis: While the students do not have an opinion about the spacing of the lights the pedestrians and technical experts say that the lights are too close together and make the street feel crowded.

4.11.4 Façade Lighting and Sustainability Analysis

All 280 people who answered the questions agree that the lighting during the day is a problem.

Visual Pollution: Everyone, whether they are students, pedestrians or technical experts says that the lights and wires make the buildings look bad during the day.

Non-Sustainable Practice: The technical experts say that the way the lights are set up on the buildings is not good for the environment uses much energy and is hard to maintain.

4.11.5 Synthesis of Stratified Findings

Pedestrian Vulnerability: The pedestrians, which is the group of people who answered the questions or 50% of the people are the most affected by the harsh lights, which shows that the current lighting is not good for people.

Critique: The technical experts say that the city’s new buildings and old lighting do not match with

Holistic aesthetic concern: Everyone who answered the questions, which's 100% of the people says that the lighting should be designed to look good during the day and not just at night.

Policy Recommendation: The data shows that the city should use lights that respect the people who walk on the streets and also save energy.

4.11.6 Difficulties in Sustainable Integration of Facade Lighting on the Building Envelope

This part of the study looks at the problems of making a good environment for lights on buildings, in the inner city of Addis Ababa. It looks at how the lights affect the way the buildings look how they make the city look during the day and night. The results show that the lights are mainly used to make the city look good at night. However the way the lights are set up does not match the style and design of the buildings.

4.11.7 Synthesis of Stratified Findings

The study findings show that the current lighting in the inner-city corridor causes problems for people. The lighting is bad for people in ways.Most pedestrians, who make up half of the respondents are bothered by the brightness and glare of the lighting. Experts and professionals say that the lighting infrastructure is not good enough for the size of the surrounding buildings.

They also do not like that similar lighting systems are used in all the corridors, which makes the city look the same and it is not nice at night. All the respondents agree that urban lighting should make the city look good during the day and at night. They think the lighting should not just be bright at night it should be nice too.

The study of lighting in Addis Ababa shows that the urban lighting should focus on making pedestrians comfortable preserving the character of the buildings saving energy and considering the street conditions.

This means that the city of Addis Ababa needs guidelines for lighting that consider peoples experience the corridor of Addis Ababa. The guidelines should help create a nighttime environment in Addis Ababa. The study of urban lighting highlights the need for an approach to urban lighting, in Addis Ababa.

4.11.8 Problems with Façade Lighting without Integration with the Building Envelope

The empirical findings reveal a fundamental problem in the implementation of façade lighting within the study corridors: lighting is frequently treated as an afterthought or decorative addition rather than as an integrated component of the building envelope.

As a result, the scale, material, location, and arrangement of lighting fixtures often fail to respond to the architectural form, rhythm, and material character of the buildings.

This lack of integration is particularly evident during the daytime, when exposed fixtures, wiring, conduits, grids, and modular equipment become visually prominent and contribute to façade clutter and deterioration of the corridor's architectural image. The findings also indicate that modular and poorly integrated systems create maintenance difficulties, while continuous operation and limited consideration of building use contribute to unnecessary energy demand.

Furthermore, the absence of sufficiently specific façade-lighting guidelines contributes to inconsistent practices in terms of intensity, fixture arrangement, architectural compatibility, and operational control. Consequently, the current approach tends to prioritize immediate nighttime brightness and decorative appearance over long-term architectural integration, technical maintainability, and energy sustainability. Façade lighting should therefore be incorporated into the original building-design process and supported by appropriate technical and regulatory guidance to ensure that nighttime enhancement does not compromise the building's daytime appearance or long-term performance.

CHAPTER FIVE

5. DISCUSSION

5.1 Urban Illumination and the Spatial Structure of the Inner-City Corridor

The findings indicate that urban illumination within the Addis Ababa inner-city corridor has largely been approached as an infrastructure and urban beautification intervention, with comparatively limited integration with the existing spatial structure of streets, buildings, setbacks, pedestrian spaces, and other urban elements.

The observed relationship between lighting infrastructure and the physical characteristics of the corridor indicates that the placement, height, and distribution of lighting elements cannot be considered independently from street width, building height, building setback, and pedestrian-space configuration. Where these relationships are inadequately coordinated, lighting infrastructure can introduce additional visual and physical elements that compete with rather than reinforce the existing spatial structure.

The findings therefore suggest that the effectiveness of urban illumination is determined not only by the quantity of light provided but also by the spatial appropriateness of its location, scale, distribution, and relationship to the surrounding built environment. Urban lighting should consequently be understood as an element of spatial design rather than solely as an electrical or infrastructural provision.

5.2 Urban Illumination and Architectural Identity

The assessment of façade lighting indicates that architectural illumination has considerable potential to reinforce the nighttime identity of buildings when it is designed in response to architectural form, proportion, materiality, rhythm, and significant building elements.

However, the observed application of repetitive and visually dominant façade luminaires demonstrates that illumination can also obscure architectural qualities when the lighting system becomes more visually prominent than the architectural

features it is intended to reveal. The extensive use of uniformly distributed fixtures may consequently contribute to visual homogenization and reduce the individual architectural expression of buildings along the corridor.

This condition suggests that façade illumination should be incorporated into the architectural design process rather than treated as an independent decorative intervention applied after the completion of the building. The quality of architectural façade lighting is therefore dependent on the extent to which the lighting strategy is integrated with the building's architectural composition.

The variation observed among privately illuminated buildings further indicates that technical guidance, although necessary, does not by itself guarantee architectural quality. The final outcome is also influenced by the decisions of building owners, architects, electrical designers, contractors, and project managers who translate general guidance into specific lighting arrangements.

5.3 Visual Quality, Brightness, and Architectural Expression

The findings demonstrate that increased nighttime brightness should not be regarded as synonymous with improved urban environmental quality. Although artificial illumination can improve visibility, identity, and nighttime activity, excessive or poorly directed light can adversely affect visual comfort, architectural depth, spatial legibility, and the perception of material and form.

The observed conditions of glare, visual competition, light trespass, reflected brightness, and excessive contrast indicate that the performance of urban illumination should be evaluated in relation to the quality and direction of light rather than solely according to the amount of light produced.

Architectural form is generally more effectively revealed through an appropriate relationship between illumination and shadow than through indiscriminate or uniform illumination. Accordingly, the aesthetic objective of urban beautification should not be interpreted as maximizing brightness, but as achieving an appropriate visual balance in which illumination supports architectural and spatial qualities.

This distinction is particularly important in the context of public-sector urban beautification initiatives, where increased brightness may be perceived as an indicator of attractiveness, modernization, or nighttime vitality. While illumination can contribute to these objectives, brightness in itself does not establish visual quality. Its contribution depends on how appropriately it is directed, distributed, controlled, and related to the surrounding urban environment.

5.4 Energy Performance of Urban Illumination

The energy assessment indicates that the energy performance of urban illumination is influenced by the combined effects of luminaire wattage, number of fixtures, lighting distribution, operating duration, and control mechanisms. Consequently, energy demand cannot be adequately assessed by considering fixture wattage alone.

The comparison between the prescribed illuminance requirements and the installed lighting capacity indicates that greater attention is required during the design stage to establish an appropriate relationship between required illumination, luminaire capacity, and actual spatial conditions. The issue should not be interpreted simply as a failure to establish a technical lighting requirement; rather, it concerns the relationship between the specified requirement, the capacity selected to achieve it, and the resulting operational condition.

The findings therefore point to a broader energy-governance and design issue in which technical lighting requirements, design decisions, installation practices, and operational management need to be more closely connected. International lighting principles and applicable local requirements provide an important basis for determining appropriate illuminance levels and luminaire capacities, but their effectiveness depends on their translation into project-specific design and implementation decisions.

Energy efficiency should consequently be considered as an integral component of lighting design from the outset. Decisions regarding illuminance, luminaire capacity, spacing, distribution, operating duration, and control should be evaluated together so that functional requirements can be achieved without creating unnecessary energy demand.

5.5 Equitable Distribution and Appropriate Allocation of Lighting Resources

The findings also suggest that energy sustainability has a spatial dimension. It is not limited to reducing the energy consumption of individual luminaires but also concerns the appropriate allocation of lighting resources across different parts of the city.

The application of relatively intensive illumination to selected urban corridors while other areas receive comparatively limited lighting raises questions concerning the spatial distribution of public lighting investment. Such variation is not necessarily inappropriate, since different streets and public spaces have different functional and social requirements. However, differences in lighting intensity should be supported by a clear hierarchy based on street function, pedestrian activity, traffic conditions, public-space use, safety requirements, and urban significance.

Accordingly, an effective urban illumination strategy should distinguish between locations requiring different levels and types of illumination rather than applying a uniform lighting approach. The objective should therefore be to achieve **appropriate illumination for appropriate urban conditions**, rather than pursuing citywide brightness as an independent objective.

This approach would allow energy resources to be directed toward locations where illumination provides the greatest functional, spatial, social, and architectural benefit while avoiding unnecessary concentration of energy-intensive systems in selected areas.

5.6 Interaction between Lighting Design and Management

The findings indicate that the observed challenges cannot be adequately explained as either design deficiencies or management deficiencies in isolation. The performance of an urban illumination system emerges from the interaction between design decisions, technical implementation, operation, monitoring, maintenance, and subsequent adjustment.

A technically appropriate lighting design may not achieve its intended performance when operating schedules, control systems, maintenance practices, or monitoring procedures are inadequate. Conversely, effective operational management cannot fully compensate for an inappropriate initial design in which luminaire capacity, positioning, distribution, or relationship to the surrounding urban form has not been properly established.

The distinction between design and management is therefore important but should not result in treating them as separate processes. The findings support an integrated approach in which design decisions anticipate operational requirements and management procedures provide continuous feedback to the design and implementation process.

5.7 Institutional Coordination and Project Governance

The findings further indicate that effective urban illumination requires coordination among the institutions responsible for electrical services, road and infrastructure development, urban planning and design, building regulation, project implementation, and property development.

Within this institutional arrangement, ESAA's technical responsibility for electrical-service and public-lighting requirements needs to be considered in conjunction with the spatial and infrastructural responsibilities of the relevant Addis Ababa road authority and the responsibilities of urban planning, building-permit, and architectural institutions.

The issue is therefore not appropriately understood as the responsibility of a single institution. Rather, the findings point to a coordination requirement in which technical lighting decisions are reviewed in relation to road geometry, pedestrian movement, building setback, architectural character, landscape, public-space quality, energy performance, and long-term maintenance.

A coordinated institutional mechanism would enable lighting requirements established at the technical level to be translated more effectively into spatially and architecturally appropriate implementation.

5.8 Local Good Practice and Architectural Façade-Lighting Management

The Sheraton Addis case provides a useful local reference for understanding how architectural façade lighting can be integrated with energy and operational management. Its relevance to this study lies not simply in its visual appearance but in the integration of architectural intent with programmable control, zoning, scheduling, dimming, electrical protection, system operation, and maintenance.

