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Title: Design-for-emergence: Balancing light and darkness in the complexity of urban life and space

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Abstract:

The experience of a city at night, positive or negative, is shaped, in part, by a balance of natural darkness and the light we introduce. All too often these complimentary elements are not considered congruently and designed outside of the physical, social or ecological context that they sit within. The importance of negotiating a balance of light and darkness in cities is underscored as research continues to reveal the extent of the deleterious effects anthropogenic light has on all aspects of ecology, from species decline to human health.

Balancing light and darkness in the nuanced typologies of places within cities is challenged further by a gap between guidelines, written so broadly as to be applicable to all contexts, and regulations that, by their nature, apply to a highly specific and narrow set of contexts. This leaves the illumination of many of our most important shared public spaces without guidance.

This thesis looks at light and darkness as part of the Complex Adaptive Systems of cities and communities. Complex adaptive systems are emergent, interactions between the different elements of a system allow new behaviours, patterns, or qualities to emerge. Rather than designing an end result design-for-emergence aims to design the building blocks or create the conditions to allow users to define and evolve any number of outcomes. Design-for-emergence acknowledges the context specific knowledge of users and gives control to them.

The approach of design-for-emergence is applied to a case study of a lighting design proposal for a public square in southwest London. Emergence is employed in the design process, to engage the opinions of the local community, and as a path to developing site-specific guidelines for light and darkness. The intent is that this process will produce an emergent space, where positive experiences of light and darkness create the conditions for life to emerge and continue to evolve in this shared public place.

ANNA GALLAGHER

Design-for-emergence

Balancing light and darkness in the complexity of urban life and space.

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With many thanks to my supervisor Mette Hvass who has provided such valuable inspiration and guidance throughout this process.

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Introduction

Vision: Support cities to move towards the inclusion of natural darkness.

Vision and background

The vision for this thesis arose from a growing interest in the values of darkness and an understanding of the deleterious effects of excessive anthropogenic light or light pollution on ecology. Another inspiration came from the appreciation of how the city of Copenhagen has worked to achieve the presence of darkness and light alongside each other, in stark contrast to many other cities across the world where over illumination is the norm. The effects of artificial light at night on ecology are extremely negative and increasing year on year (Morgan-Taylor Morgan-Taylor, 2023). It is necessary to sever the growth of cities from the equal growth of light pollution to protect and hopefully restore the ecological systems that sustain us.

From an ecological perspective the 'correct' amount of anthropogenic light at night is none. However, as part of ecology, people need nighttime illumination to fulfil functional, social, economic and aesthetic needs (Boyce, 2019). This thesis aims to explore the balance of light and darkness in cities, where human and others' habitats are intertwined, and these opposing needs are most in conflict.

Encouragingly, some cities are beginning to develop nighttime strategies that acknowledge the importance of darkness, integrating it into their lighting masterplans (Jurševska & Vugule, 2022). An analysis of the guidelines and standards regulating the inclusion of light and the preservation of darkness demonstrate the challenge of balancing these complementary elements across a wide range of contexts.

The theory of cities as complex adaptive systems provides a novel lens through which to view this challenge. Design-for-emergence was identified as a tool to address the complexity of balancing light and darkness in cities through engagement with the contextual knowledge of local communities.

This thesis explores these challenge through a case study of a lighting design proposal for a public square in southwest London. Emergence is employed in the design process, to engage the opinions of the local community, and as a path to developing context specific guidelines for light and darkness. The intent is that this process will also produce an emergent space, where positive experiences of light and darkness create the conditions for life to emerge and continue to evolve in this shared public place.

This chapter will introduce the topics explored in this thesis and present the structure the thesis will be follow.

The challenge of regulating for light and darkness

The challenge of concurrently regulating for the inclusion of light and the protection of darkness in cities is exacerbated by a gap between guidelines, written so broadly as to be applicable to all contexts, and regulations that, by their nature, apply to a specific and narrow set of circumstances.

Dark Sky International and the Illuminating Engineering Society's Principals for Responsible Outdoor Lighting are intentionally designed to apply to all contexts, as their aim is to prevent and reduce light pollution across all outdoor electric lighting (Dark Sky International, 2023). Their first principal states that light should only be used where it is 'needed.' But 'needed' in cities is complex. In cities light could be seen as needed to provide wayfinding and safety for people, bikes, and cars, to provide a sense of security, to support social cohesion and connection to place, to communicate the culture of a city or neighbourhood and to support the nighttime economy (Boyce, 2019).

This is not such an issue where time and resources allow for lighting designers to navigate this question with nuance, understand the context and engagement with the local community. However, in practice, this is not always the case and when working with public spaces municipalities are understandably inclined to find a regulation and meet it, even if the context doesn't fit. The European Standard EN 12464-2:2024 is often used as a fall back in these cases despite it relating specifically to 'lighting requirements for humans in outdoor work places.'

This disparity between broad guidelines and specific regulations that do not reflect the nuanced typologies of places within cities can lead to lighting solutions being introduced that do not relate to their actual setting, see figure 01.

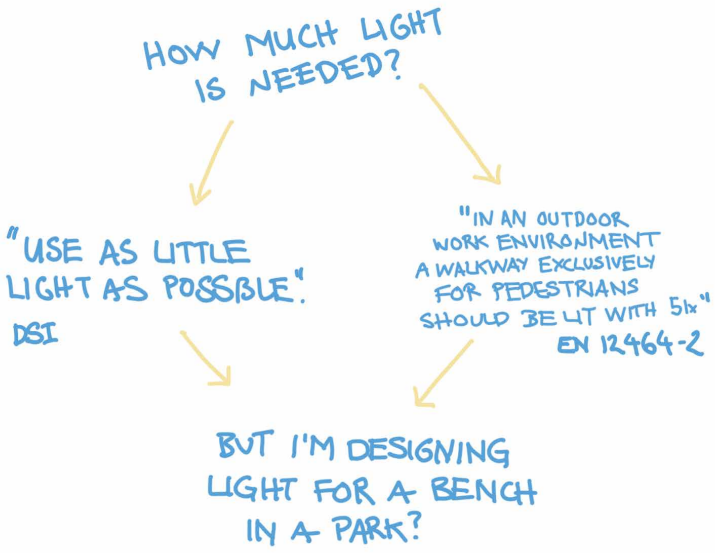

Figure 01 - The gap of current standards and guidelines, self produced, 2025.

Cites as complex adaptive systems

Complex systems are described as having the property of emergence. Emergence is often explained with the common phrase 'the whole is greater than the sum of its parts.' A complex system is one where many elements interact with each other and produce qualities that the individual elements do not possess on their own. An example is water and the property of wetness. A single molecule of water could not be described as wet, this is a property that only emerges when many water molecules come together (Holland, 2014).

Complex adaptive systems differ in that the individual elements, learn and change due to their interactions with each other (Holland, 2014). Through these interactions and evolutions new, unexpected, and varied outcomes arise. Complex adaptive systems are constantly in a state of shifting, adapting and evolving.

The human body is a complex adaptive system, ecology is a complex adaptive system, and of particular interest to this thesis, cities have also been studied as complex adaptive systems (Portugali, 2023).

Cities are made up of recognisable elements (people, buildings, parks, roads, ecology, social structures, political structures, etc.) interacting with each other. These elements come together in different ways to form, unique communities and places with identities as distinct as London, Copenhagen or Tokyo. Cities themselves are made up of smaller districts and local communities, that are their own complex adaptive systems, where similar sets of elements (people, buildings, parks, roads etc.) interact in unique ways to form areas and communities with individual personalities and characteristics. This 'perpetual novelty', that arises from a set of recognisable elements interacting in unique ways is a characteristic of most complex systems. 'Analysis of complex systems almost always turns on finding recurring patterns in the system's ever-changing configurations' (Holland, 2014). This leads to the initial research question: **How does understanding the city as a complex adaptive system help us to design with light and darkness?**

One way that this lens may support the field of lighting design is to allow us to see the array of guidelines and regulations as a pallet of elements/tools that can be combined in an endless variety of ways, creating an equally vast array of lighting atmospheres. This may allow us to build context specific collections of 'tools' that can guide and validate the design of light and darkness in an urban context, where any one location has a different set of multitudinal needs.

Complexity theory can also aid in understanding how light and darkness sit with within the context of complex adaptive systems like cities and communities.

Light and darkness as an element in the complex adaptive systems of communities and public spaces

In cities at night, the play of light and darkness is one of the essential elements that shapes our experiences of a place. As these elements are part of the complex adaptive system of a place, light and darkness cannot be isolated from the specific context. Light and darkness interact with the physical context, the social context and the ecological context of a place. While simultaneously these contexts impact how light and darkness are shaped and perceived, figure 02 provides examples of this.

Darkness and light's impact on physical context	**Physical context's impact on light and darkness**
E.g. A single light source introduced into a space interacts with every form, surface and texture and in turn makes every form, surface and texture interact with each other.	E.g. The same lighting installation will appear appropriate or inappropriate dependant on the physical context. The typical lighting for a road way would feel awful in a park and vice versa.
Darkness & light's impact on social context	**Social context's impact on light and darkness**
E.g. Certain lighting can create atmospheres (positive or negative) that effects how people use a space.	E.g. An individual's knowledge of the social context of a space may effect if they see a more dimly lit area as peaceful of unsettling.
Darkness & light's impact on ecological context	**Ecological context's impact on light and darkness**
E.g. Anthropogenic light at night has a myriad of negative effects on plants animals and people whose biology evolved with the natural cycles of light and darkness of the day and night.	E.g. The lighting effect of street lights may be entirely different in winter and summer when trees are bare or full of leaves.

Figure 02 - Light and darkness interacting with context, self produced, 2025.

Not only do light and darkness interact with each of these contexts, but the contexts also interact with each other. The emergent quality that arises from these (and more) interactions could be seen as the atmosphere of a place. Due to the emergent nature of complex adaptive systems that atmosphere will interact with and impact all the elements that brought it into being, continuing the evolution of each, see Figure 03.

Any intervention taken with any of these elements will influence all of them. For the purpose of this thesis interventions will be introduced through the balance of light and darkness in the public realm space. The intent will be to understand the social context before introducing a lighting proposal that aims to positively affect the atmosphere. If treated as part of the system these interventions may flow through, having positive effects on all other elements.

To have these positive effects the interventions must come from within the system. Light and darkness cannot be isolated from the social context of a space, equally it is not effective to separate the social context from the design of light. 'Any attempt to control the system from a fixed viewpoint outside is a misaligned intervention that will fail' (Yunkaporta, 2020). As the light and darkness of a public place will affect the people who use it, there should be direct participatory engagement with these people throughout the process, through the design, installation, use, and beyond. It is their local contextual knowledge that defines the atmospheres that the design proposal should aim to create. Involving people strengthens the connection between light, darkness and the social context and increases the possibility that the atmosphere, determined in part by light and darkness, will be imbued with meaning for the community.

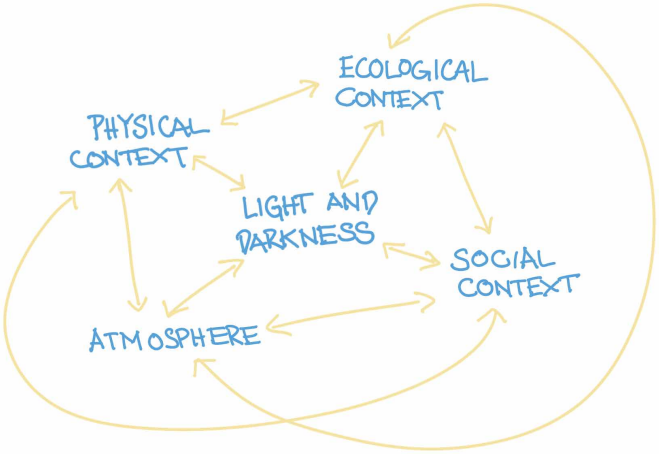

Figure 03 - Light and darkness as part of a complex adaptive system, self produced 2025.

Design-for-emergence

The idea of complexity and emergence is integrated into the design process by developing a design proposal from the contextual knowledge of the local community and viewing the myriad guidelines and regulations of light and darkness as a set of 'tools' that can be combined to move towards a desired atmosphere.

Through working in this way the hope is that the *result* of the design process will also allow for emergence. The idea of Design-for-emergence is often described with the analogy of a Lego brick. The Lego brick is a designed object, that can be connected in standard and limited set of ways, yet it allows for endless possibilities for what can be created. The designer of the brick, cannot know what the user will create with it (Klimes, 2021). Design-for-emergence aims to be non-prescriptive, to allow for composability by the user as well as continued evolution in unknowable ways.

An example of how this concept manifests in the design of public spaces can be seen when large amorphous shapes or non-prescriptive sets of rungs and ladders are

included in a park/public square. These objects are as likely to be used by children playing as adults exercising, or to act as a meeting point of a group walk or a teenage loitering spot etc. see figure 04.

Figure 04 - Design-for-emergence in the physical context of the public realm. Left free form object, Copenhagen. Right multiuse platform, London. Self produced, 2025.

Can lighting design in public spaces be equally non-prescriptive and allow for composability through use? Perhaps this can be achieved through the focus on atmosphere over function. For example, instead of lighting that communicates 'this is a path,' perhaps it could focus on an inviting atmosphere. Or instead of 'what light is appropriate for a bench,' ask what light creates a peaceful atmosphere. Atmospheres (both positive and negative) are emergent in that they encourage social interaction in a certain direction, but in a way that is not prescriptive but open for interpretation, allowing for emergence through use. *'Atmospheres themselves cannot be designed as such, because we cannot predetermine, control or predict people's experiential worlds. Instead, the role of design is to create interventions that make possible the circumstances that might encourage particular types of atmosphere to emerge.'* (Sumartojo & Pink, 2018).

Light provides an additional opportunity to embrace emergence beyond the initial installation of a scheme. Unlike the physical examples of design-for-emergence in public space, light does not have to be static. The increasing prevalence of smart lighting that is simple to control and adapt, provides the opportunity to allow for emergence and continued evolution of the light by the community. This requires that lighting projects look beyond installation, considering how they can allow for adaption through control systems as the context they are within continues to evolve.

Conclusion

This chapter has outlined the vision and background of this thesis, and introduced the main concepts. In chapter 2 a literature review investigates further the topics introduced above, including the values of light and darkness, the challenge of applying regulations to these nuanced and context dependent elements, the lens of complexity theory and design-for-emergence. Chapter 3 provides some examples of where complexity and design-for-emergence can be seen in other lighting design projects which helps to define the final research question: **Can design-for-emergence introduce positive experiences of light and darkness into a shared public place?** In chapter 4 the approach of design-for-emergence is applied to a case study of a public realm square in London to produce a new lighting design proposal. Chapter 5 provides a discussion and analysis of the design proposal, to identify if design-for-emergence supported the introduction of a balance of light and darkness into this space and whether this may create the conditions for life to emerge and continue to evolve in this shared public place. And finally chapter 6 concludes with a discussion of key findings and future works.

Thesis structure

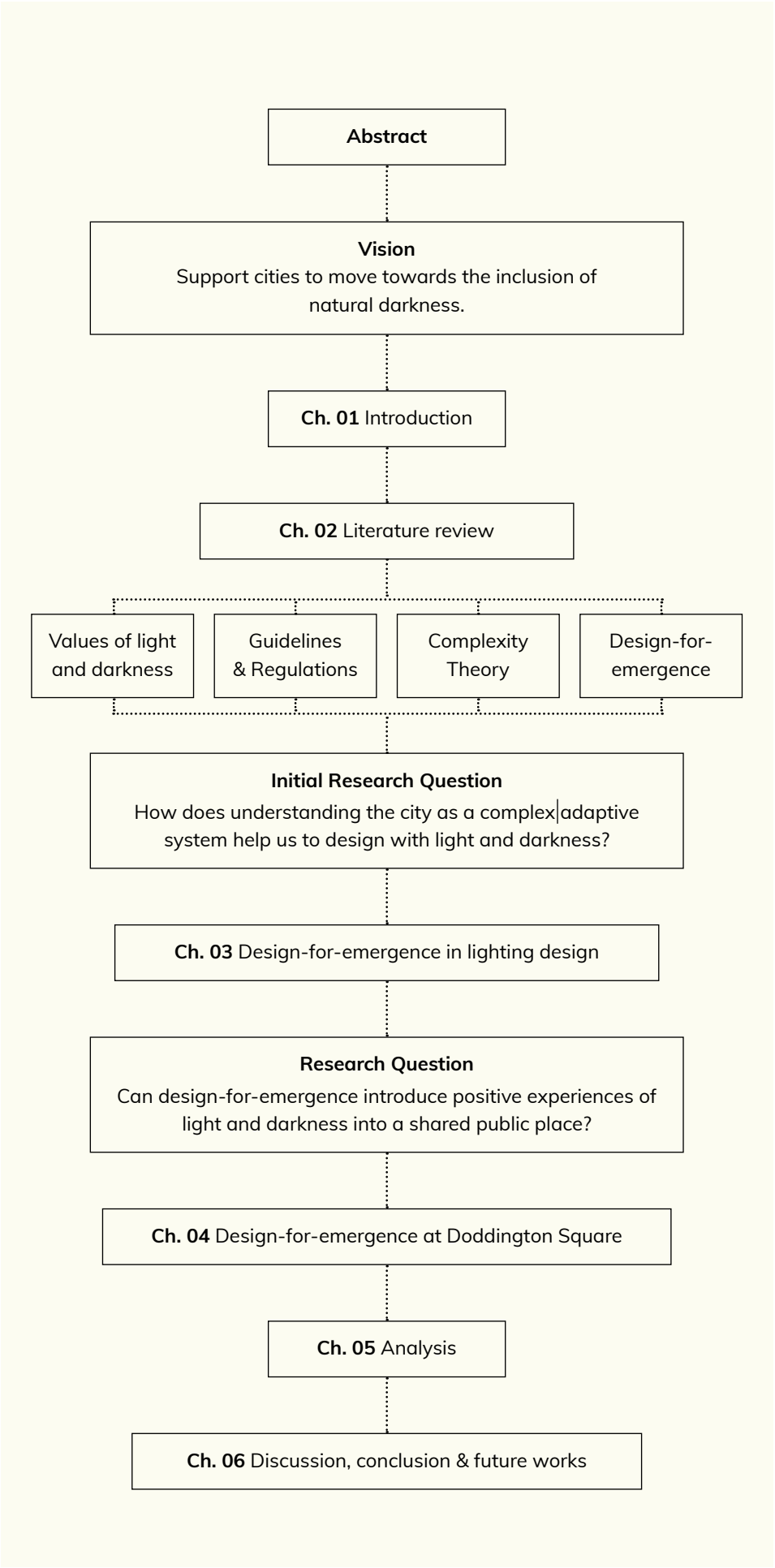

Figure 05 - Thesis structure, self produced, 2025.

Literature review

Introduction

This chapter contains a literature review that first establishes the values of darkness and the values light to determine why it is important to strive for a balance of light and darkness in an urban context. Then some elements of the current guidelines and regulatory framework are examined - which identifies the challenge of concurrently regulating for the introduction of light and the preservation of natural darkness within the many typologies of places in a city. The lens of complexity theory is explored as a method for navigating this challenge, specifically focusing on the idea, within complexity theory, of 'emergence.'

Balancing light and darkness

In this thesis the balance of light and darkness in an urban context is defined as the ability to positively perceive both light and darkness when moving through the outdoor public realm. The technical director of Dark Sky International, Pete Strasser, made reference to this experience of balance when he asserted, 'we're called Dark Sky not Dark Ground,' (Shalaby & Villar, 2021). The organisation aims is to preserve natural darkness, but they do not negate the need for anthropogenic light. The balance of light and darkness, relates to the perception of a space or series of spaces. Experiential descriptions help to clarify ways that a balance of light and darkness could be perceived - 'when I look down I can see the path in front of me but when I look up I have a view to the night sky,' or 'as I move through the city areas of more and less brightness create an understanding of the context,' or 'balanced low illumination means I can see my surroundings but areas beyond are not obscured by high contrast.' In these examples the balance of light and darkness can be experienced either in a static way, by looking around at the elements within a space. Or alternatively light and darkness can be experienced in a dynamic way as an observer moves through space encountering brighter and darker areas of a city or place.

Values of darkness

In the dissertation, 'Designing for Darkness' Stone sets a premise of tackling light pollution not by finding acceptable limits for light but instead by identifying what is valuable about natural darkness and incorporating this into sustainable lighting strategies (Stone, 2019). Stone also acknowledges that the perceived 'geographical dualism between cities and wilderness,' can have a limiting effect on the impetus to tackle light pollution in urban contexts (Stone, 2019).

Stone establishes the practical values of darkness; responsible use of light can result in fiscal savings as well as minimising use of energy and unrenewable resources (Stone, 2019). These goals are well established in the construction and urban planning worlds which can be seen throughout sustainability accreditations such as

LEED, BREAM, and SITES. These goals are practical, easily quantifiable, and have an immediate impact (on budgets etc.) making these values, the ‘easiest sell’ in regards to achieving buy-in from those often in charge or our urban light and therefore our urban darkness.

Stone then explores the ecological values of darkness, its ability to protect and support biodiversity and habitats for all life (Stone, 2019). This value holds the most significant moral imperative, as all anthropogenic light, as the name suggests is introduced by and for humans, so it is ours to control, and that responsibility should be taken seriously . However, the preservation of natural darkness for ecology’s sake is not a selfless goal, as long as we recognise ourselves as part of that ecology, not separate from it. It serves our own interests to fiercely protect the ecological systems that support life. The impacts of these values are harder to quantify, complex to measure and require a long-term vision for the future.

Already potential conflicts can be identified between these different values. Considering the practical values, it may be possible to use less energy and fewer luminaires if a light temperature of 4000k were employed, however from an ecological values perspective a warmer light temperature, or specifically excluding all wavelengths below 600nm from the spectral power distribution of lighting may significantly reduce the impact of light on many species (Longcore, 2023).

Immediate financial incentives are easier to grapple with than to consider multi-generational timelines of habitat preservation, however another of the values of darkness presented by Stone can bring the discussion back into the present tense, this is to extend the value of darkness from ecological health to human health. As with all life, people have evolved with the natural cycles of day and night it stands to reason, and is being demonstrated through many studies, that darkness plays a significant role in human health. Studies continue to identify the link between appropriate levels darkness throughout the day to human circadian entrainment, sleep and stress (Davis et al., 2023).

Finally, Stone addresses the more experiential and poetic values of darkness that include ‘human happiness, connection to nature, stellar visibility, heritage and tradition, and wonder and beauty (Stone, 2019). These values are likely the most challenging to ‘sell,’ to those in charge of the public lighting, where the historic understanding of darkness as ‘un-safe’ still prevails. Hvass looks to challenge the idea that an increase in brightness runs parallel to an increase in safety, among other findings this research demonstrates that a balanced light field with reduced brightness and managed contrast levels can increase the feeling of safety, co-presence amoung people and improve the atmosphere of the space in general (Hvass, 2022), demonstrating that more light is not always better.

The work of organisations such as Dark Sky International has mobilised the romantic nature of these values of darkness, bringing dark skys as a topic into public discourse. This has encouraged the adoption of dark sky initiatives by large entities and corporations as a worthy cause and an act that can ingratiate them to the public. If dark sky principals are not implemented earnestly by these large entities however it could risk the necessity of the term ‘dark washing’ to come into existence, which, thankfully, still relates only to doing laundry.

Romanticisation of darkness is a useful tool to shift perspectives, but these phenomenological values of darkness should not be dismissed as frivolous. These values as listed by Stone could be housed under the heading of ‘connection with nature.’ Seeing ourselves outside of nature implies it is something we can live without, seeing ourselves as more important than the world around us gives us the perception that we can put off finding solutions to the grave ecological challenges we face today,

including that of light pollution. Indigenous botanist, Robin Wall Kimmerer describes this separation from nature as the original wound of humanity (Kimmerer, 2020) Aboriginal author Tyson Yunkaporta goes further to say '...the most destructive idea in existence: I am greater than you; you are less than me. This is the source of all human misery,' (Yunkaporta, 2020). Connection with nature is most often thought of as a daylight experience, but connection with nature at night can be equally potent. Restoring this connection with nature may provide the perspective needed to address the crisis of light pollution with the vigour it deserves.

Values of light

There is overwhelming evidence for the need to value darkness and reduce light pollution. The fundamental challenge remains that the ideal amount of anthropogenic light at night is none, but this does not support urban community's needs. Is it justifiable to introduce light anywhere? The answer should be – yes, but with great care, therefore it is vital to understand the nuanced values of light to communities and cities to balance these with the values of darkness.

In his article 'The benefits of light at night' Boyce discusses several fundamental values of light and how they can be related to the Maslow's hierarchy of needs. At the most fundamental level the value of anthropogenic light at night is to extend the capabilities of our primary sense, vision, into the hours of darkness (Boyce, 2019). Although human vision is highly capable of adapting to low levels of illumination, where the light from the moon can be enough to navigate safely (Rathsach & Hvass, 2022) we consistently choose to add additional light to our nightscapes.

Boyce relates the values of safety in movement and an increased perception of security to Maslow's most basic physiological needs. Research into safety often looks at the levels of light required to carry out visual tasks. In regards to security Boyce points out that light levels do not directly reduce the level of crime, however, the presence of people and activity and the appearance of community investment that quality lighting can bring about does increases people's feelings of security (Boyce, 2019).