This approach demonstrates that architectural quality and energy efficiency need not be treated as competing objectives. When lighting is conceived as an integrated system, the intensity, timing, distribution, and control of illumination can be coordinated with the architectural purpose of the building and its operational requirements.

The case therefore provides a useful methodological reference for Addis Ababa's future façade-lighting practice. Rather than reproducing a particular lighting appearance, the city can learn from the underlying principles of integrated architectural lighting, programmable control, operational scheduling, and systematic maintenance and adapt them to different building types and urban contexts.

5.9 Macro-Scale Implications of Increasing Nighttime Illumination

The nighttime-light analysis provides a broader spatial perspective on the changes identified through the ground-based assessment. The increase in nighttime radiance between the baseline period and 2025 indicates a substantially more pronounced concentration of artificial illumination along the developed inner-city corridor.

The satellite-derived radiance values should not, however, be interpreted as direct measurements of electricity consumption. Rather, they provide complementary macro-scale evidence of changes in the intensity and spatial distribution of artificial nighttime illumination. When considered alongside the ground-based assessment of lighting capacity and operating practices, the satellite analysis helps demonstrate that the implications of intensive illumination extend beyond individual luminaires and buildings to the wider urban nightscape.

The increase in brightness also highlights an important relationship between urban perception and energy use. In some urban development and beautification contexts, increased nighttime brightness may be associated with modernization, attractiveness, safety, or urban vitality. Nevertheless, greater brightness requires additional energy and operational resources, and its contribution to urban quality depends on whether the illumination is functionally justified, appropriately directed, and spatially coordinated.

The findings therefore suggest that the objective of urban illumination should not be to maximize nighttime brightness but to achieve an appropriate relationship between visual benefit, functional requirement, spatial distribution, architectural expression, and energy demand**.**

5.10 Synthesis of the Findings

Taken together, the findings indicate that the principal challenge associated with urban illumination in the Addis Ababa inner-city corridor is not the provision of artificial lighting itself, but the limited integration of spatial planning, architectural design, technical requirements, energy considerations, institutional coordination, operation, and maintenance.

The study consequently identifies a need to move beyond a project-based understanding of illumination toward an integrated urban illumination approach. Such an approach would recognize lighting as a component of the urban environment whose performance depends on the relationship between its physical design, architectural purpose, technical requirements, energy implications, operational management, and institutional governance.

The overall discussion therefore supports a transition from a predominantly brightness-oriented and implementation-focused approach **toward a** performance-based urban illumination framework**,** in which lighting is evaluated according to its functional adequacy, spatial integration, architectural contribution, visual comfort, energy performance, equitable distribution, operational controllability, and long-term maintainability.

CHAPTER SIX

6. RECOMMENDATIONS

6.1 Establish an Integrated Urban Illumination Planning Framework

Addis Ababa should establish an integrated urban illumination planning framework that brings together spatial planning, road infrastructure, architectural design, public-space development, electrical engineering, energy management, operation, and maintenance.

Urban illumination should be incorporated into corridor planning and urban-design processes from the initial planning and design stages rather than being introduced primarily as a subsequent beautification or infrastructure intervention.

The proposed framework should establish a clear relationship between the functional classification of streets and public spaces and the appropriate type, intensity, distribution, and operational requirements of illumination.

6.2 Establish an Inter-Institutional Coordination Mechanism

A formal coordination mechanism should be established among ESAA, the appropriate Addis Ababa road and transport infrastructure authority, relevant urban planning and design institutions, building-permit authorities, project-management offices, building owners, architects, and other responsible stakeholders.

The mechanism should provide for joint review of major illumination projects before implementation, ensuring that electrical and photometric requirements are considered together with road geometry, pedestrian movement, building setback, building height, architectural character, landscape, public-space quality, energy performance, and maintenance requirements.

Rather than assigning responsibility for observed deficiencies to a single institution, the proposed mechanism should clarify institutional roles while ensuring that decisions made by one responsible sector are compatible with the objectives and requirements of the other sectors.

6.3 Introduce Pre-Implementation Lighting Design Review

Major urban illumination projects should undergo a formal technical and design review before installation. The review should assess illuminance requirements, luminaire wattage, spacing, mounting height, light distribution, glare potential, architectural compatibility, energy demand, operating duration, control systems, maintenance requirements, and relationship to surrounding urban form.

Photometric calculations and simulations should be undertaken for representative corridor conditions to establish that the selected lighting capacity is proportionate to the actual functional requirement.

6.4 Establish Appropriate Illuminance and Luminaire-Capacity Selection

Illuminance levels and luminaire wattages should be determined according to the functional classification and spatial characteristics of each street or public space. Applicable local requirements should be considered together with recognized international lighting principles to establish technically defensible and contextually appropriate design values.

Luminaire selection should be based on the required lighting performance rather than maximum available output. In particular, high-wattage decorative systems should not be selected merely because they produce greater brightness when lower-capacity systems can satisfy the required visual conditions.

Lighting design should therefore establish an appropriate relationship between **lux** requirement, luminaire capacity, spacing, distribution, mounting height, and operating condition**.**

6.5 Establish Citywide Lighting Hierarchy and Equitable Distribution

A citywide lighting hierarchy should be established to ensure that illumination resources are distributed according to the functional, spatial, and social importance of different urban areas. Primary corridors, secondary streets, local streets, pedestrian routes, public spaces, and landmark areas should not necessarily receive the same level or type of illumination.

Lighting provision should therefore respond to factors such as street function, pedestrian activity, traffic conditions, public-space use, safety requirements, urban significance, and nighttime activity patterns. This approach would help avoid the assumption that increasing illumination uniformly across the city represents an improvement in urban quality.

Equitable distribution should also be considered in relation to energy and infrastructure resources. The objective should be to provide appropriate levels of illumination where they are functionally and spatially justified**,** rather than concentrating excessive lighting capacity in selected corridors while other areas remain comparatively underprovided. A citywide hierarchy would consequently support more balanced allocation of lighting investment, energy consumption, and maintenance resources.

6.6 Integrate Façade Lighting into Architectural Design

Façade lighting should be incorporated into the architectural design process rather than treated as an independent installation following building completion. Architects, electrical designers, building owners, and project managers should coordinate fixture position, light direction, intensity, colour characteristics, wiring, mounting systems, and control mechanisms with the architectural form and materiality of the building.

Façade-lighting proposals should demonstrate how the proposed system enhances significant architectural features without creating excessive brightness, glare, light trespass, visual competition, or unnecessary daytime façade clutter.

6.7 Reframe the Façade Lighting Regulatory Framework

The local façade lighting regulatory framework should be revisited and strengthened to move beyond controlling fixture type, positioning, spacing, intensity, and colour characteristics toward a more integrated relationship between façade design and illumination. The findings indicate that current practice often emphasizes lighting installation and visual brightness more than the architectural and spatial relationship between the façade and its lighting system. The revised framework should therefore establish clearer requirements for the coordination of lighting with façade composition, architectural form, material, building identity, visual comfort, and energy performance. It should also address the visibility and integration of fixtures, cables, and other supporting infrastructure during both daytime and nighttime conditions. This would help ensure that façade illumination functions as an integrated component of architectural and urban design, rather than as an independent decorative or technical installation.

6.8 Establish Sustainable Façade-Lighting Guidelines

The responsible authorities should develop more detailed façade-lighting guidance addressing fixture density, light direction, colour characteristics, intensity, mounting position, operating periods, control systems, and relationship to significant architectural elements. Particular emphasis should be placed on the principle that architectural lighting should reveal rather than obscure architectural form.

The guidance should also encourage programmable control, scheduling, zoning, dimming, and automatic switching where appropriate so that façade lighting can respond to building operation and changing nighttime conditions.

6.9 Apply the Sheraton Addis Approach as a Local Learning Reference

The principles demonstrated by the Sheraton Addis approach should be considered as a local good-practice reference for future architectural façade-lighting projects. The transferable lessons include the integration of architectural lighting intent with programmable control, zoning, scheduling, dimming, electrical protection, maintenance, and operational management.

The objective should not be to reproduce the specific appearance of the Sheraton Addis but to adapt the underlying system-based approach to the architectural character, function, scale, and operational requirements of different buildings within Addis Ababa.

6.10 Strengthen Energy Management of Urban Illumination

Energy performance should be incorporated into the approval and evaluation of urban illumination projects from the design stage. Project assessment should consider installed capacity, expected operating duration, lighting distribution, control strategy, maintenance requirements, and anticipated energy demand before implementation. Where technically appropriate, adaptive operating strategies such as scheduled dimming, zoning, automatic switching, and programmable control should be incorporated to reduce unnecessary operation while maintaining required levels of visibility, safety, and architectural presentation.

6.11 Establish Post-Implementation Monitoring and Evaluation

Urban illumination projects should undergo systematic post-implementation monitoring to assess whether the installed systems achieve their intended spatial, architectural, functional, visual, and energy objectives. Monitoring should include assessment of actual illuminance, glare, light distribution, operating schedules, energy performance, equipment condition, maintenance requirements, and user response.

The results of post-implementation monitoring should be used to identify deficiencies and inform subsequent adjustments, maintenance, upgrading, and future project design.

6.12 Strengthen Institutional Follow-Up of Illumination Projects

ESAA and the relevant road, urban-development, planning, and building authorities should establish a continuing follow-up mechanism for completed illumination projects. Such follow-up should extend beyond project completion and should include periodic technical inspection, operational review, maintenance assessment, and evaluation of whether the lighting system continues to correspond with the functional and spatial requirements of the corridor. This would establish a feedback relationship between design, implementation, operation, monitoring, and future project improvement**.**

6.13 Strengthen Professional Capacity in Architectural and Urban Lighting

The responsible institutions should strengthen professional capacity in urban lighting design, architectural façade lighting, photometric analysis, energy-efficient technologies, lighting controls, nighttime urban design, and maintenance management.

Architects, urban designers, electrical engineers, road-infrastructure professionals, building owners, contractors, and project managers should be encouraged to participate in multidisciplinary lighting-design processes because urban illumination simultaneously involves spatial, architectural, technical, environmental, and energy considerations.

6.14 Develop Context-Sensitive Lighting Standards and Design Guidance

Future lighting guidance should combine international good practice with local urban conditions rather than applying external standards without contextual adaptation.The development of guidance should consider Addis Ababa's street hierarchy, urban

morphology, architectural diversity, pedestrian conditions, building setbacks, infrastructure limitations, energy resources, climatic conditions, and nighttime activity patterns. This would allow technical requirements to be translated into lighting solutions that are both internationally informed and locally appropriate.

6.15 Establish a Long-Term Urban Illumination Management System

Urban illumination should be managed as a long-term urban infrastructure system rather than as a one-time beautification project. A continuous management process should connect planning, design, technical review, approval, implementation, commissioning, operation, monitoring, maintenance, evaluation, and periodic upgrading**.** The performance of future illumination projects should consequently be evaluated against a balanced set of criteria comprising functional adequacy, spatial integration, architectural expression, visual comfort, energy efficiency, equitable distribution, operational control, and maintainability.