These other values, creating attractive places, encouraging people to use recreational facilities and contribute to the nighttime economy are related to the higher 'psychological and self actualization' needs (Boyce, 2019). The guidelines from the European research project ENLIGHTENme that address Urban Lighting For Health and Well-being emphasise that urban lighting can profoundly impact social goals, including fostering inclusion, equality, diversity, and overall quality of life (Tondelli, S., et al, 2025).

The values Boyce sets out for why light is important remain relevant and his analogy that guides his thinking rings true, 'Light at night is like food, some is essential, an occasional treat is welcome, but too much, for too long is bad' (Tondelli, S., et al, 2025).

The challenge of regulating for light and darkness in the nuanced typologies of cities

Research on the values of darkness provides municipalities and the commercial infrastructure of cities with fiscal, environmental and romantic justification for prioritising the preservation of natural darkness. Much of this research concludes with a similar set of practical guidelines for the reduction of light pollution through considered lighting design: Downward directed, well controlled use of light, as little as possible, as warm as possible, only where it is needed only when its needed, variations of the responsible use guidelines published by Dark Sky International (Dark Sky International, 2023).

The ambiguity of caveats such as 'where it's needed,' or 'as little as possible' in these guidelines are necessary to allow for an extremely broad range of contextual applications. But what is meant by 'where' and what is meant by 'needed?' With the

understanding that the only reason to introduce light at night is for human benefit the most pragmatic reading of 'where it's needed' can be - where humans are present and carrying out an essential task, outdoors, at night. In more rural contexts where pockets of human habitat can be somewhat distinguished from natural habitat the principals of responsible light at night can be implemented without much friction. If there are no humans, there? Don't add light.

It is more complex in cities, where people are an almost constant presence, and our habitat is shared directly with the rest of nature. In this context the 'where' is much more ambiguous and identifying areas appropriate for preserving or creating dark infrastructure are very fragmented.

'Needed' is also more complex in cities. As seen through the values of light discussed earlier. 'Needed' should encompass the ability to navigate and to be and feel safe, but in cities light is often also used, formally and informally, to support social cohesion and connection to place, to communicate the culture of the city's residents and to support the nighttime economy and express the unique character of its built environment. Where lighting standards and regulations exist they are often extremely specific in the context they govern. This is the nature of standards that characteristically aim to delineate the elements they are addressing into individual measurable units and provide exact figures that can be met. While useful, the extreme specificity of regulations, creates a gap in understanding when a project falls outside of the regulations. This is a frequent occurrence as regulations do not tend to reflect the nuanced typologies of places within cities. When working with public spaces municipalities are understandably inclined to find a regulation and meet it, even if the context of the regulation doesn't match that of the project. This can lead to poor outcomes where lighting solutions are introduced that do not relate to their specific context.

This is not to dismiss the necessity and benefit of regulations and guidelines. Regulations play a role in the equity experienced in our cities. One of the reasons to care greatly about how regulations are written and how they can be interpreted is because they will be treated as the bare minimum and implemented across areas where additional resources are not available. When reflecting on this topic at the Illuminating the Future: Balancing Light and Dark Nightscapes conference, Steve Fotios of Sheffield University stated that 'if we really want better light we have to pay more taxes, and solve social inequality...' (Fotios, 2025). At the same conference Don Slater of the ENLIGHTENme project and the London School of Economics went on to state that 'All light is intervening in social spaces' (Slater, 2025). Thoughtfully constructed regulations can be a tool for equity and social good.

This begins to address the idea that light and darkness are intrinsically linked to the surroundings they exist in and the people perceiving those surroundings. They are all relational characteristics of a complex experience.

Complexity theory of cities as a lens

This remainder of this chapter looks at light and darkness as part of the Complex Adaptive Systems of cities and communities. Complex adaptive systems are emergent, interactions between the different elements of a system allows new behaviours, patterns, or qualities to emerge (Klimes, 2022).

Yungkaporta first differentiates between complicated and complex, 'They are two very different things. Viewing the world through a lens of simplicity always seems to make things more complicated, but simultaneously less complex (Yunkaporta, 2020). Complexity is positive, it provides the diversity and adaptability required for systems to evolve and thrive, Holland asserts that 'Solutions to some of the most important problems of the 21st century—enhancing the immune system, making ecosystems sustainable, regularizing global trade, curing mental disorders, encouraging

innovation, and so on—depend upon a deep understanding of the interaction of adaptive agents in [complex adaptive systems](Holland, 2014). Yungkaporta continues by stating that 'all humans evolved within complex, land-based cultures' (Yunkaporta, 2020). It is not difficult to recognise these complex systems, our bodies are complex systems, as are our communities and even our cities, we exist within complex systems at all times. The challenge arises when we try to understand how we can, or if we should influence or control them.

Complexity theory defines complex systems as having the property of 'emergence,' which is 'roughly described by the common phrase 'the action of the whole is more than the sum of the actions of the parts (Holland, 2014), an analogy is made by considering two properties of water; weight, and wetness. The weight of a body of water is the sum of its single molecules, comparatively a single molecule of water could not be described as wet, wetness is a property that emerges only from an aggregate of water molecules, but is a property that the individual molecules do not hold (Holland, 2014).

Complex systems are made up of elements or 'agents' that interact with each other, following a set of constraints, to create an endless array of possibilities (Holland, 2014). For example the two base pairs 'AT' and 'CG' that combine to make up the DNA of billions of genetically unique humans, or the 26 letters of the alphabet, constrained by spelling and grammar, that can be used to construct endless sentences, stories... theses.

Specifically, complex adaptive systems, are systems where the 'agents' learn or adapt as they interact with one another. Holland provides a typical biological example, *'a leafy bush has a wide range of herbivorous insect predators. Then, as the bush evolves, it develops a protein, say quinine, that is poisonous to most insects. However, after further evolution, some insect species develops an enzyme that digests quinine. Still later, the bush evolves quinine-b that is poisonous to these insects, and so it goes on. Note that, while the bush and the insect seem to be running in a Lewis Carroll's 'Red Queen's race', neither gaining much ground with respect to the other, the co-evolving pair is better off in relation to its surroundings. The bush only has to 'protect itself' from a single predator, while the predator has a food supply that it does not have to share with other competitor species'* (Holland, 2014).

In addition to emergence there are several other properties inherent to complex adaptive systems. Complex adaptive systems will self-organise into patterns, the typical example of this is a flock of birds, where each bird is responding to those directly adjacent but when looked at as a whole there are clear and repeated patterns. Another property is 'chaotic behaviour,' where a small change can have a cascade of results that could not necessarily be predicted (Holland, 2014).

Since the 1960's and 70's theories of complexity have been applied to design and specifically architecture, with the field of Complexity Theory of Cities acknowledging the emergent nature of our urban landscapes, and the challenges and opportunities this provides (Portugali, 2023). The initial research question of this thesis arises here **Dow does understanding the city as a complex adaptive system help us to design with light and darkness?**

Emergence in design & design-for-emergence

To answer this question a closer look is taken at the idea of emergence in relation to design. Rather than designing an end result design-for-emergence aims to design the building blocks or create the conditions to allow users to define and evolve any number of outcomes. Design-for-emergence acknowledges the context specific knowledge of users and gives control to them.

The idea of design-for-emergence is often exemplified by the Lego brick, a designed

object, that can be connected in limited ways, yet allows for endless possibilities for what can be created. The designer of the 'tool,' the Lego brick, cannot know what the user will create with it. Design-for-emergence questions the idea of top-down design where the designer holds the knowledge and is in control of the outcome. It also goes beyond user centred design where the knowledge of the user is integrated into the design process but the designer is still responsible for the outcome. Design-for-emergences provides for users to employ their contextual knowledge and create and continue to evolve the outcome. See figure 06 (Klimes, 2022).

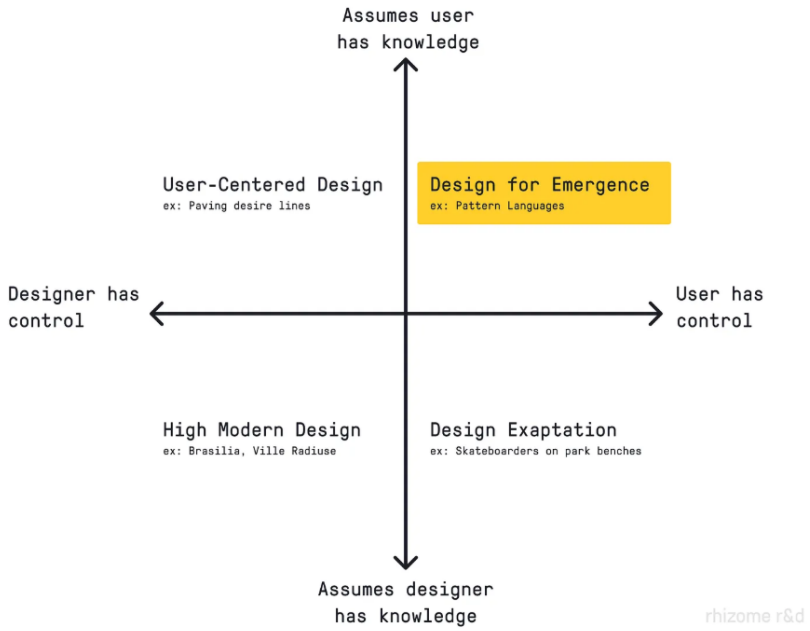

Figure 06 - Design-for-emergence, (Klimes, 2022).

This idea of creating flexible building blocks that can be combined in countless ways to adapt to specific needs, can be adopted into the process of design as well as being the desired outcome of the design. In this thesis emergence in the design process could be achieved by viewing the regulations and guidelines about light and darkness as a set of blocks that can be combined in endless configurations to achieve a desired outcome. While the desired outcome could be a lighting design that provides a nighttime atmosphere that allows for emergence in how the space a space is used, and allows for continued evolution of the space by the community.

In A Pattern Language Christopher Alexander lays out a series of over 200 'rules of thumb' about the built environment expressed as patterns (Alexander et al., 1977). Published in the 1970's A Pattern Language 'is believed to be the first book written in hypertext, with non-hierarchical links between closely related patterns. This was by necessity, as patterns form an interconnected web which can generate a vast range of combinatorial possibilities to address unique, contextual needs (Klimes, 2021). The second to last 'rule of thumb' in A Pattern Language appears to be the only one referring to electric light. It presents the idea of 'Pools of Light,' a pattern that will be very familiar to lighting designers, that has proven to be relevant in many contexts. After a short essay on the topic Alexander presents his conclusion – 'Place the lights low, and apart, to form individual pools of light which encompass chairs and tables like bubbles to reinforce the social character of the spaces which they form. Remember that you can't have pools of light without the darker places in between.' He goes on to 'link' to other patterns that could be combined with this one including: ... small social spaces like ALCOVES (179) and WORKSPLACE ENCLOSURE (18 3), larger places like COMMON AREAS AT THE HEART (129), ENTRANCE ROOM (13O), and FLEXIBLE OFFICE SPACE (146), and the furnishing of rooms like EATING ATMOSPHERE (182), SITTING CIRCLE (185), and DIFFERENT CHAIRS (251). It even

helps to generate WARM COLORS (250). (Alexander et al., 1977). Klimes describes Alexander's way of designing as more similar to gardening, where 'the designer accepts more limited control over outcomes in exchange for the generativity and context-sensitivity of an open-ended compositional process' (Klimes, 2021).

Design-for-emergence implies that if we want a space to be for people it has to be by them. And because a community is not static it has to allow for continued evolution and adaption, which in turn continues to connect people to their space, and so on. This is not to say that a designer (or any other person from a discipline with specific knowledge) should not be included in the process, simply that their expertise is just one of the areas of knowledge that is collected and given equal weight as the design process unfolds. It is a fallacy that the designer or anyone else can affect change positively from outside of a complex system, 'interventions are possible from within these dynamic systems, they cannot be controlled from the outside. Systems are heterarchical - composed of equal parts interacting together' (Yunkaporta, 2020).

People in design-for-emergence

The nature of complex systems is that all the 'agents' interact with each other and change due to these interactions. In the context of this thesis, light and darkness cannot be isolated from the physical space and or the community that use the space. To understand the context and how light could support an emergent design in a specific place for a specific community, as many varied perspectives should be integrated into the process as possible, 'talk to everybody and listen carefully... every viewpoint is useful and it takes a wide diversity of views for any group to navigate this universe, let alone to act as custodians for it' (Yunkaporta, 2020).