6.16 Overall Recommendation

The central recommendation of this study is that Addis Ababa should transition from a project-based and brightness-oriented approach to an integrated, context-sensitive, and performance-based urban illumination system**.** Urban illumination should be considered as part of urban design and architectural development from the planning stage, with decisions on lighting guided by the spatial structure, functional hierarchy, architectural character, public-space requirements, energy performance, and nighttime activity of each corridor.

This transition requires stronger coordination among lighting authorities, road and urban-development institutions, architects, electrical engineers, building owners, and project-management bodies**,** supported by pre-implementation design review, clear local standards, and post-implementation monitoring. Street and façade lighting should be assessed not only according to technical adequacy and visual brightness, but also according to spatial integration, architectural expression, visual comfort, energy efficiency, environmental effects, equitable distribution, operational control, and maintainability**.**

Particular attention should be given to reframing façade-lighting regulation so that fixture spacing, positioning, intensity, colour, and technology are evaluated together with façade composition, architectural identity, materiality, daytime appearance, and energy use. Similarly, street lighting should be selected and positioned according to street hierarchy, building setbacks, pole-to-building relationships, pedestrian movement, and required illumination levels. Adaptive controls, scheduling, dimming, and systematic maintenance should be incorporated where appropriate to reduce unnecessary energy consumption while maintaining functional and architectural objectives.

Ultimately, the guiding principle for future urban illumination should be "appropriate light for the appropriate place, purpose, and time." The success of an illumination project should therefore not be measured by how brightly or extensively a corridor is illuminated, but by whether it improves nighttime visibility and identity, strengthens spatial and architectural quality, supports public activity, protects visual comfort and the surrounding environment, uses energy responsibly, distributes resources appropriately, and remains technically and institutionally manageable throughout its operational life**.**

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Appendix I: Publishable Manuscript

URBAN ILLUMINATION AND CITY BEAUTIFICATION IN ADDIS ABABA: SPATIAL, ARCHITECTURAL, AND ENERGY IMPLICATIONS OF INNER-CITY CORRIDOR LIGHTING

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ABSTRACT

Urban illumination has become an increasingly visible component of corridor redevelopment and city beautification in Addis Ababa. This study examines how contemporary street and façade lighting practices in selected inner-city corridors relate to spatial structure, architectural expression, visual perception, energy use, and operational management. A mixed-method case-study approach was used, combining field observation and photographic documentation, GIS-based spatial analysis, technical and energy assessment, institutional interviews and documentary evidence, and a structured questionnaire involving 280 respondents. The analysis was organized around four evaluation domains: formal-process and regulatory consistency; spatial and visual integration; illumination as a medium of architectural and urban perception; and sustainability and operational management.

The findings indicate that the principal challenge is not the provision of illumination itself, but the limited integration of lighting with the physical and institutional structure of the urban corridor. Street-lighting installations are frequently positioned with limited setbacks and are not consistently calibrated to surrounding street width, building height, pedestrian space, and architectural scale. These conditions contribute to glare, light trespass, visual dominance, and reduced spatial coherence. Façade lighting is commonly applied as a post-construction intervention, with dense and repetitive fixtures, exposed wiring, and high-intensity illumination that can obscure architectural depth and create daytime visual clutter. Technical assessment of a selected secondary arterial corridor identified 58 poles over approximately 29,756 m², with each pole carrying a 770 W lighting assembly. The study also found an installed

connected load of 745.36 kW across 968 poles, compared with an 180 W-per-pole optimized benchmark used in the thesis analysis. Six representative façade-lighting cases collectively contained approximately 1,323 point-source fixtures and an estimated annual demand of 53,118.45 kWh under the stated operating assumptions.

Nighttime-light imagery provides complementary evidence of a stronger concentration of artificial illumination in the study corridor between the 2021–2022 baseline and 2025, although satellite radiance is not interpreted as a direct measure of electricity consumption. Questionnaire findings further indicate strong concern regarding glare, inadequate spatial integration, visual dominance, façade clutter, and the need to balance visual quality with energy efficiency. The study argues for a transition from a brightness-oriented, project-based approach toward an integrated and performance-based urban illumination framework in which spatial fit, architectural expression, visual comfort, energy performance, operational control, maintenance, and institutional coordination are considered together.

Keywords: urban illumination; city beautification; street lighting; façade lighting; spatial integration; architectural identity; visual comfort; energy sustainability; Addis Ababa

1. Introduction

1.1 Background and Research Problem

Urban illumination is increasingly treated as part of the urban public realm rather than as a purely technical service. Lighting affects visibility, movement, safety, nighttime activity, spatial legibility, architectural expression, and the image of the city. From the perspective of urban design, illumination is therefore another layer through which streets, buildings, public spaces, landscapes, and landmarks are perceived after dark (Lynch, 1960; Boyce, 2014; Narboni, 2016). Contemporary city beautification has extended this role by using decorative street lighting and architectural illumination to reinforce attractiveness, identity, and nighttime activity.

In Addis Ababa, recent corridor redevelopment has increasingly incorporated decorative street lighting and façade illumination into the transformation of major inner-city routes. The study focuses on the Bole Airport–Meskel Square axis, the Filwuha–National Palace corridor, and selected central corridors in Piassa, Churchill

Avenue, and Mexico. These areas contain different relationships among streets, buildings, pedestrian spaces, landscape elements, and lighting infrastructure, providing a useful setting for examining whether illumination responds to the existing urban structure.

The central problem identified by the thesis is not a lack of lighting, but a gap between illumination provision and urban integration. Where lighting infrastructure is positioned without sufficient consideration of street width, building height, setbacks, pedestrian movement, architectural form, and lighting hierarchy, decorative elements can become visually dominant. Similarly, façade lighting installed after construction can introduce exposed equipment, repetitive fixture patterns, excessive brightness, and maintenance difficulties. Energy implications are also shaped by the number of fixtures, installed capacity, operating duration, distribution, and control systems rather than by luminaire efficiency alone.

The study consequently asks how contemporary illumination practices respond to the spatial and architectural characteristics of Addis Ababa's inner-city corridors, how they affect nighttime perception and visual quality, and how their energy and management implications can be improved.

1.2 Research Objective

The study aims to investigate the extent to which urban public-space illumination and city beautification practices in Addis Ababa's inner-city corridors are consistent with principles of urban development, urban design, public-space quality, illumination, and energy sustainability, with particular emphasis on spatial, functional, aesthetic, perceptual, management, and energy dimensions.

2. Conceptual and Analytical Framework

The study treats illumination as a medium through which urban space and architecture are perceived rather than as an end in itself. This position is consistent with Lynch's (1960) emphasis on legibility and imageability and Cullen's (1961) concept of serial vision, in which the city is experienced through a sequence of changing views. Lighting can reinforce paths, edges, nodes, landmarks, and architectural features, but excessive brightness, glare, poorly controlled distribution, or visually dominant fixtures can undermine the same legibility that lighting is intended to support.

The literature review also establishes that sustainable illumination requires more than efficient lamps. Shielding, targeting, intensity calibration, temporal control, spectral selection, maintenance, and spatial planning operate together. A technically efficient LED installation can remain unsustainable if too many fixtures are installed, if output is excessive, if light is directed beyond the intended area, or if systems operate at full output when nighttime activity is low (Boyce, 2014; Gaston et al., 2013; IES, 2020).

Four evaluation domains were therefore used to connect the literature to empirical analysis: (1) formal-process and regulatory consistency, examining planning, approval, coordination, implementation, and regulation; (2) spatial and visual integration, examining street width, pole height, spacing, building height, setback, output, and distribution; (3) illumination as a medium of architectural and urban perception, examining architectural expression, visual hierarchy, identity, legibility, glare, clutter, and visual comfort; and (4) sustainability and operational management, examining intensity, targeting, operating duration, control, energy demand, maintenance, and long-term performance.

Table 1. Analytical domains and principal evidence

Evaluation domain	Main analytical focus	Principal evidence
Formal-process and regulatory consistency	Planning, design process, institutional responsibility, approval, coordination, implementation, corrective management	Institutional interviews, documents, standards, technical records, observation
Spatial and visual integration	Street width, pole height and spacing, building height, setback, output, distribution, pedestrian space	GIS, field observation, photographs, technical data, simulation
Architectural and urban perception	Architectural expression, visual hierarchy, identity, legibility, glare, visual comfort, clutter	Photographs, field observation, questionnaire, project intentions
Sustainability and operational management	Energy demand, fixture density, operating duration, shielding, targeting, controls, maintenance	Energy records, technical specifications, calculations, interviews, observation, remote sensing

The analytical framework distinguishes between design problems, implementation problems, and management or corrective-action problems. This distinction is important because an observed deficiency does not necessarily originate at the same stage at which it becomes visible. A lighting system may have passed through an approval process but still produce poor spatial or visual outcomes, while an initially appropriate design may perform poorly because of inadequate operation or maintenance.

3. Methodology

3.1 Research Design and Study Area

The research used a mixed-method case-study design. The case-study approach allowed illuminated urban elements to be examined within their actual spatial, architectural, institutional, and operational contexts. The selected corridors were chosen because they contain substantial recent redevelopment and beautification interventions involving street, façade, landscape, and related forms of illumination. The study was primarily concerned with contemporary practices implemented during the recent corridor redevelopment period identified in the thesis, with field and analytical evidence extending through 2026.

The research distinguished between public-sector-managed illumination associated with corridor and public infrastructure projects and designer-managed/private cases associated with individual building owners or development teams. The Sheraton Addis façade-lighting system was used as a local good-practice reference for integrated architectural lighting management rather than as a direct numerical benchmark.

3.2 Data Collection

Field observation involved repeated daytime and nighttime visits to document fixture location, mounting arrangements, spatial distribution, façade conditions, pedestrian environments, glare, excessive brightness, exposed cables, visual clutter, and relationships between lighting infrastructure and surrounding urban elements. Photographs were used to record both nighttime effects and daytime consequences.

GIS-based analysis quantified street width, building height, building setback, pole location, pole spacing, and relationships between pole height and corridor dimensions. Technical and energy analysis examined installed capacity, luminous output, operating duration, illuminance, and control practices. A structured five-point Likert questionnaire was administered to 280 respondents to obtain perceptual evidence concerning glare, visual comfort, spatial integration, architectural quality, and energy utilisation. Institutional interviews with the Addis Ababa City Administration Electric Service Administration Authority (ESAA) and the Mega Project Office provided

evidence on project objectives, design decisions, implementation, coordination, monitoring, maintenance, and technical requirements.

The thesis describes the questionnaire sample as stratified purposive, selected to include respondents with professional knowledge of the built environment or lighting and respondents with direct experience of the study corridors. The survey results are therefore interpreted as evidence of perceptual tendencies within the selected respondent group rather than as statistically representative estimates for the entire population of Addis Ababa.

3.3 Technical and Analytical Procedures

For the selected secondary arterial corridor from the Ambassador area toward the National Palace, the study used an area of approximately 29,756.019 m² and 58 lighting poles. The local requirement identified in the thesis was 10 lux for the secondary arterial classification. Each pole was documented with a 770 W assembly and a combined luminous output of approximately 85,000 lm, consisting of 45,000 lm from the upper decorative components and 40,000 lm from the downward components. The thesis used a lumen-method calculation incorporating a coefficient of utilisation of 0.45 and a light-loss factor of 0.80.

At the wider study-area scale, 968 decorative street-lighting poles were assessed at 770 W each, giving a connected load of 745.36 kW. The thesis compared this with an 180 W-per-pole optimized benchmark, equivalent to 174.24 kW, producing a calculated connected-load difference of 571.12 kW. This comparison is treated as a benchmark-based indication of installed-capacity surplus, not as proof that a single universal wattage is appropriate for every street.

Façade-lighting energy was examined through representative building cases. Six selected buildings contained an estimated 1,323 point-source fixtures at 10 W each under an assumed operating duration of 11 hours per night. The resulting aggregate estimate was 145.53 kWh per night and 53,118.45 kWh per year. These calculations illustrate the cumulative effect of fixture density and operating duration rather than claiming to represent all private façade lighting in Addis Ababa.

Nighttime-light remote sensing was used as complementary macro-scale evidence. The thesis reports an increase in maximum observed radiance from 109.452 during the 2021–2022 baseline to 256.357 in 2025, an increase of approximately 134.2% in the reported radiometric value. This evidence is interpreted as a change in the

intensity and spatial concentration of nighttime illumination, not as a direct measurement of electricity consumption.

4. Results

4.1 Spatial Integration of Street Lighting

The field and GIS analysis indicates a recurring mismatch between decorative street-lighting infrastructure and the spatial structure of the inner-city corridor. Pole location, mounting height, spacing, and visual profile were not consistently calibrated to street width, building height, building setback, pedestrian space, or the degree of spatial enclosure. In constrained locations, large decorative structures occupy a substantial part of the pedestrian visual field and can compete with the surrounding built form.

The comparative cases reinforce this interpretation. Tianfu Avenue in Chengdu accommodates prominent lighting within a broad boulevard with substantial landscape buffers and building separation, while Avenue Montaigne in Paris demonstrates a different form of integration based on established streetscape rhythm, architectural frontage, and visual restraint. The Addis Ababa cases differ because decorative infrastructure is often introduced within more constrained relationships among roadways, pedestrian areas, and building frontages. The implication is not that large lighting infrastructure is inherently inappropriate, but that its suitability depends on the spatial capacity and visual order of the receiving corridor.

4.2 Glare, Light Trespass, and Visual Comfort

The spatial mismatch has direct perceptual consequences. Where poles and luminaires are positioned close to building edges, windows, balconies, façades, and pedestrian areas, uncontrolled light can enter private interiors, produce direct or reflected glare, and increase visual contrast. The questionnaire findings support the field observations. Of the 280 respondents, 115 strongly agreed and 95 agreed that unshielded street lighting causes glare that reduces visual comfort, giving a combined agreement of 75.0%. Similarly, 90 respondents strongly agreed and 125

agreed that poorly controlled street lighting negatively affects the quality of the urban night environment, giving 76.7% combined agreement.

Respondents also showed strong support for mitigation. A combined 80.7% strongly agreed or agreed that shielded street lights can provide adequate illumination while reducing unnecessary light spill, while 83.2% supported replacing unshielded street lights with shielded fixtures. These perceptions are consistent with the study's analytical framework, which treats shielding and targeting as design measures that should keep useful illumination within the intended spatial boundary.

4.3 Architectural Expression and Façade Lighting

Façade lighting produced a distinct set of architectural challenges. Field observations indicate that many installations function as post-construction additions rather than as components of the original architectural design. Dense point-source arrangements, exposed cables and conduits, and repetitive fixture patterns can become visually prominent during the day. At night, high-intensity or unmodulated lighting can flatten building volumes, obscure shadow relationships, and reduce the depth through which architectural form is normally perceived.

The survey evidence reinforces the importance of this dual-temporal issue. Of the 280 respondents, 170 strongly agreed and 82 agreed that façade-lighting design should consider the appearance of the building during the day as well as at night, representing 90.0% combined agreement. Similarly, 158 strongly agreed and 94 agreed that visible and disorganized fixtures reduce the architectural quality of building façades, again representing 90.0% combined agreement.

The study also identified a regulatory implementation gap. The local façade-lighting guidance reviewed in the thesis addresses fixture type, positioning, maximum spacing, intensity, colour temperature, and architectural integration. The guidance includes maximum spacing values of 2.4 m for wall-washing, 2.0 m for up-lighting and grazing systems, 4.0 m for linear LED arrays, and 5.0 m for floodlighting, together with an emphasis on low-intensity and warm-white lighting for historically significant or sensitive façades. The existence of guidance, however, does not establish compliance. The field evidence indicates that translation from guidance to building-level design and installation remains inconsistent.

4.4 Energy Performance and Operational Management

The energy assessment identifies a substantial difference between installed capacity and the functional requirements considered in the thesis. Across 968 public decorative street-lighting poles, the recorded 770 W per pole gives a connected load of 745.36 kW. The thesis benchmark of 180 W per pole gives 174.24 kW, resulting in a difference of 571.12 kW. The significance of this result lies in the relationship between capacity, required illumination, distribution, and operating practice. High wattage alone does not establish poor performance, but the combination of high capacity, decorative upward components, and extended operation increases the potential for unnecessary energy demand.

The selected secondary arterial corridor provides a more localized example. The 58-pole system generates approximately 4.93 million lumens before application of the study's utilisation and loss factors. The thesis compares this installed capacity with the 10-lux local requirement and an IES range of 10–20 lux for arterial classifications. The field analysis therefore points to a calibration problem in which installed output and fixture configuration are not sufficiently matched to the functional role and spatial characteristics of the corridor.

Private façade lighting presents a different management condition because fixture selection and operation are strongly influenced by individual building owners. The six-building sample produced an estimated 53,118.45 kWh/year under the stated assumptions. The study found that façade systems commonly operated for approximately 11 hours without clear evidence of systematic late-night dimming. The Sheraton Addis reference demonstrates an alternative approach in which programmable control, zoning, scheduling, and dimming can connect architectural expression with energy management. Its value for the study is therefore methodological rather than a claim that the same system should be copied across all buildings.

4.5 Macro-Scale Nighttime Illumination

The nighttime-light analysis provides a broader spatial perspective on the ground-based findings. The thesis reports that maximum observed radiance increased from 109.452 during 2021–2022 to 256.357 in 2025. The strongest concentration was associated with the upgraded and illuminated corridor, while surrounding areas

showed comparatively lower and more gradual patterns when the corridor was excluded from the analysis.

This result should be interpreted cautiously. Satellite radiance cannot directly measure electricity consumption and cannot identify the contribution of an individual fixture. Its value in this study is complementary: it shows that the increasing intensity of lighting is spatially visible at the urban scale. Considered alongside the documented installed capacity, prolonged operation, and limited adaptive control, the result strengthens the argument for energy-conscious management rather than brightness maximization.

4.6 Public Perception and Overall Pattern

The questionnaire results reveal broad agreement that illumination should be integrated with the urban environment. A total of 220 respondents strongly agreed or agreed that street lights should be designed as part of the overall street space rather than as isolated elements, representing 89.3% of the sample. Similarly, 235 respondents strongly agreed or agreed that façade lighting should balance city-wide identity with the expression of individual buildings, representing 84.0%. These findings support the central analytical proposition that illumination should contribute to a coherent urban composition rather than function as an independent decorative layer.

Taken together, the results reveal a consistent pattern across physical, perceptual, technical, and institutional evidence: the current system has increased nighttime visibility and visual activity, but the benefits are accompanied by spatial mismatch, glare, visual competition, façade clutter, high installed capacity, extended operation, maintenance difficulties, and incomplete coordination among responsible actors.

5. Discussion

5.1 From Lighting Provision to Spatial Design

The findings indicate that the principal issue is the treatment of illumination as a project or infrastructure package rather than as part of the spatial design of the corridor. This is significant because the visual effect of a pole or luminaire is relative to its receiving environment. The same large structure can be accommodated within a broad boulevard but become visually dominant where the building edge and

pedestrian route are close to the road. Lighting design therefore needs to begin with the spatial section of the corridor and then determine the appropriate height, setback, spacing, output, outreach, and distribution.

This interpretation is consistent with the literature's treatment of urban design as an interaction among morphological, perceptual, visual, functional, social, and temporal dimensions (Carmona et al., 2010). It also supports the local emphasis of the AACRA street-lighting guidance on pole location, setback, outreach, spacing, and lighting performance. The implication is that Addis Ababa's challenge is not simply the absence of standards, but the application and coordination of existing principles within changing urban conditions.

5.2 Illumination and Architectural Identity

The façade findings demonstrate that lighting can either reveal architecture or compete with it. This distinction is important for a city beautification programme because visual attractiveness at night does not automatically mean architectural quality. When repeated fixtures dominate façades, individual buildings can become visually homogenized. When lighting follows architectural rhythm, materials, structural elements, and significant features, it can instead reinforce identity and legibility (Lynch, 1960; Narboni, 2016).

The results also show why architectural lighting needs a dual-temporal perspective. A façade is experienced during the day as well as at night. Exposed conduits, grids, and fixtures can therefore undermine the daytime appearance of a building even when the nighttime effect is considered attractive. The architectural integration of lighting should consequently include fixture concealment, mounting coordination, material compatibility, maintenance access, and control from the beginning of building design.

5.3 Brightness Is Not the Same as Quality

The study challenges the assumption that a brighter corridor is necessarily a better corridor. Lighting contributes to safety, activity, identity, and attractiveness, but its benefits depend on direction, distribution, intensity, contrast, and timing. Excessive brightness can produce glare and reduce visual comfort; poorly directed light can create trespass and visual competition; and uniform high illumination can weaken visual hierarchy. This supports a shift from maximizing brightness toward providing appropriate light for a specific function, place, and time.

The findings therefore extend the evaluation of beautification beyond visual spectacle. A successful nighttime corridor should allow important landmarks and architectural elements to become identifiable without turning every surface and fixture into a competing focal point. This is consistent with Cullen's (1961) concept of serial vision and the literature's emphasis on visual hierarchy in the nighttime city.

5.4 Energy, Management, and Governance

Energy performance emerges from the interaction of design and management. The number and wattage of fixtures establish potential demand, while operating schedules, dimming, zoning, targeting, and maintenance determine how that capacity is used over time. The façade-lighting cases demonstrate this interaction particularly clearly: relatively small individual fixtures become a significant cumulative load when hundreds of units operate simultaneously for long periods.