The Place Standard Tool aims to provide a framework for the gathering and synthesising of diverse opinions from the community to determine the quality of a shared place. 14 different aspects of a place are considered including 'moving around,' 'identity and belonging,' 'natural space,' and 'influence and sense of control' (Hasler & Howie, 2020), see figure 07. In a number of ways this tool acknowledges the complexity of public spaces and allows for a diversity of opinions to come together in

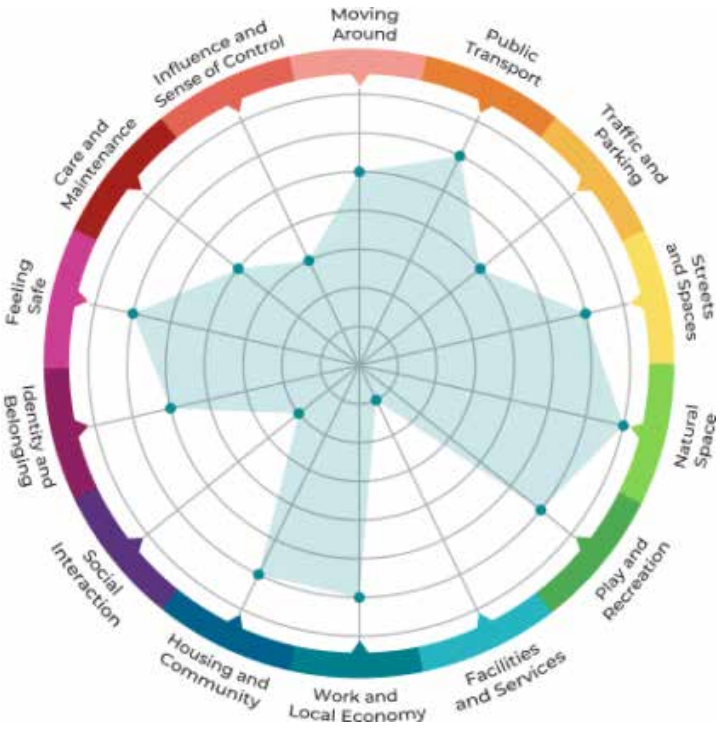

Figure 07 - Place standard tool, (Hasler & Howie, 2020).

a collaborative way. The 14 aspects that are identified refer to the physical elements of a space as well as the social aspects of the place. The opinions are gathered and mapped through a collaborative process of guided conversation around each topic. The resulting graph acknowledges the relationality of the different topics, it highlights the assets of the place as well as areas for improvement and could be repeated to track the evolution of a place (Hasler & Howie, 2020).

Yunkaporta presents a narrative of a song that was introduced by an elder in his community. The song cannot become a part of the culture of this community until it has been used, changed, adapted and evolved by the community – 'Most lasting cultural innovations occur through the demotic - the practices and forms that evolve through the daily lives and interactions of people and places in an organic sequence of adaption' (Yunkaporta, 2020). And ultimately it wasn't the song that was important, it was the process that produced the song that brought real connection. But the song exists as a representation of that process and will continue to evolve and shift with the community.

A direct correlation can be seen between this narrative and the results of a lighting design project carried out in a London estate by Light Follows Behaviour. The lighting design team spent time on site engaging with locals to 'understand residents' current thoughts and concerns about the estate after dark,' (Martinez & Bordonaro, 2022). They worked with the community to introduce a temporary light installation, to shift perspectives of the space. But it was so successful that residents convinced the local authority to make it a permanent feature, and it has encouraged discussion at many levels of community and local authority on the potential of light to positively shape social spaces.

The implemented festoon lighting was simple in technical terms and not a completely novel approach however the result isn't entirely what's important. It's the time that was taken to make the decision collectively. The physical result exists as a tangible manifestation of that collaboration, that continues to reinforce that connection as members of the community walk through it every evening.

Figure 08 - Meaning making through community engagement (Martinez & Bordonaro, 2022)

Conclusion

This chapter has explored the contrasting values of darkness and light. The aim of this thesis will be to emphasizing the importance of achieving a balance between the two within urban environments. Through a review of existing guidelines and regulatory frameworks, a gap has been identified in how to provide illumination and preserve natural darkness across diverse urban typologies. The chapter introduced complexity theory as a lens, and the concept of 'emergence' as a tool to achieve the aim of balancing light and darkness in our cities.

Design-for-emergence in the field of lighting design

Introduction

This chapter will present examples of design-for-emergence, within the field of lighting design. The projects do not explicitly site complexity theory or deign-for-emergence, but these concepts are evident in the process and approach. This further understanding of how design-for-emergence can be integrated into the feild of lightingdesign leads to the final research question. Two example projects are identified and examined. The first represents a case where emergence is embraced in the design process through a novel approach to regulating for light and darkness. The second project is one where the complexity of light in urban spaces is fully appriciated, here smart lighting is acknowledged as one method for embedding emergence into lighting in public places.

An example of design-for-emergence in lighting regulations

This first project presents an example where lighting regulations have been designed in a way that allows for emergent design solutions to unfold - emergence is embraced in the design process. In this project the governing body of a large region aimed to achieve Dark Sky International recognition while implementing a development that included over 100 hotels and 10,000 homes, as well as sports stadiums, airports and other associated infrastructure (Red Sea Global, 2020).

Cundall consultants were brought in to design the lighting masterplan that should achieve this seemingly impossible feat of completing a large scale development while preserving ‘pristine skys’ (Cundall, 2020). This project was presented by Andrew Bissell at the *Illuminating the Future: Balancing Light and Dark Nightscapes* conference at the University of London in April 2025. The setting for this ambitious lighting masterplan is the Red Sea area in Saudi Arabia. There were no existing lighting regulations in place, so this project presented a unique opportunity to design new regulations with an extremely strong mandate for preserving natural darkness. Existing regulations from around the world were analysed and the most relevant and effective elements were consolodated to this unique context (Bissell, 2025).

Bissell described previous experiences of setting light pollution limits within masterplans; rather than aiming to avoid all light pollution, those responsible for lighting would often treat the limits as an allocation of permitted light pollution, turning these figures into targets rather than the limits they were intended to be (Bissell, 2025).

The Red Sea lighting masterplan employed a different tactic. The improbable nature of the task was embraced and an impossibly high light pollution standard

was established. The entire region was designating LZ0 as per the Model Lighting Ordinance developed by International Commission on Illumination (Illuminating Engineering Society & Dark Sky International, 2011). This is the strictest lighting zone, where the ambient light levels desired by the community are described as: *'No ambient lighting - where the natural environment will be seriously and adversely affected by lighting' . Impacts include disturbing the biological cycles of flora and fauna and/or detracting from human enjoyment and appreciation of the natural environment. Human activity is subordinate in importance to nature. The vision of human residents and users is adapted to total darkness, and they expect to see little or no lighting. When not needed, lighting should be extinguished'* (Illuminating Engineering Society & Dark Sky International, 2011).

Bissell referenced a guiding principal of the lighting masterplan stated that 'Every light on every project must protect or restore the pristine night sky' (Bissell, 2025). These standards set a mandate for all those responsible for electric light across the region to innovate, from the earliest phases of development, strategies for eradicating the light pollution that would usually be accepted as an unavoidable consequence of such a development (Bissell, 2025).

Setting these aspirational standards created the conditions for innovative lighting solutions to emerge from developers, architects, engineers, interior designers, lighting designers and contractors working on the project. Where justification could be provided that light outside the regulations was essential the planning authorities could agree deviations to the regulations. But rather than these deviations being given as standard they became the exception, not the rule, making a clear statement that the preservation of natural darkness is seen as the priority.

Emergence can be recognised in the creation of this master plan, where the palette of existing regulations in other countries were referenced, to create site specific guidelines tailored to this unique setting. Emergence could also be seen in the framing of the masterplan as aspirational, creating the environment for creative solutions to arise. Although this project is of a huge scale and is very unique, it is a point of inspiration in how to design with light now for an imagined future where natural darkness is an accepted presence in developments such as this. As designers could we set ourselves equally ambitious standards. We could take the perspective that the world is moving in the right direction in regards to light pollution and design for that future. Acknowledging this and the fact that most public realm projects take several years to be implemented and will be in place for many more, we should design for the regulations we would hope to see in ten years time, not only what is mandatory now, design for vision of urban nightscapes that isn't here yet.

An example of design-for-emergence in lighting design

The second project is the *EU Horizon 2020 ENLIGHTENme project: Innovative policies for improving citizens' health and wellbeing* which intends to understand the effects of indoor and outdoor light particularly in elderly populations, to help both citizens and city leaders improve public health and wellbeing (Tondelli, S., et al.).

One element within this large project conducted a population based lighting study on older adults to experiment with 'co-creating urban lighting interventions' (Tondelli, S., et al.). The aim of this research project was to understand how lighting in cities is influencing the lives of older people in different areas across Europe. The scale and the longitudinal nature of this study reveals the complexity of working with light in the public realm. Although the researchers do not use the phrase design-for-emergence it is easily recognisable in their recently published guidelines. They suggest approaching the complexity of light and public spaces through enabling ongoing interaction between the community and the lighting installations, allowing for people to continue to shape and adapt the lighting in their shared spaces after it is installed (Tondelli, S., et al.).

The project selected three sites across three cities in Europe, Bologna, Amsterdam, and Tartu, each site was adjacent to or used by a significant population of older people. The sites had other comparable traits such as containing both transition and gatherings spaces.

This project installed adaptive lighting systems in each city, in all cases it was possible to change the characteristics of the lighting including intensity and colour temperature in real time, allowing engagement with the local communities. In Bologna, the installation included dynamic LED lanterns and projectors as well as a multi-head pole with adjustable spotlights in a gathering area allowing users to achieve uniform lighting, enhancing safety and comfort while also changing the lighting for different events. In Amsterdam, integrated tunable white LEDs in a bridge handrail, allowed for adjustments in brightness and colour temperature to suit various conditions and aesthetics, improving safety for pedestrians and cyclists while transforming the bridge into a nighttime landmark. In Tartu, adaptive LED lighting in bridge handrails optimized visibility while preventing glare, RGBW projectors and multi head poles at the bridge's base and adjacent lakeside beach created dynamic lighting effects to support seasonal activities (Tondelli, S., et al.).

The researchers had a unique opportunity to spend an extended period of time in each of these sites. The researchers were able to spend significant time with the communities, building relationships with the participants. It was only through this relationship building where the participants began to discuss and appriciate the impact of light that co-creation became possible, 'As people learn about and experience different light qualities, more and more options open up for design' (Tondelli, S., et al.).

This project demonstrates very well the complexity present in public realm work. The project parameters could be considered quite narrow as they were researching one element, light at night, and its effects on one segment of the population, older adults within the community. However, some very clear truths became evident through the process of completing this research, firstly that the category of 'older people' is in no way a homogeneous group, secondly that it takes time and education for people to engage with light in a meaningful way, and thirdly that light cannot be looked at as an isolated variable, it is always in relation to the physical and social context (Tondelli, S., et al.).

The research found that in the three different cities the cultural differences dictated that what the communities wanted from their public space was vastly different. The research also made evident the incredibly broad spectrum of needs and wishes within the three populations of older people that they encountered (Tondelli, S., et al.).
This project highlights the fact that light is not an isolated variable and exemplifies the necessity of engaging with the community in an ongoing way and assessing light in situ. It is with continued and practical engagement that the knowledge and opinions of the local community can meaningfully shape the intent for a lighting proposal.
This project also highlights that through the integration of controls, lighting design does not need to be seen as a static one-off installation. Instead, it can be an ongoing service that could adapt and evolve with/by the community using each place.

Conclusion

These examples, demonstrate that the ideas of complexity and design-for-emergence can be identified in the lighting design field.

One project focussed on achieving a balance of light and darkness in a extensive development, embracing emergence in the development of standards and within the design process. The other example emphasises the importance of involving people in the evolution of their spaces and highlights the potential of lighting controls as a way for light and darkness to be adapted by and for the community.

These insights helped to clarify the final research question: **Can design-for-emergence introduce positive experiences of light and darkness into a shared public place?**

The following chapter aims to answer this research question by applying elements of design-for-emergence to a case study of a public square in southwest London. The intention is that through engaging with the knowledge and opinions of the community, creating positive experiences of light and darkness, along with a vision for how the lighting proposal can shift and adapt over time, this may create the conditions for life to emerge and continue to evolve in a shared public place.

Design-for-emergence at Doddington Square

Introduction

The site for this case study, Doddington Square, was identified as an area where imbalances of light and darkness in the current lighting scheme are very apparent. A historic analysis of the site is conducted, and the current lighting scheme is assessed, along with elements of the design process that produced it. This reveals that there were oversights in this process that run counter to the ideas of complexity and emergence. It appears that light was isolated from the context, and the individual lighting fixtures were also selected in isolation from one another. In ways the lighting is prescriptive in how the space is to be used, and it is static, not allowing for further evolution.

Although the community was consulted in the design process, this too was not carried out in a generative way, as seen with the Place Standard tool, instead the questions, specifically those relating to lighting, were isolated from the context. Could this have been approached differently and yielded better results? The selection of the case study places the research question in context; **Can design-for-emergence introduce positive experiences of light and darkness into this community's shared public place?** Through the design process light and darkness are considered within the physical, social and ecological context of Doddington Square. An understanding of the social context guides the direction of the design proposal, defining the atmospheres that the community would like to see in their space. A diversity of opinions from the local community are analysed to identify these atmospheres (within the limited scope of this thesis).