The governance implication is equally important. The study identifies responsibilities across electrical services, road and corridor development, urban planning and design, building regulation, project management, architects, contractors, and property owners. When these responsibilities are not coordinated, technical decisions can be disconnected from spatial and architectural requirements. A performance-based system therefore needs institutional mechanisms that connect planning, design review, implementation, operation, monitoring, maintenance, and corrective action.

6. Conclusions and Implications

The study concludes that contemporary illumination has become an important component of Addis Ababa's inner-city redevelopment and nighttime identity, but its effectiveness is constrained by limited integration across spatial, architectural, technical, energy, and management dimensions. The evidence does not suggest that illumination should be reduced simply because it produces impacts. Rather, it indicates that the type, location, intensity, distribution, duration, and control of illumination should be calibrated to the function and physical character of each corridor.

Four principal conclusions emerge. First, street-lighting infrastructure should be treated as part of the spatial composition of the corridor. Pole height, spacing, setback, luminaire position, and output need to respond to street width, building height, pedestrian space, and surrounding architecture. Second, façade lighting should be

integrated into architectural design rather than added as an aftermarket decorative layer. Third, energy efficiency requires corridor-scale and building-scale management, including appropriate capacity, targeting, scheduling, dimming, and maintenance. Fourth, effective implementation depends on institutional coordination and post-implementation feedback rather than on standards alone.

The study therefore proposes a transition from a brightness-oriented and project-based model toward an integrated, performance-based urban illumination framework. The governing principle should be appropriate light for an appropriate place and purpose. Performance should be evaluated through functional adequacy, spatial integration, architectural contribution, visual comfort, energy performance, equitable allocation of lighting resources, operational controllability, and maintainability.

7. Practical Recommendations

- Establish an integrated urban illumination planning framework linking spatial planning, road infrastructure, architecture, public-space design, electrical engineering, energy management, operation, and maintenance.
- Introduce mandatory pre-implementation lighting design review for major corridor and façade-lighting projects, including spatial, photometric, architectural, glare, energy, control, and maintenance assessment.
- Develop a corridor-based lighting hierarchy so that primary corridors, secondary streets, local streets, pedestrian areas, public spaces, and landmarks receive lighting appropriate to their functions rather than a uniform level of brightness.
- Integrate façade lighting into the architectural design process and require coordination of fixture location, direction, intensity, colour, wiring, mounting, and controls with building form and materiality.
- Strengthen application and monitoring of local façade-lighting guidance, particularly regarding fixture spacing, intensity, colour characteristics, architectural integration, and visual impact.
- Replace or retrofit poorly controlled street-lighting systems with shielded and appropriately targeted luminaires where technically justified, while recalibrating output to actual functional requirements.

- Introduce programmable control, scheduling, zoning, and dimming for decorative and façade lighting, particularly during periods of reduced nighttime activity.
- Establish post-implementation monitoring that measures illuminance, glare, operating schedules, energy performance, equipment condition, maintenance needs, and user response.
- Create an inter-institutional review mechanism involving ESAA, road and urban-development authorities, planning and design offices, building-permit authorities, project-management bodies, architects, and building owners.
- Manage illumination as long-term urban infrastructure rather than as a one-time beautification project, with continuous feedback from operation and maintenance into future design.

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APPENDIX II: Academic Research Questionnaire

Dear Participant!

The purpose of this survey is to gather data for research being conducted as partial fulfilment of the requirements for a Master of Science (M.Sc.) degree in Urban Design and Development at the School of Built Environment (SBE)

Address

- Post Graduate Student, Urban Design and Development
- Addis Ababa University, School of Built Environment(SBE)
- Tel: +251701723123
- E-mail:-tedtecture@gmail.com
- Addis Ababa, Ethiopia

- Regards,
- Date; Jan, 2026

Introduction:

This questionnaire aims to obtain professional opinions to help identify and understand
"Urban public space illumination practice and city beautification In the inner-city corridor of Addis Ababa: Spatial, architectural, and energy implications

." Specifically, it explores how illumination affects:

- Safety and visibility for pedestrians and vehicles
- Aesthetic and architectural expression of streets and buildings
- Energy use and sustainability of lighting strategies
- Environmental and community impacts, including glare and light pollution
- Spatial Context integration with urban street and corridor design Instructions

Please indicate your level of agreement with each statement using the scale:

Section1: General Information of Respondents

1. Academic Background ☐ School ☒ Masters ☐ Diploma

☒ PhD

Others: _____

In what way did you experience the inner-city corridor?

☐ I live in the inner city of Addis Ababa

☐ It is my workplace area

☒ I feel it as I pass by some means of transport or vehicles/ regularly walk on foot

2. How familiar are you with the application of street lighting, decorative lighting, and façade lighting in urban areas?

☐Very familiar ☐ Familiar ☐ Neutral ☐ Slightly familiar ☐ Not familiar

Section 2: Street Lighting Quality and Impact

Please indicate your level of agreement with the following statements by marking in the box

3. Unshielded street lighting causes glare that reduces visual comfort at night.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

4. Street lights that allow light to spill upward contribute to sky glow and light pollution.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

5. Poorly controlled street lighting negatively affects the quality of the urban night environment.

☐ Strongly agree ☒ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

6. Shielded street lights provide adequate illumination while reducing unnecessary light spill

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

7. Replacing unshielded street lights with shielded fixtures improves Overall Street lighting performance.

☒ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

8. Street lighting should balance safety needs with environmental and visual quality considerations.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section 3: Street Lighting and Urban Spatial Context

Please indicate your level of agreement with the following statements

9. Street lights in my area are positioned with adequate setback from buildings and property boundaries.

☒ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

10. The placement of street lights responds well to the height and proportion of surrounding buildings.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

11. Inadequate setback between street lights and buildings makes the lighting feel visually dominant in the street.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section 4. Street lighting complements the overall spatial volume of the street corridor. In this context the street light complimentary introduced to accentuate spatial volume

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

12. Poor alignment between street light placement and urban context disrupts the night-time streetscape.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

13. Street lights should be designed as part of the overall street space rather than as isolated elements.

☒ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

14. Façade lighting should balance city-wide identity with the expression of individual buildings.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section 5: Decorative Street Lighting and Energy Utilisation on Arterial Streets

15. Decorative street lighting in the inner-city corridor is applied according to the hierarchy between primary and secondary arterial streets.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

16. The use of decorative lighting on secondary arterial streets sometimes leads to excessive brightness compared to the street's functional role.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

17. Decorative street lights are designed in a way that balances aesthetic appeal with energy efficiency.

☒Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

18. Misalignment between street hierarchy and decorative lighting reduces the functional clarity of urban streets.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

19. Decorative street lighting should be adapted to street type (primary vs. Secondary) to optimize energy use and visual impact

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

20. Excessive or poorly placed decorative lighting increases unnecessary energy consumption.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section 6: Modular-Based Façade Lighting as a Non-Sustainable Practice

21. Modular-based façade lighting systems consume excessive energy due to the large number of fixtures.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

22. Façade lighting that cannot be controlled or dimmed contributes to unnecessary night-time energy use.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

23. Maintenance of grid-based façade lighting is difficult, leading to inefficient replacement or repair of fixtures.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

24. The current practice of grid-based façade lighting does not promote sustainable use of energy in urban buildings.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

25. Façade lighting should be designed to minimize energy consumption while maintaining visual impact.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

26. Non-sustainable façade lighting practices negatively affect the environmental quality of the urban nightscape.

☐Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section 7: Daytime Influence of Façade Lighting Fixtures

27. Exposed cables and poorly positioned lighting fixtures create visual clutter on building façades.

☒Strongly agree ☒ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

28. Façade lighting design should consider the building's appearance during the day, not just at night.

☒Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

29. Visible and disorganized fixtures reduce the architectural quality of the building façade.

☒ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

APPENDIX III: Government Office Survey: Corridor, Facade Lighting Energy Utilization

Section 1: Respondent Information

1.1 About You (Optional & Confidential) _____

Section 2: Project Goals

2.1 What are the main goals of the Inner-City Corridor Lighting Project?

☐Safety & Security

☐Night-time Economy & Tourism

☐Urban aesthetics

☒Other

2.2 Main reason for installing decorative lighting poles

☐ Cultural/Aesthetic Value

☐ Landmark/Identity Creation

☐Functional Illumination

Other:

Section 3: Lighting Design & Impact

3.1 Was glare impact studied?

☐Yes ☐No

3.2 Was a visual aesthetic study considered for facade lighting at night?

☐Yes ☐No

3.3 Was a study done on daytime facade lighting impacts (aesthetic/safety)

☐Yes ☐No

Section 4: Technical Specifications

1 Decorative Street Light Pole (per unit) _____

LED Wattage (upper decorative bulbs): _____

LED Wattage (down main lighting): _____

Lumen Output (upper bulb): _____

Lumen Output (down bulb): _____

4.2 Smart technologies integrated:

☐Remote Monitoring

☐Dimming/Adaptive Control

☐Motion/Traffic Sensors

☐Energy Metering

Section 5: Documentation & Regulations

5.1 Is there an official report guiding street lighting implementation?

☐Yes ☐No

If yes, how can it be accessed?

☐Public Website ☐ Email Request ☐Internal Access Only ☐No access

5.2 Do you follow building facade lighting regulations?

☐Yes

☐No

If yes, specify:

Section 6: Energy Source & Standards for Street Light

6.1 Street lighting power supply

☐National Grid

☐Solar Power

☒Hybrid (Grid + Solar)

☐ Other:

6.2 Power designation standards by street type:

Primary Arterial Street (PAS): _____ (LUX)

Secondary Arterial Street (SAS): _____ (Lux)

Section 7: Energy Consumption

7.1 Average energy consumption of all Decorative Pole

Per Month: _____ (KWh)

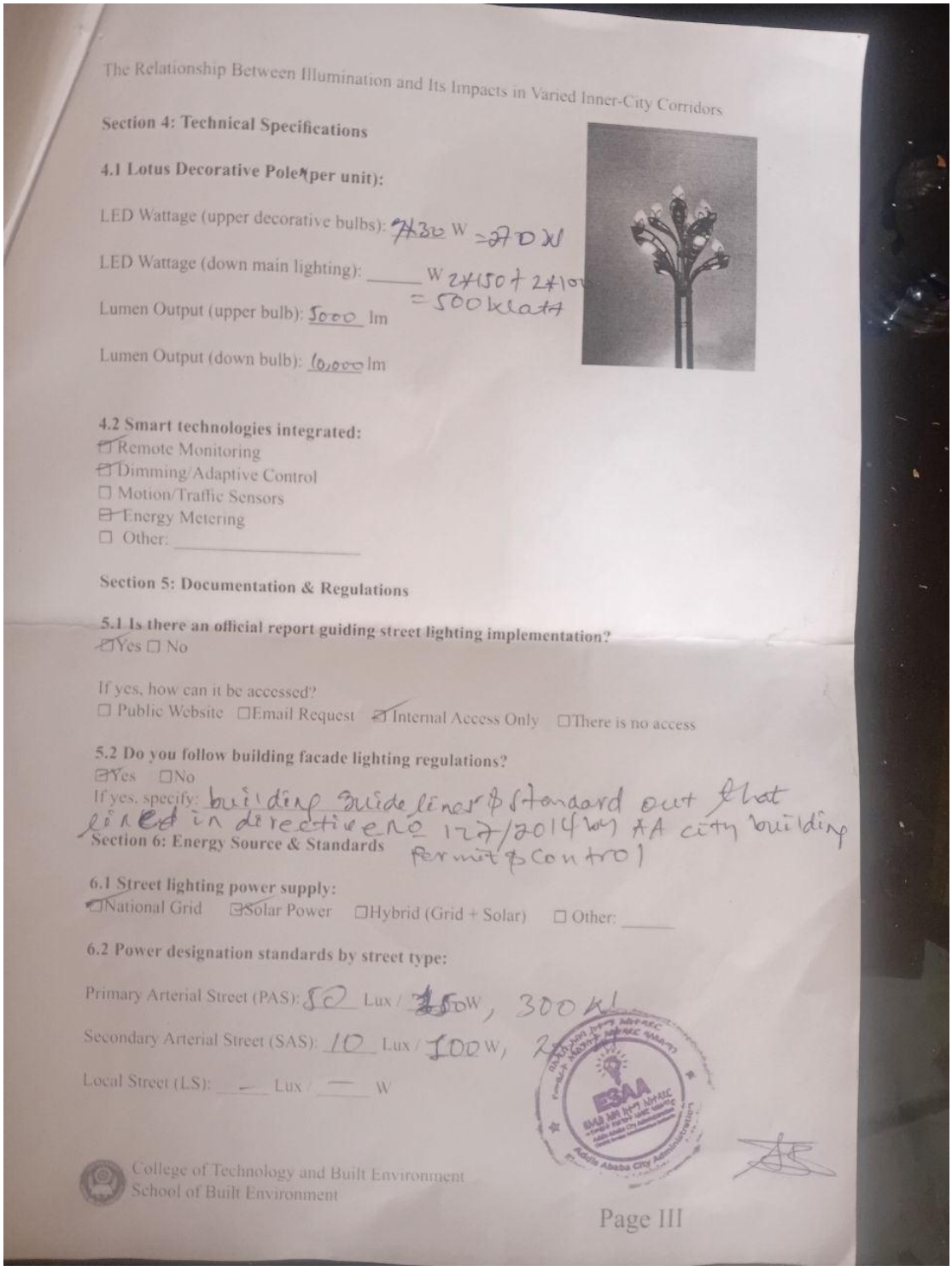
Per Year: _____(KWh)

7.3 Average energy consumption (all streetlights in Addis Ababa)

Per Month: _____(KWh)

Per Year: _____(KWh

Responded questions From Addis Ababa City Administration Authority Electric service Administration Authority



The Relationship Between Illumination and Its Impacts in Varied Inner-City Corridors

Section 4: Technical Specifications

4.1 Lotus Decorative Pole (per unit):

LED Wattage (upper decorative bulbs): 7*32 W = 270 W

LED Wattage (down main lighting): _____ W 2*150 + 2*100 = 500 Watt

Lumen Output (upper bulb): 5000 lm

Lumen Output (down bulb): 10,000 lm

4.2 Smart technologies integrated:

- ☑ Remote Monitoring
- ☑ Dimming/Adaptive Control
- ☐ Motion/Traffic Sensors
- ☑ Energy Metering
- ☐ Other: _____

Section 5: Documentation & Regulations

5.1 Is there an official report guiding street lighting implementation?

☑ Yes ☐ No

If yes, how can it be accessed?

☐ Public Website ☐ Email Request ☑ Internal Access Only ☐ There is no access

5.2 Do you follow building facade lighting regulations?

☑ Yes ☐ No

If yes, specify: building guide liner & standard out that fined in directive no 127/2014 by AA city building permit & control

Section 6: Energy Source & Standards

6.1 Street lighting power supply:

☐ National Grid ☑ Solar Power ☐ Hybrid (Grid + Solar) ☐ Other: _____

6.2 Power designation standards by street type:

Primary Arterial Street (PAS): 50 Lux / 250W, 300 W

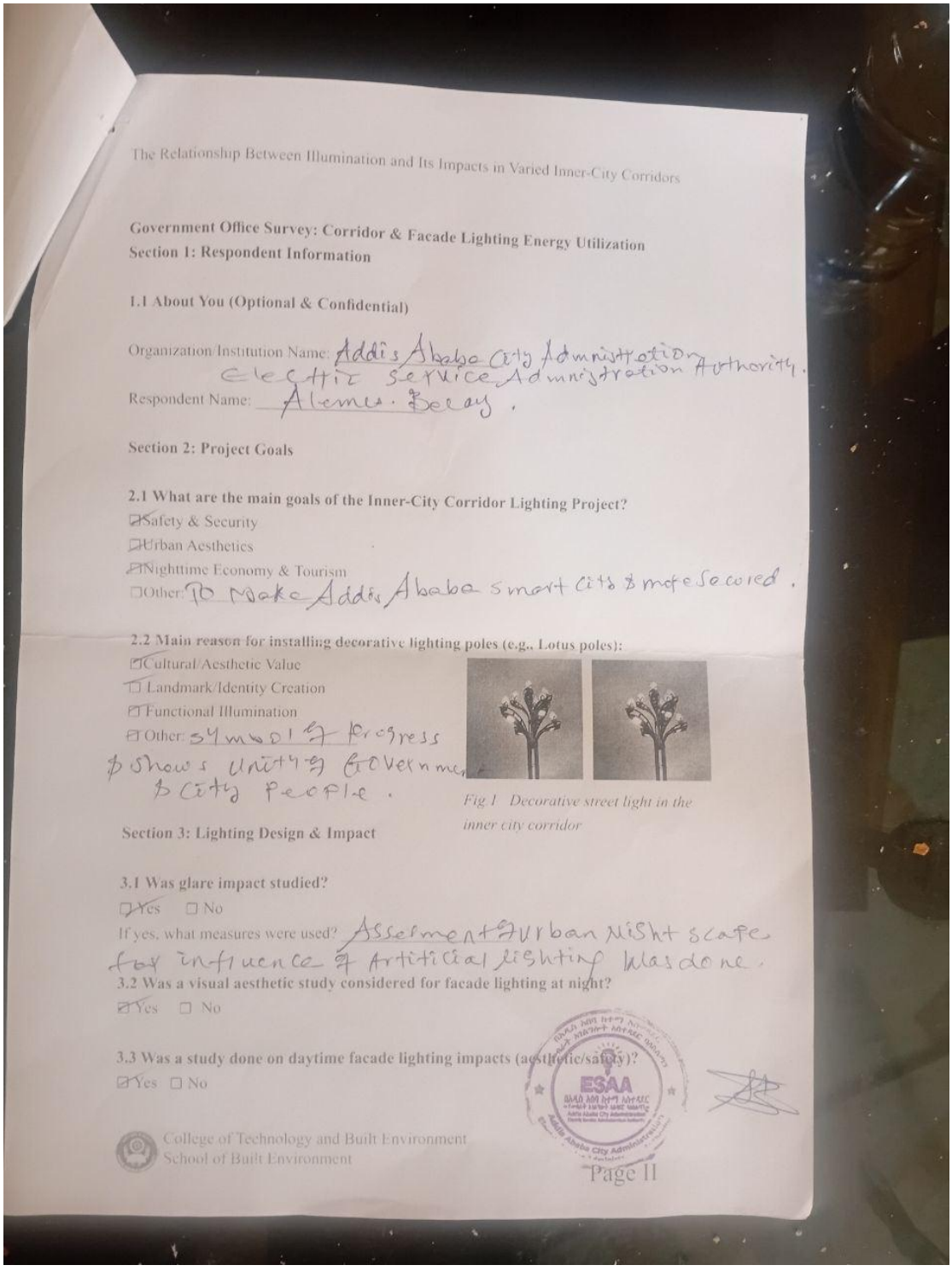
Secondary Arterial Street (SAS): 10 Lux / 100 W, 2

Local Street (LS): — Lux / — W

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Figure 56. Questionnaire response from ESAA



The Relationship Between Illumination and Its Impacts in Varied Inner-City Corridors

Government Office Survey: Corridor & Facade Lighting Energy Utilization
Section 1: Respondent Information

1.1 About You (Optional & Confidential)

Organization/Institution Name: Addis Ababa City Administration Electric Service Administration Authority.
Respondent Name: Alemu. Beray.

Section 2: Project Goals

2.1 What are the main goals of the Inner-City Corridor Lighting Project?
☑ Safety & Security
☑ Urban Aesthetics
☑ Nighttime Economy & Tourism
☐ Other: To Make Addis Ababa smart city & more Secured.

2.2 Main reason for installing decorative lighting poles (e.g., Lotus poles):
☑ Cultural/Aesthetic Value
☐ Landmark/Identity Creation
☑ Functional Illumination
☑ Other: Symbol of progress & shows Unity of Government & city people.

Fig 1 Decorative street light in the inner city corridor

Section 3: Lighting Design & Impact

3.1 Was glare impact studied?
☑ Yes ☐ No
If yes, what measures were used? Assesment of Urban Night scape for influence of Artificial lighting was done.