Site-specific guidance for light and darkness is developed referencing elements from existing guidelines, regulations and current research that could relate to this site's specific context. This creates a palette of 'tools' to achieve the desired atmospheres through lighting interventions.

Using this palette of tools, an initial lighting design is proposed that aims to provide the desired atmospheres, and create a nighttime experience of Doddington square that is non-prescriptive and allows for composability through use.

A control strategy is then suggested that would allow for the continued evolution of the lighting proposal. Finally, a strategy is outlined for how the community could be engaged in the development of this proposal and beyond installation, if this project was to be implemented.

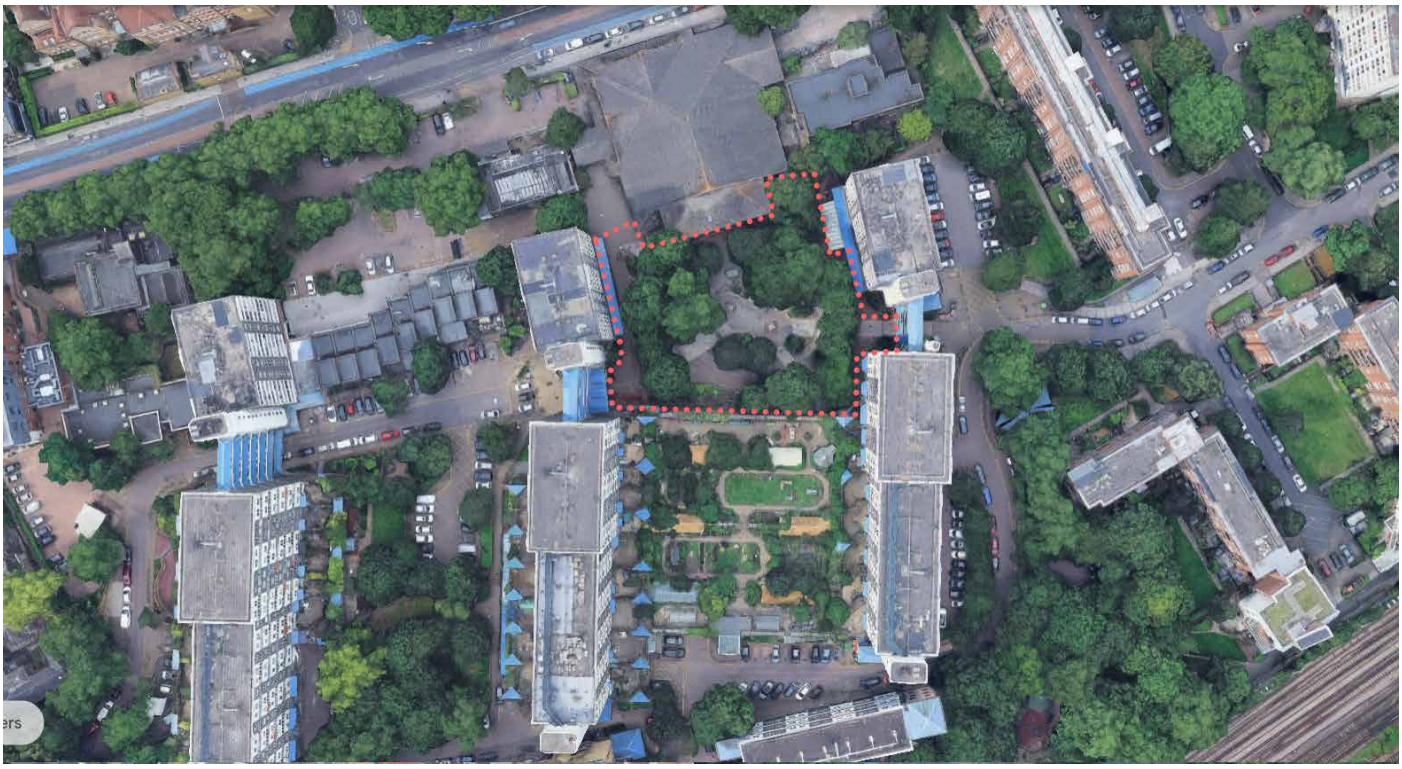

Figure 09 - Doddington Square in context, self produced with background from Google. (n.d.). Retrieved [Mar, 2025].

Doddington square is located in the borough of Wandsworth in south west London, this public realm square features mature trees, seating and several key paths of travel for pedestrians and cyclists, encircled by high rise residential buildings, that house small commercial and community businesses at ground floor level. A community garden is situated on a the roof of a carpark adjacent to the square.

The site context

Doddington square is located in the Doddington and Rollo housing estate which from the beginning of its development in the early 1960's has had a troubled history, struggling with poor construction, economic deprivation, social isolation and crime (Boughton, 2018). It is clear that the city planner who conceptualised these large estates was suffering from an 'I am greater than you,' complex, as evident from his patronizing statement where he refers to the resident's as 'them,' while reflecting on his ideals of the scheme, *'It was heaven to them. Now they have a separate kitchen, separate toilets. It was unheard of in the old days there. You went down the end of the garden...'* (Boughton, 2018).

Through the 1980's the challenges facing the community continued. Since then the Doddington and Rollo estate has received significant investment from local government to improve the accommodations and the local area for residents. Although recent census data concluded that the Doddington and Rollo estates are still amongst the 30% most deprived neighbourhoods in England (Wandsworth Council, 2024). An Age UK study into the 'Risk of Loneliness' in those aged 65+ classifies the Doddington and Rollo area as 'High Risk' (Wandsworth Council, 2024).

Observation of the square over a number of months demonstrated that it is mostly used to pass through, with minimal evidence of its use as an active recreational or community space. Further research into the area revealed the presence of strong community led initiatives from the Doddington and Rollo Residence Association and other community organisations. Of particular note is the Doddington and Rollo Community Roof Garden, which is situated on a large rooftop area just above, and

Figure 10 - Doddington Square in the 1980's and now. Right self produced, left url: https://www.drca.co.uk/ Retrieved [Mar, 2025].

accessed from Doddington square itself. This space in contrast to the square is very active and successful in bringing the people of the area together. *'The garden is a very equalising space. When you're all digging the earth together, you can't help but make friends.'* - Malissa Ritchie, Chair of the Doddington Garden Committee (London Square, 2023). The contrast of this active and vibrant community place alongside a seemingly underutilised public space is quite stark. Perhaps this can be seen as an example of emergent and non-emergent community spaces. In the community garden the curation of the space is up to those involved, where upkeep of planting and a shared purpose bring a sense of ownership to those involved. The community garden is producing more than the sum of its parts. While Doddington Square, in contrast, stands still and vacant. How could some of that energy be brought from the garden into the square.

The presence of the community garden also makes it an interesting place to investigate light and darkness as there is a meeting point of highly urban setting and a community actively trying to connect with nature.

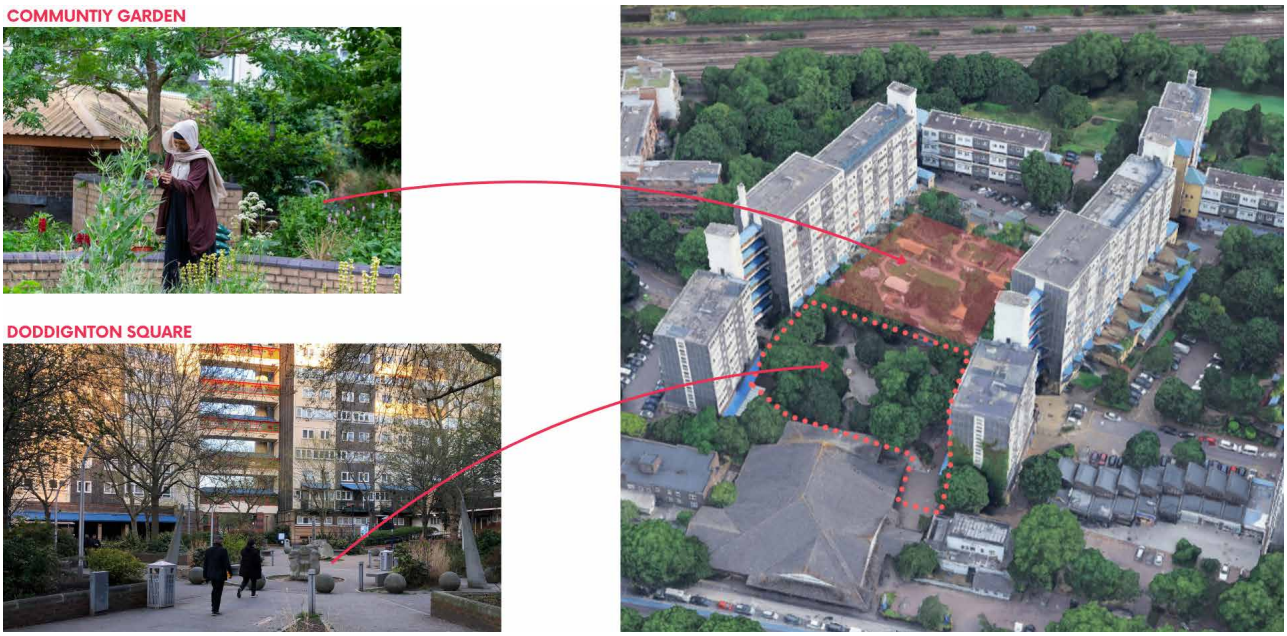

Figure 11 - Doddington Square and community garden - Top url: https://londongardenstrust.org/log2024/gardens/Doddington.html Retrieved [Mar, 2025], bottom self produced,.

The current lighting at Doddington Square

The current lighting scheme of Doddington square is what first drew curiosity about this location. It is the blessing and the curse of being a lighting designer that once your eyes are opened to power that light has to impact the experience of a place it quickly becomes the first thing you see everywhere you go. This opens you up to many beautiful moments in the world but also makes you very aware when anthropogenic light has been implemented poorly. The most prevalent lighting is a series of 10 large, high power linear luminaries embedded into the ground, along the main paths. These fixtures are extremely bright, with clear lenses, completely unshielded, causing very high levels of glare as you walk or cycle over them. It was possible to find the company that provided these luminaires and look into the photometric data, these luminaires were designed to uplight facades of large buildings, they are not direct view luminaires suitable for embedding into a path.

Further examination of this square revealed a series of very opposing lighting interventions throughout the space. Ironically, there are a set of very low glare bollards providing quite soft, indirect light installed alongside the extremely high glare in ground linears. Integrated lighting into the concrete benches provides some highlight to the seating areas. But any positive hierarchy that this detail could provide is washed out by the inclusion of two different overhead post luminaires that wash light across the whole space.

There are some prominent statues in the space, each side of which had been up-lit with one lonely narrow beamed in-ground spotlight. And finally there are a large

Figure 12 - Overview of Doddington Square layout, self produced 2025.

number of floodlights and wall packs mounted to the adjacent buildings further washing the square with light. The light within the square is a somewhat consistent 3500k temperature, however the older luminaires that line the walls provide a contrasting high-pressure sodium orange hue, while the flood lights are anywhere from 4000 to 6000k.

The square represents a break in the ‘standard’ street lighting that leads to it from most directions, so it was clear that there had been intentions to use lighting to make this area a feature within the nighttime experience of this neighbourhood. With a quick look at the number of fixtures one could also deduce that a significant budget would have been needed to supply and install the lighting scheme. The space was such a cacophony of different lighting elements, good and bad, with a combination of seemingly good intentions and poor execution that it would make any lighting designer wonder how had this come to be?

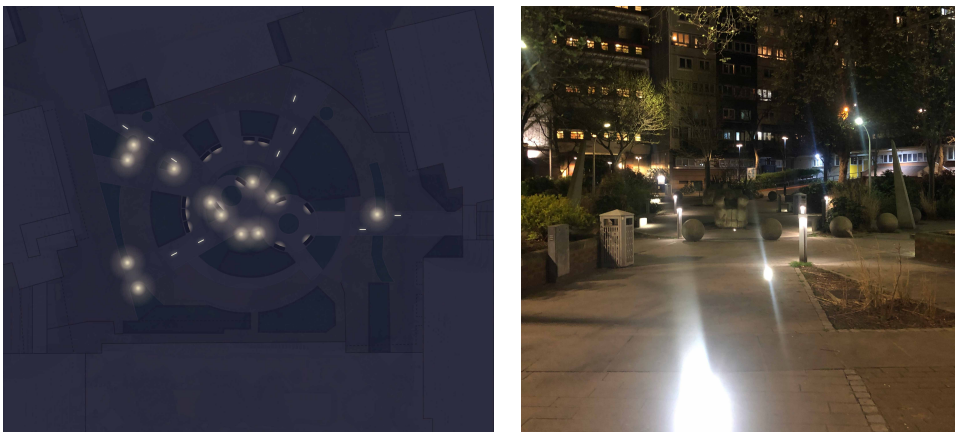

Figure 13 - Layers of light at Doddington Square, self produced 2025.