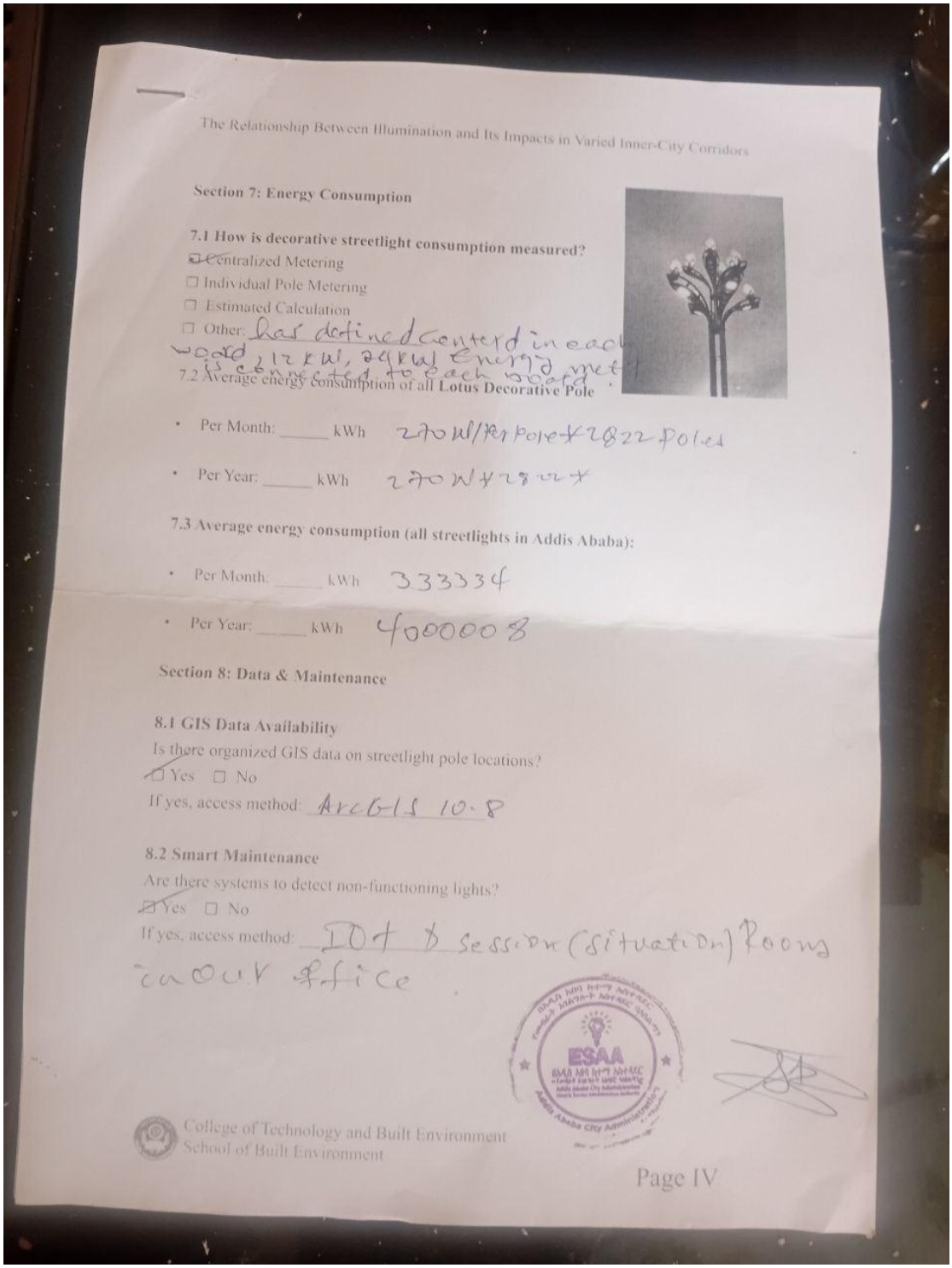
3.2 Was a visual aesthetic study considered for facade lighting at night?
☑ Yes ☐ No

3.3 Was a study done on daytime facade lighting impacts (aesthetic/safety)?
☑ Yes ☐ No

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Figure 57. Questionnaire response from ESAA



The Relationship Between Illumination and Its Impacts in Varied Inner-City Corridors

Section 7: Energy Consumption

7.1 How is decorative streetlight consumption measured?

- ☒ ~~De~~centralized Metering
- ☐ Individual Pole Metering
- ☐ Estimated Calculation
- ☐ Other: has defined centerd in each board 212 kW, 24kW) Energy met is connected to each board.

7.2 Average energy consumption of all **Lotus Decorative Pole**

- Per Month: _____ kWh 270W/Pr Pole * 2822 Poles
- Per Year: _____ kWh 270W * 2822 *

7.3 Average energy consumption (all streetlights in Addis Ababa):

- Per Month: _____ kWh 33334
- Per Year: _____ kWh 4000008

Section 8: Data & Maintenance

8.1 GIS Data Availability

Is there organized GIS data on streetlight pole locations?

☒ Yes ☐ No

If yes, access method: ArcGIS 10.8

8.2 Smart Maintenance

Are there systems to detect non-functioning lights?

☒ Yes ☐ No

If yes, access method: IOT & Session (situation) Rooms in our office

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Figure 58. Questionnaire response from ESAA

APPENDIX IV: Visual Examples Artificial Light Practiced in the Inner-city corridor from 2022 to 2026

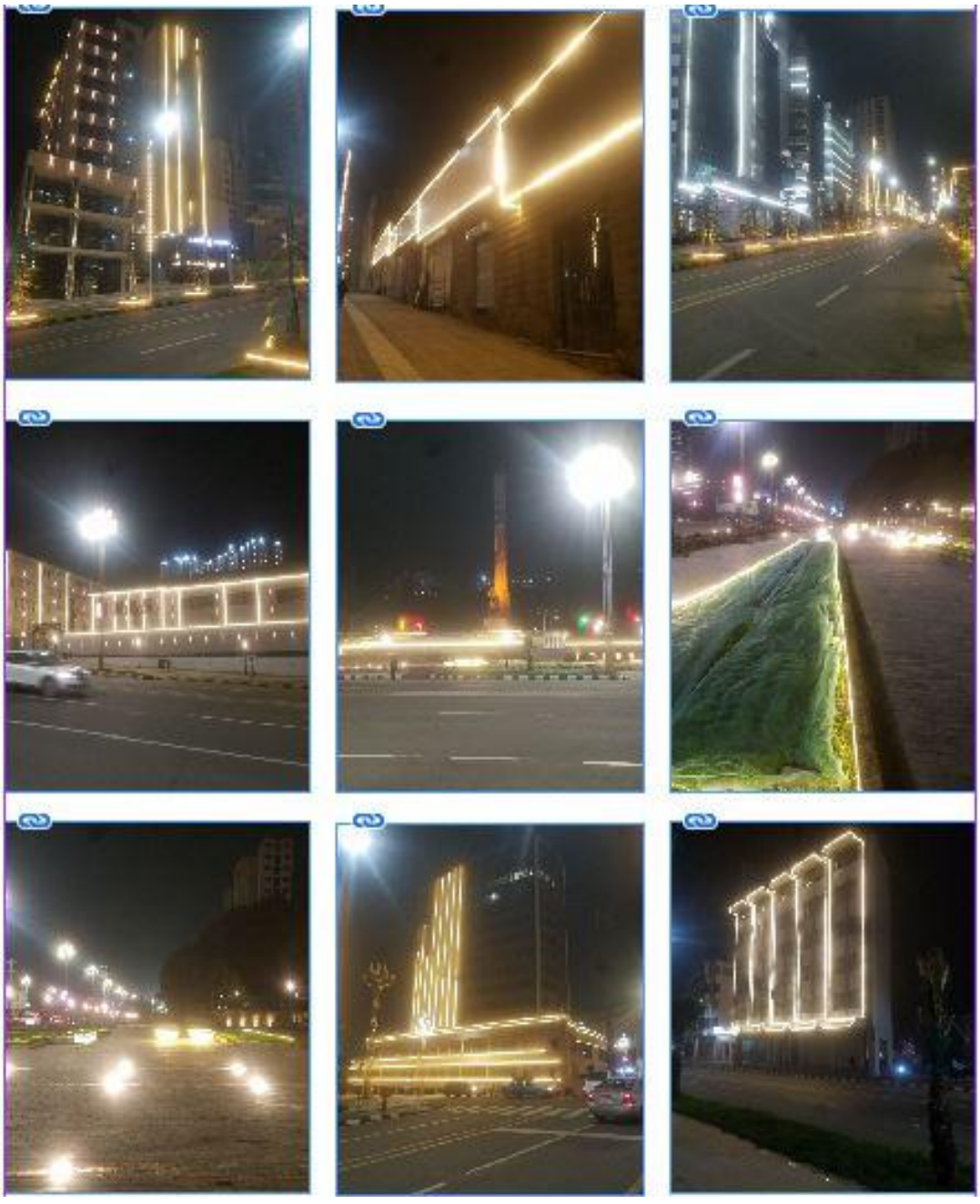


Figure 59. The illustration of illumination practice in the inner city of Addis Ababa.

Source: authors' photograph 2025

Inconsistence Lighting Practice in the Inner –City Corridor of Addis Ababa

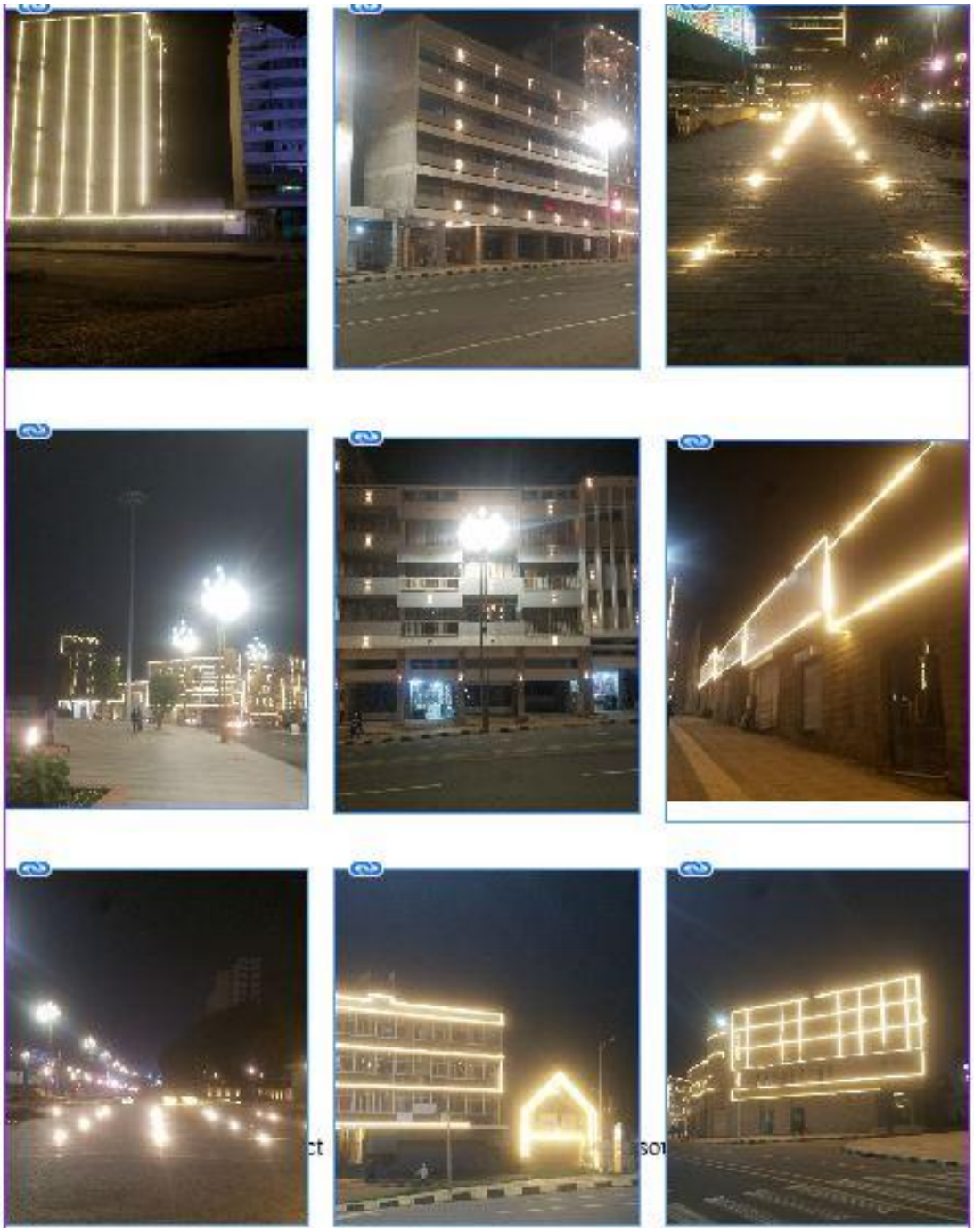


Figure 60. The illustration of street and facade lighting across the corridor of the inner city.