1. Low glare bollards and bench lighting alongside large high power, unshielded in ground linear luminaries.

2. Two layers of post luminaries cover the remainder of the square.

3. Numerous 4000k to 6000k flood lights affixed to the buildings that enclose the square. In contrast, a series of high-pressure sodium luminaires line other buildings on other sides of the square.

An exploration of the previous design process

Interestingly, it was possible to find a significant amount of information pertaining to the recent redevelopment of Doddington Square that included the implementation of the current lighting. The redevelopment of the square took place between 2018 and 2020 when a community group submitted a successful application to the Wandsworth Local Fund for a grant to complete improvements to the square (Wandsworth Council, 2018). To shape the design a public consultation took place to gather input from the community, as to what improvements they would like to see.

The public consultation consisted of an online survey. Representatives also handed out paper copies of the survey in the local area. This public consultation included one question about the type of light that people would like to see in the new design. As seen in the ENLIGHTENme research, it is very challenging to engage people meaningfully about the impact of light on their surroundings through a one-off interaction, as a shared vocabulary to easily describe the experience of light, what is inadequate about it and what would improve it, does not generally exist across the general public (Tondelli, S., Et al, 2025). And unfortunately, the question that was asked about light in this public consultation did not succeed in bringing much nuance to this task.

The question asked which style of lighting residents would prefer to see; 'in-ground LED lighting; higher level lighting; bollard lighting; a mixture of all of the above; none of the above,' and showed two small images to represent each of these 'styles' of lighting (Wandsworth Council, 2018). As light is such an experiential entity it is very difficult to represent in still images. When faced with such an ambiguous set of options it is unsurprising that the path of least resistance, 'a mixture of all of the above,' came out on top with 48.7% of the 286 total respondents choosing this option. This goes some way to explaining the lighting installation that was introduced, it is indeed a 'mixtures of all of the above'.

Similarly isolated questions were asked about other elements such as seating,

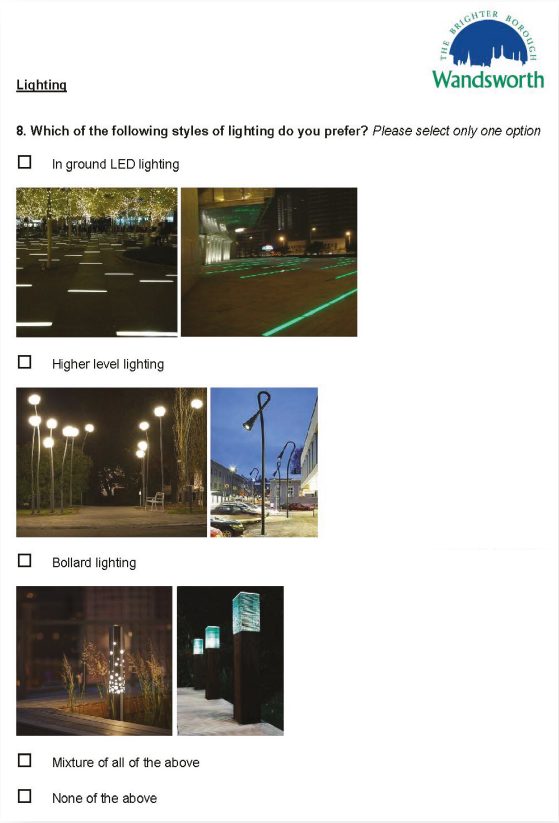

Figure 14 - Question pertaining to light in community engagement survey, (Wandsworth Council, 2018)

planting and paving. Looking at some of the questions that are outside my field of expertise allows me to empathise with those asked the question relating to light. The question related to planting, for example - the descriptions and the images give me almost no understanding of what I'm selecting or why and definitely no idea of how all these elements might come together to make a better space.

There are several broad questions that ask things like 'which additional elements or activities would you like to see included in the square?' and 'what changes they would like to see made to the square that would make them feel safer?' (Wandsworth Council, 2018). These questions do represent the interests of the community and where their key concerns lie but it is unclear how these responses shaped the outcome or impacted the design of the lighting.

This is not meant to disparage the effort here as there were so many things that the community and the municipality did understand... They understood that investing in the public realm spaces in areas dealing with social issues is important and can lead to positive changes for the communities living there. They understood that well designed public squares can become a meeting point and a place for positive social interaction. They understood that light is an important factor to these types of public spaces after dark. They knew that putting in more than the standard street lighting can improve the experience of the space. They knew they should engage the community when designing for the community. So the asked the community what light they wanted. And they knew they should listen to what the community says, so they followed the responses.

However, the questions isolated light from the other elements of the physical context. Each of the elements, the lighting, the planting, the paving etc. were all queried individually. The answers were combined without consideration of how these elements would relate to each other in the space, and how they might add up to a vision of what the atmosphere of the square should be.

This is most evident in the lighting scheme. There were some additional comments from the survey that referred to the desire for 'more or better lighting', but what does that mean to this community in this case? Batty and Marshall write of one of Britain's early proponents of town planning, Patrick Geddes, who by the early 1900's had already 'shattered the notion that town planning could be a simple matter of an indiscriminate 'mechanical mixture' of urban elements' (Portugali et al., 2012). One of the reasons a simple combination of individual elements placed together may not appear cohesive is discussed by Pallasma as the 'diffuse but comprehensive,' ability of people to instantaneously read the atmosphere of a space', he describes this innate ability as being *'instantly able to differentiate a scene of potential danger from a setting of safety and nourishment... such judgements cannot be consciously deducted from details; they have to be instantaneously grasped as an intuitive reading based on a 'polyphonic' grasp of the ambience... An elementalist approach to conceiving architecture as an additive entity of definable and pre-conceived elements is equally misguided'* (Pallasmaa, 2014).

This 'elementalist' approach can be seen again in the 'aims' and 'constraints,' of the public consultation document. The key aim of the project was stated - 'to create a sense that the square is the heart of the estate where community activities and events can take place.' However the following sentences states a strict constraint that 'the improvements should not lead to additional maintenance costs' (Wandsworth Council, 2018). The latter implies that the desire from the municipality is to make an effort once, to spend the money once, have the community be grateful for this, and not have to think about this square again for 15 years. But if the aim of this project was really to make this place the heart of the community, this 'one and done,' approach cannot succeed.

How could this have been approached differently

The current lighting scheme at Doddington Square does not provide either a positive experience of light or a positive experience or darkness. There are so many layers of light across the space that any awareness of natural darkness is eliminated. The over-abundance of illumination has blurred into a wash of light with little hierarchy in general brightness levels, but many instances of glare.

Could the idea of design-for-emergence have supported a better outcome in this case? Could positive experiences of light and darkness provide the atmospheres that may enable Doddington Square to emerge 'as a centre of the community.'

Understanding that design-for-emergence can relate to a way of approaching the design process as well as the result. The new proposal will consider light and darkness as part of the larger context of the space and involve the diverse viewpoints and contextual knowledge of the residents. The intent is to produce a nighttime experience where both light and darkness can be positively experienced, creating a space that allows for emergent use of this shared place.

Engage with the local contextual knowledge of the community

In a real world setting the ideal way to gather this diverse local and contextual knowledge would be through a collaborative discussion process as presented in the Place Standard tool. As this was not possible within the resources and time restraints of this thesis, the data already gathered from the 200+ residents through the engagement survey was looked at. As discussed, the responses to the question relating to light are not a good indicator of what lighting the community would like to see. But what if the responses to all the other questions were looked at instead. If the question we should be asking is what environment, atmospheres or experiences the lighting design should provide, perhaps the answer can be found in collating the responses to questions not about light.

All the elements mentioned by the residents were mapped in a way that was inspired by the Place Standard tool, which acknowledges that these elements cannot be considered in isolation, as they are all relational. The number of people that mentioned each element is taken as an indication of how important each is to the community, see figure 15.

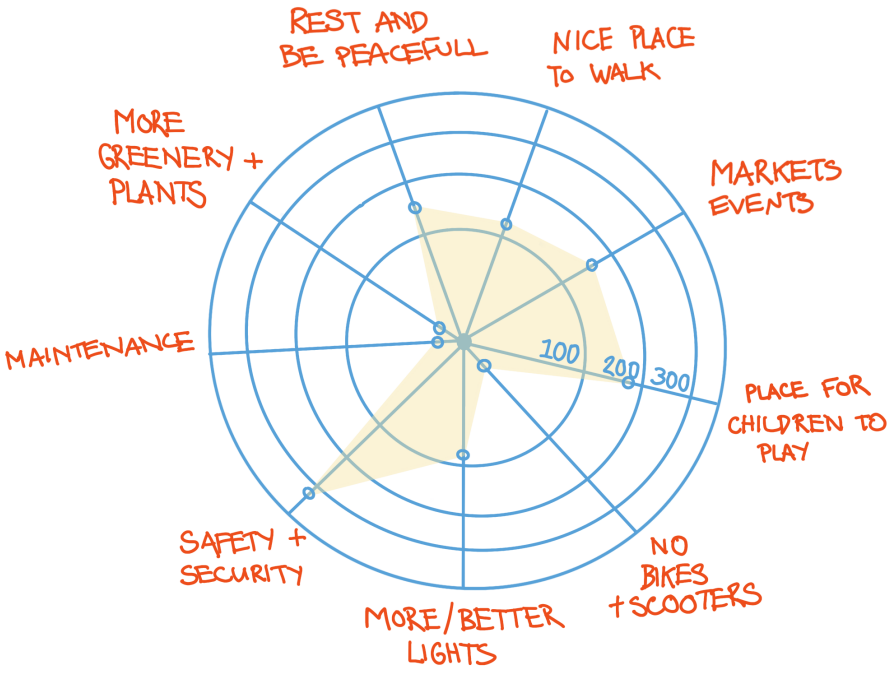

Figure 15 - Mapping of community's desires for Doddington Square, self produced 2025.

Within the constraints of this thesis this analysis allows us to acknowledge the diverse opinions of the community and to ensure that the lighting proposal is grounded in the current context of the space while looking towards the desired future of this shared public place.

It is clear from this analysis that the primary concern for the residents is that the square should feel safe and secure, it is likely that the request for more/better lighting also pertains to this. There is a vision of the square as somewhere nice for people to walk and children to play. The residents would also like the square to provide an opportunity to rest and be peaceful. And the final aspiration is for the square to be active, a place where community events or markets could happen. This can be distilled into four atmospheres that a lighting proposal should try to support:

- Safe & Secure – overarching atmosphere of safety and security throughout.
- Inviting – An inviting atmosphere, bring people to the space to walk and play.
- Peaceful – A peaceful atmosphere, providing a moment to rest.
- Active – An active atmosphere, connecting the square to the other aspects of community life.

Gather regulations and research to create site-specific guidance

With a greater understanding of the social context that the lighting proposal will interact with the next step was to pull from the many 'patterns' of light represented through regulations, guidelines and research to create site-specific set of guidance.

After establishing some of the atmospheres that the community would like to see in Doddington Square, 'patterns' of light and darkness that may support the emergence of these atmospheres were identified. Several types of documents were referenced, lighting regulations, professional guidance documents, masterplans and research studies, see figure 16. References were identified in these documents where a criteria of light or darkness was shown to relate to one of the atmospheres we hope to promote in Doddington Square. These references have been distilled into a set of 8 'patterns' that the lighting proposal should aim to align with, see figure 17.

CIE 150:2017 (Guide on the limitation of the effects of obtrusive light from outdoor lighting installations, 2017).	The quality of the lighting is not necessarily improved by adopting higher lighting levels. Improved visual conditions for the participants of the activity can often be obtained by giving greater attention to the uniformity of illuminance over the design area and the control of glare from luminaires.
LG06 The exterior environment (The Chartered Institution of Building Services Engineers, 2016)	Reducing street clutter though the use of integrated lighting - Visual clutter can be defined as a visually chaotic scene, caused by the inclusion of multiple elements of street furniture without consideration of the overall scene, which detracts from the overall quality of the environment.
Light + Darkness in the City - A Lighting Vision for the City of London, (Speirs + Major, 2018)	Low level lighting promotes views out to the City
	Positively illuminated thresholds and end views support legibility
	Well illuminated routes reinforce pedestrian movements
Safer Parks-for Women and Girls Guidance, (The Safer Parks Consortium, 2023)	Low and even light can be safer than bright lights that create strong contrast and glare.
	Using lighting helps activate key routes and spaces
	Human-scaled lighting rather than floodlights
Balanced Brightness Levels, (Hvass, 2022)	A dimmed and balanced brightness level tend to have advantages in terms of a relaxed atmosphere, a better view to the surroundings and an increased feeling of safety.
Urban lighting for health and wellbeing: new guidelines, (Tondelli, et al. 2025).	Lighting technologies (e.g. control systems, dimming schedules, tunable colour temperatures, 'smart') are increasingly adaptable: lighting is no longer simply an infrastructure to be maintained in a steady state over decades. Lighting can now be seen as on-going area of city intervention, monitoring and innovation.