Source: authors' photograph in 2025 and 2026

Uncontrolled Modular Lighting on the Building Façade in the Inner-City

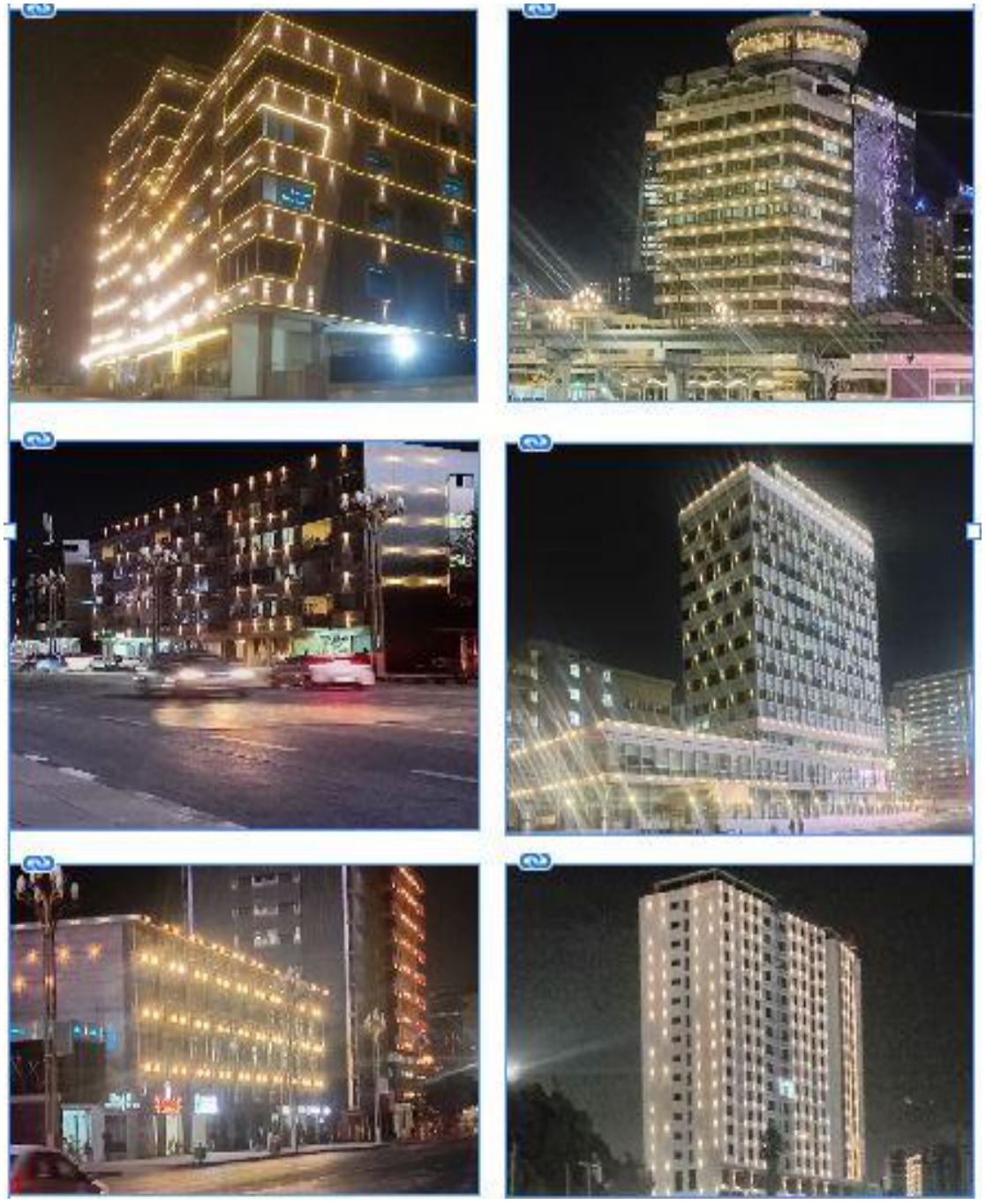


Figure 61. The illustration of street and facade lighting across the corridor of the inner city.

Source: authors' photograph 2026

Visual Cluttering on the Clean Surface of Buildings and Urban Elements



Figure 62. The illustration of street and facade lighting across the corridor of the inner city

Source: authors' photograph 2026

APPENDIX V:

Environmentally Sensitive Lighting Practices in Landscape and Public Park Settings at Night.

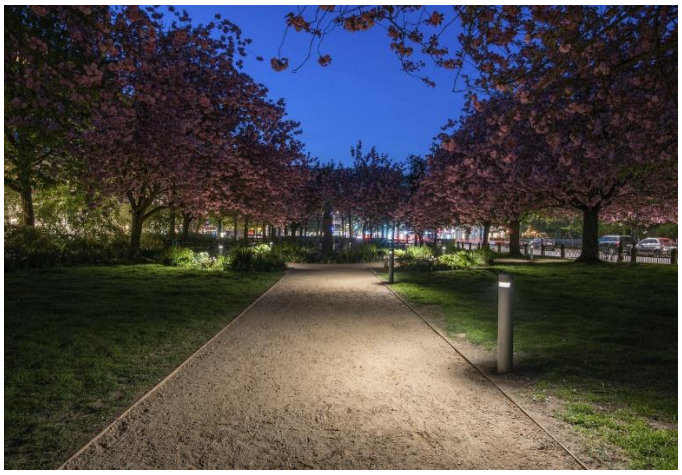
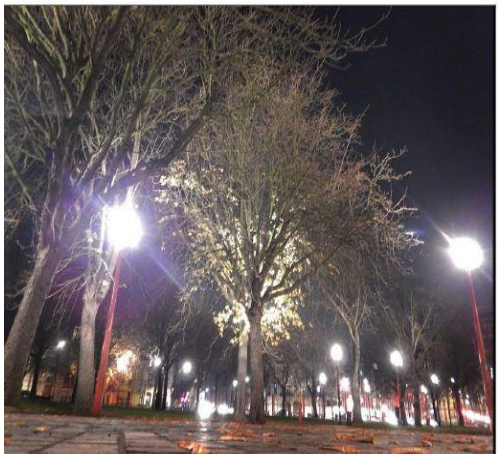



Figure 63. Illustrate ecological sensitive landscape pathway lighting practice

Source. Google picture, Langelinie Park in Copenhagen, Denmark.

APPENDIX VI:

Effects of Artificial Light Placement on Urban Vegetation




Fighr64. Illustrate artificial Light impact on Chestnut Tree Leaf Retention, Lille, December 2016.

Source. **Source:** Wikimedia Commons, *Effet de la pollution lumineuse sur l'arbre urbain / Effect of light pollution on urban trees and dead leaves 03.jpg*

APPENDIX VII:

Façade Lighting Practices: Revealing Architectural Aesthetics on Building

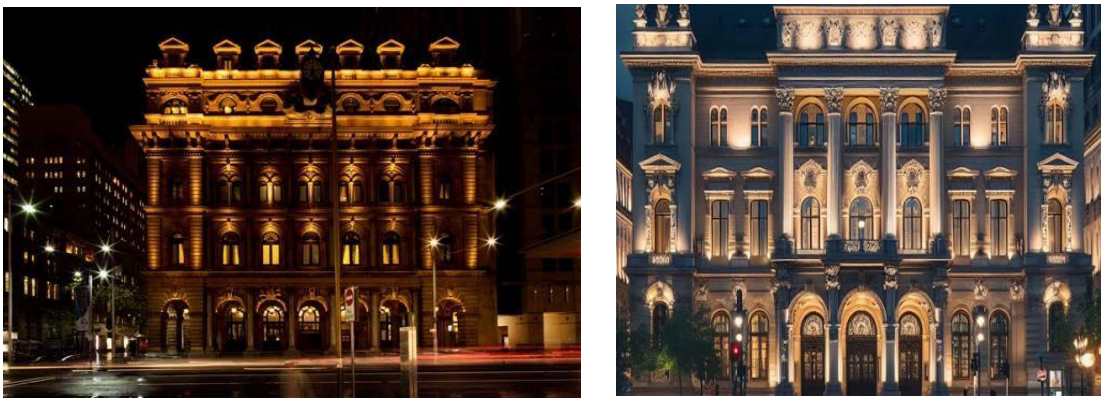


Figure 65. Illustrate façade lighting practice revealing architectural aesthetics, illustrated.

Source. Google image.com

Through warm floodlighting on two heritage buildings, emphasising rusticated stonework and arched bays of the facade, and fluted columns with neoclassical ornamentation on the facade features of the building exterior. Both demonstrate how directional, warm-toned light unifies with and reveals architectural form at night.



Figure 66. Illustrate façade lighting practice revealing architectural aesthetics, illustrated.

Source. Google image.com

Through cool white structural floodlighting on two sculptural landmark buildings, emphasizing the curved titanium panels and flowing geometric forms of the museum exterior, and the layered shell-like roof structure and tiled texture of the opera house facade features of the building exterior. Both demonstrate how directional, cool-toned

light unifies with and reveals the sculptural and structural form of contemporary architecture at night.

Façade Lighting: Media Façade Practice



Figure 67. Illustrate media façade lighting practice transforming building exteriors into dynamic visual displays, illustrated.

Source. Google.com

Media façade lighting uses LED panels, projection mapping, or embedded screens to turn building exteriors into large-scale dynamic displays capable of showing color, pattern, animation, or branded content. Unlike traditional architectural floodlighting which uses static, directional light to reveal a building's existing form, texture, and detailing media façade lighting treats the building envelope as a canvas, often overriding or reinterpreting its architectural identity in favor of visual storytelling, advertising, or artistic expression. This practice is common in dense urban and commercial districts where buildings double as landmarks for nighttime spectacle and city branding.

APPENDIX VIII:

Water Feature (Fountain lighting practice)

Illumination can enhance water features by revealing water movement, reflections, and form, thereby strengthening their role as visual focal points within public spaces. The lighting approach should respond to the type and movement of water, with appropriate positioning and beam direction used to emphasize water jets, reveal volumes, and enhance the surrounding spatial environment (Tulla, 2016; Philips, 2015).



Figure 68. Illustrate Illumination Integrated with a Water Feature in public space, Piassa, Addis Ababa.

Source. Image retrieved from Facebook.



Figure 69. Illumination of a Water Feature in the Open Space of Sheraton Addis, Addis Ababa

Source. Image retrieved from Facebook.