Figure 16 - Referenced guidelines, regulations and research, self produced 2025.

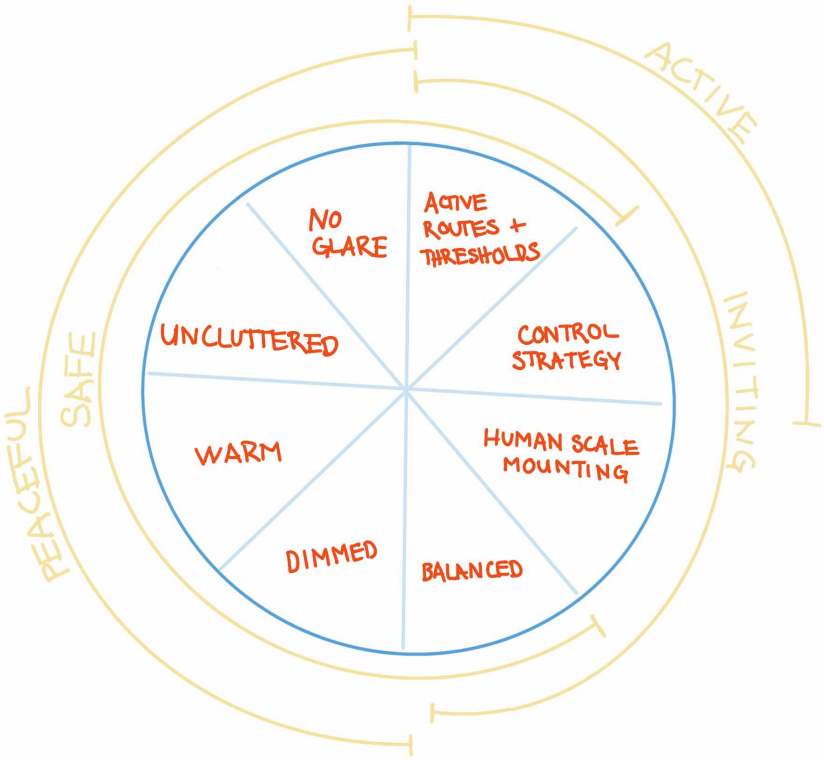

Figure 17 - Overview of patterns of light in site specific guidlines, self produced 2025.

Figure 17 represents the building blocks that will allow a lighting design proposal to emerge that fits this context.

It should be noted at this point that, nowhere in their responses did the community request for the inclusion of natural darkness in their space. So, this was not included in the list of atmospheres. However, looking at the patterns the lighting proposal will follow, it is easy to see that these patterns all overlap with Dark Sky Internationals, principals of useful, targeted, low level, warm and, controlled light. This demonstrates that the inclusion of light and the protection of darkness are complimentary rather than contradictory. Positive experiences of light are likely to make room for positive experiences of natural darkness.

Light and darkness in the physical context

As discussed it is not possible to isolate light from the social context or the physical context. With an understanding of what we are trying to achieve and the 'patterns' we may employ to achieve it the next step that was taken was to look again at the physical context of Doddington Square, how might it hold the different atmospheres that the community would like to see.

The current lighting at Doddington reinforces the physical design where the vast majority of the space is made up of paths, there is very little positive space or 'centre', to spend time in. All but a few of the benches sit right on these paths, which does not provide much opportunity for moments of peace and rest. The paths and the linear luminaires that emphasis them draw you to the centre of the square and immediately back out again, making it very difficult to 'stroll' or enjoy walking through the space. Combined this makes it very difficult to 'be in' the square, anywhere you sit, you are sitting on the edge of a path, and anywhere you walk you are brought straight out of the square, see Figure 18.

By reframing these spaces with light it may be possible to both create a calm centre to Doddington Square and also highlight paths in a way that encourages walking around this space, not just through it. Bringing areas of light to the ring of paths

around the square instead of the ‘spokes’ that segment it may create enough positive space in the centre of the square, allowing people to ‘be in,’ the space. This brighter circumference then enables the possibility of introducing a calm centre to the square, where balanced levels of lower illumination could be utilised to create a peaceful setting, see figure19.

A more cohesive lighting strategy for the community business and organisations at the perimeter, where the square interacts with other elements of community may help to bring more activation to these spaces. The thresholds and entrances in this perimeter are also key in bringing people to the square and connecting it to the other areas of the housing estate. In this way active, inviting, and peaceful atmospheres may exist in the square supported by a balance of light and darkness by providing:

- A peaceful centre - a way to be in the square;
- An inviting ring - opportunities to stroll around the square;
- Active edges - relating the community businesses and other residential areas to the square

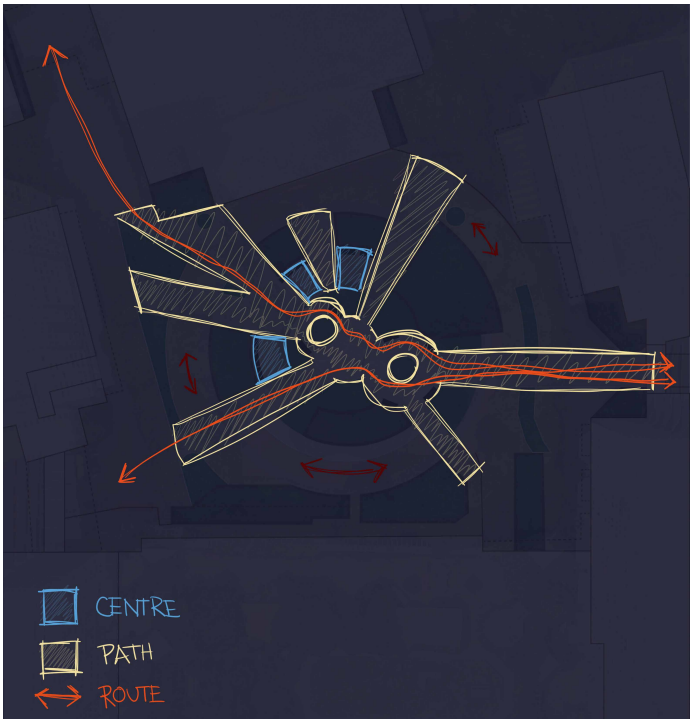

Figure 18 - Existing zones, self produced, 2025.

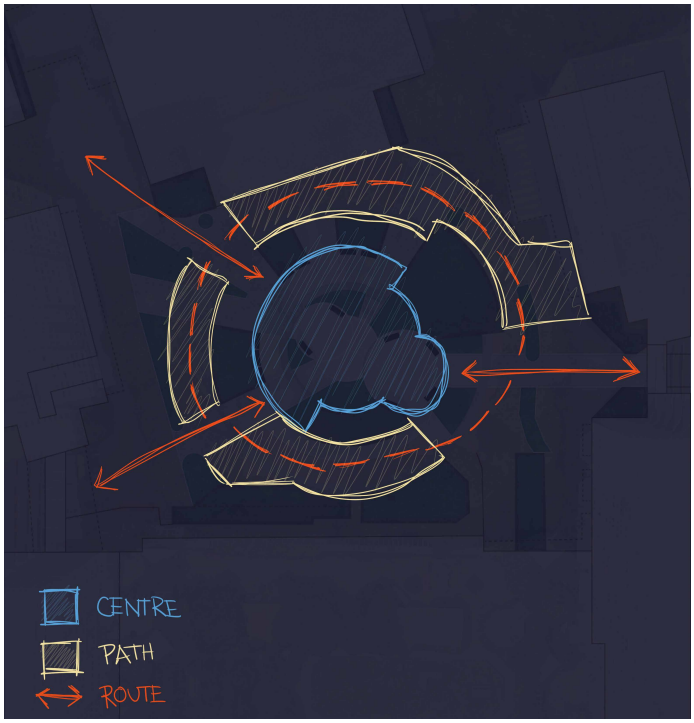

Figure 19 - Proposed zones, self produced, 2025.

Design proposal

The lighting design proposal will resolve these three key areas in different ways. A gently dimmed core of the park will retain the bench lighting, alternative optics and detailing will be explored to soften and extend the wash of light that is cast by these elements. This will allow for some of the bollards to be removed from the core, which will reduce the visual clutter and help bring a sense of calm to the centre of the square. The brightness levels of these elements will be balanced to create a navigable but peaceful space. The absence of overhead lighting in this area may be conducive to a peaceful and relaxing atmosphere.

The lighting for the ring of paths that encircle the core will work with the structure of the raised planting beds already in place drawing inspiration from integrated lighting that may be seen in handrails of walkways or bridges. This hopes to create an inviting atmosphere that draws people around, instead of just through the square.

The optic selected for this element provides an asymmetric beam angle in both axes. This allows for a wide spread of illumination to be cast across the paths, while also throwing a small amount of light backwards, bringing some vertical brightness, highlighting the brick raised beds and the edges of the planting, see figure 21. Reflected light from the path will subtly illuminate the people walking there. Pairs of bollards are positioned at the edge of the square to mark the tree main entrances to the paths, inviting people into the space.

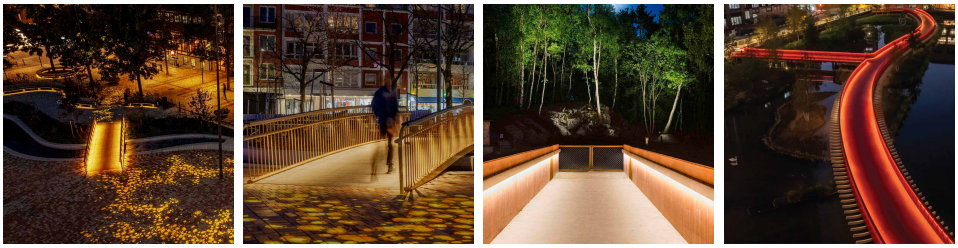

Figure 20 - Mood images - 1-3 url; https://lightbureau.com/ 4 url: https://smlightarchitecture.com/ (accessed: April 2025.)

The edges of the square and particularly the entrances will have a slightly higher and more uniform brightness level. The design proposal will make use of the vertical surfaces of the buildings that surround the square, illuminating these local businesses and community organisations, providing wayfinding and also connecting the square to the other entities that surround it. Rather than using the buildings as a platform for flood lights, the businesses will be lit in a way that emphasises the activity happening at the edges of the square. This will be achieved with discrete post luminaires and low glare wall mounted fixtures.

The final element that is essential to the design proposal is a control strategy that puts in place the structure for how the lighting may change in accordance with the astronomical clock, while leaving room for specific settings to be tested and adapted by the community, to allow the lighting to be shaped by the people it is for.

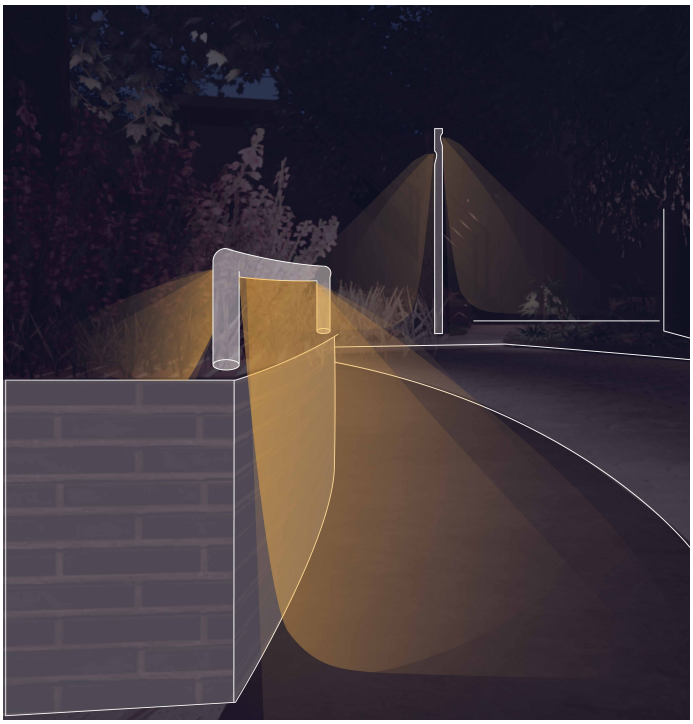

Figure 21 - Handrail detail, self produced 2025.

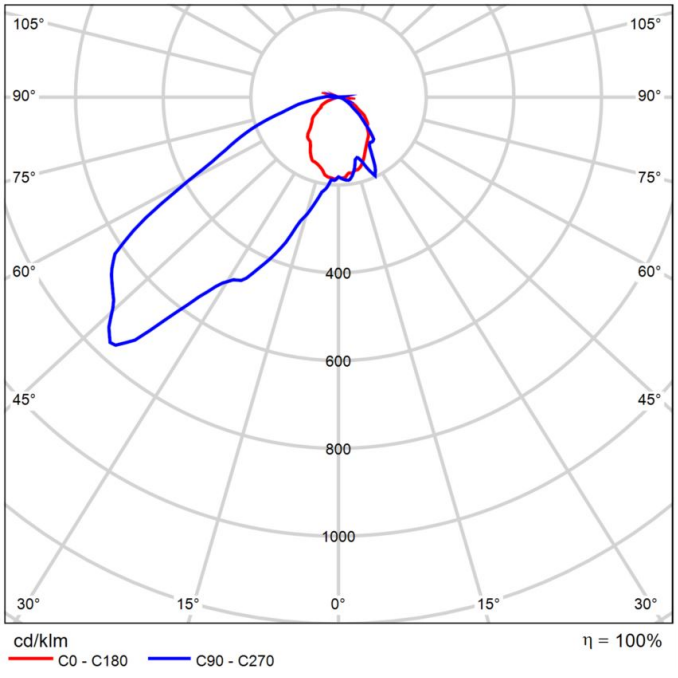

Figure 22 - Light distribution of handrail luminaire, produced from DIALux calculations, 2025.

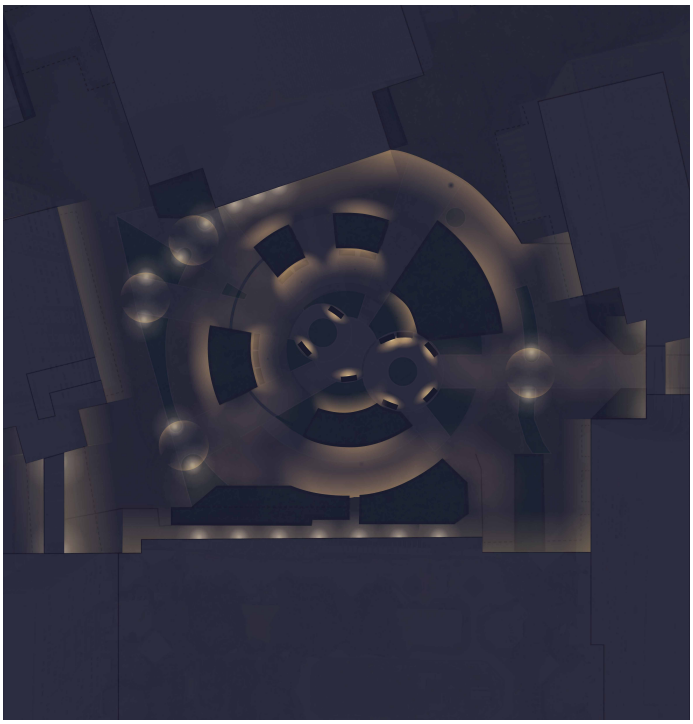

Figure 23 - New design proposal, self produced 2025.

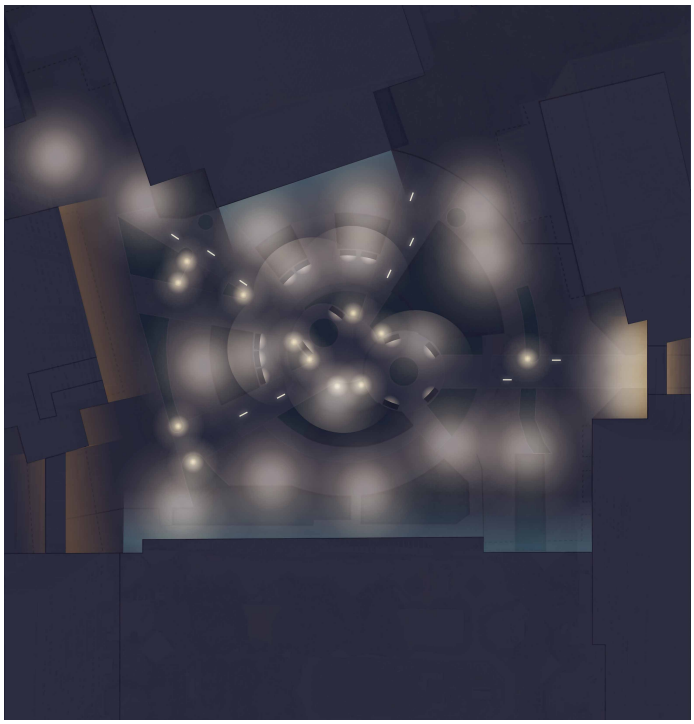

Figure 24 - Existing conditions, self produced 2025.

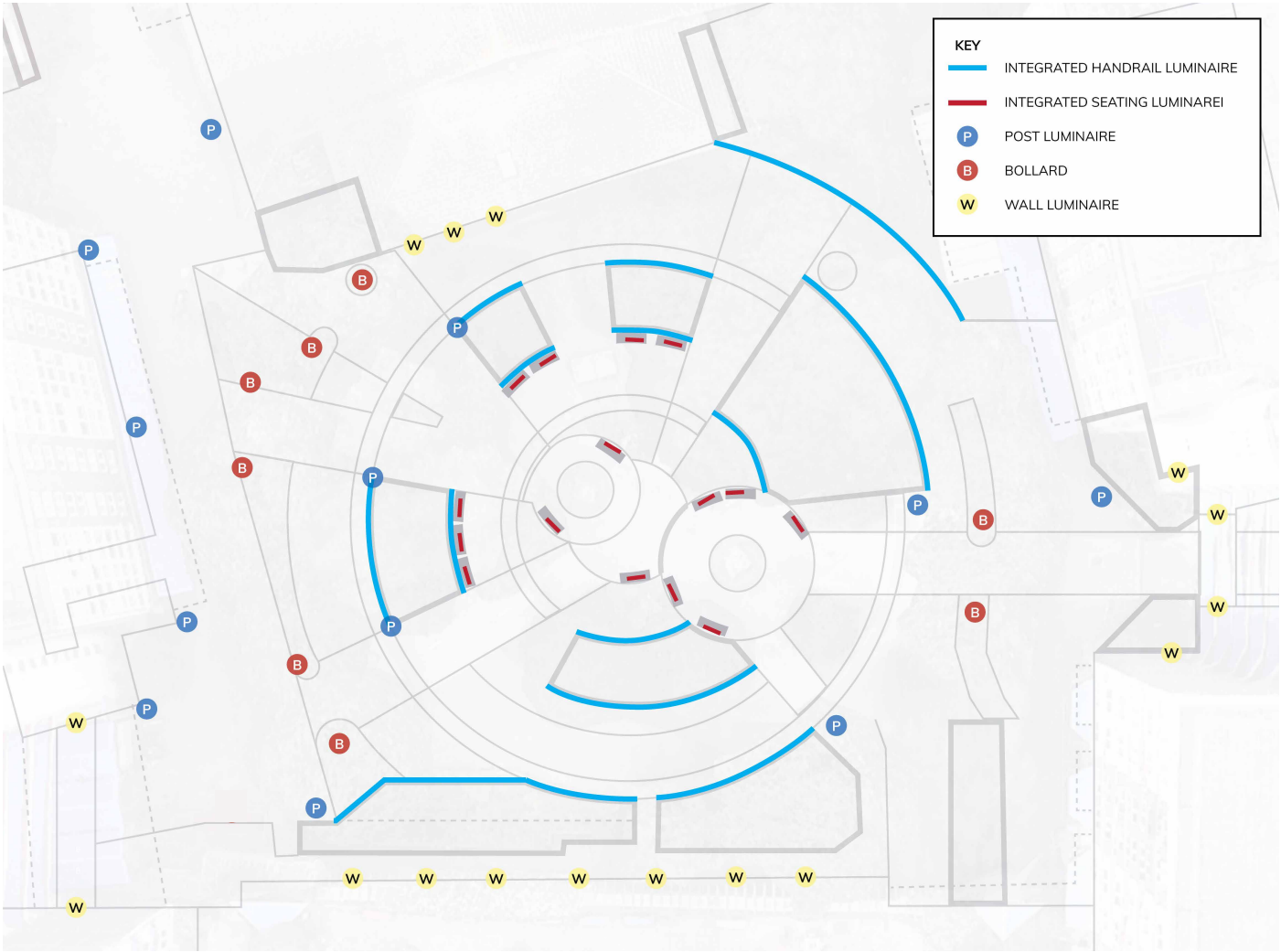

Figure 25 - Lighting layout markup, self produced 2025.

LOCATION	CIRCUIT NUMBER	LUMINAIRE TYPE	COLOUR TEMPERATURE RANGE	CONTROL PROTOCOL	SCENE 1 - DUSK		SCENE 2 - EVENING		SCENE 3 - NIGHT		SCENE 4 - DAWN		SCENE 4 - DAY		SCENE 4 - EVENT		REQUIRED CONTROL DEVICES	NOTES
					6:00pm -OR- 30mins before sunset, whichever occurs earlier (1hrs transition time) - 1 hour after sunset		1 Hour after sunset - 11:00pm (1hrs transition time)		11:00pm (1hr transition time) -1hr before sunrise -OR- 6am, whichever occurs earlier		1hr before sunrise -OR- 6am, whichever is earlier (1hr transition time) - 1hr after sunrise		1hr after sunrise (1hr transition time) - 6:00pm -OR- 30mins before sunset, whichever occurs earlier		Manual override of other scenes.			
					Brightness	Colour	Brightness	Colour	Brightness	Colour	Brightness	Colour	Brightness	Colour	Brightness	Colour		
Benches	01	Integrated lighting	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k	Casambi App	1. Scenes 1-5 to transition based on time of day. 2. One hour fade time for all Time Clock triggered scene transitions of light intensity/dimming levels. Transition triggered at the stated scene start time. 3. The scene transition time as listed in table head is determined by the event that occurs earliest. For example, in Evening Scene 4 the system to trigger scene transition at 6PM if sunset is later than 6PM, or 30mins before sunaset time if sunset is earlier than 6PM.
Walkway	02	Integrated lighting	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k		
Start of pahts	03	Bollards	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k		
Square interior	04	Post luminaires	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k		
Square periphery	05	Post luminaires	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k		
Local businesses	06	Wall light	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k		
Estate entrances	07	Wall light	2200 - 4000	CASAMBI	75%	3000k	100%	2700k	50%	2200k	75%	2700k	Off	N/A	100%	3000k		

Figure 26 - Control strategy, 2025.

The structure of the control system is formalised in the table in figure 26. But a basic understanding of it could be communicated to the community as a series of phases:

- Dusk
- Evening
- Night
- Dawn
- Day
- Special Event

And a series of elements, the benches, the walkways, local shops and entrance ways, that can each be brighter or dimmer, warmer or cooler. This could allow the community to experiment with what colour temperatures and what balance of brightness levels really provide them with experiences of light and darkness that are conducive to a peaceful atmosphere at the core of the square, an inviting walkway, and active edges.

Conclusion

This chapter applied the idea of design-for-emergence to a case study in order to understand how this tool may support a balance of light and darkness in this shared public space. A diversity of opinions from the community were gathered to understand the context and site-specific guidelines were constructed. This allowed for the lighting design to be considered as part of the complex system of this place. An initial lighting design was proposed that aims to be non-prescriptive and allow for composability of the space through use. A control strategy was devised to allow for continued evolution.

The next chapter will analyse the design proposal to see if design-for-emergence did support a balance of darkness and light and also looks to what the next stages of this process would be if the proposal was to be implemented.

Analysis

Introduction

This chapter provides an analysis of the design proposal to test if the aim of creating a balance of light and darkness in Doddington square was achieved by integrating the idea of design-for-emergence into the lighting design process.

Visualisation of the design proposal provide qualitative information on the atmosphere the design proposal may contribute to. DIALux calculations provide quantitative data that demonstrates the balance of light and darkness across the space. These calculations also demonstrate that achiving a balance of light and darkness can significantly reduce light pollution compared to the existing conditions. The intent of introducing a balance of light and darkness in Doddington square was to create an emergent place allowing for composability of the space through use as well as encouraging further evolution beyond the initial installation of a lighting design. A discussion looks at how this may be supported by the proposed control system. Finally, some limitations are discussed.

Positive experiences of light and darkness, qualitative assessment

A series of visuals were created in Twinmotion to provide insight into the experience of the balance of light and darkness in the existing lighting and the new design proposal, see figures 27 - 30.

Figure 28 demonstrates that the current lighting is dominated by high brightness levels and fixtures that produce significant glare. This combination of elements provides little hierarchy in the visual field. The points of brightness of the luminaires themselves are the most dominant feature in the scene.

The new proposal combines all of the patterns identified in the site-specific guidance that may support the desired atmospheres at Doddington Square, see figure 27. The mounting height of the walkway lighting is reduced and integrated at handrail level, which eliminates glare. Working at this human scale, presents the walkway as an inviting place to move through. The facades of the local businesses are illuminated, as is the entrance to the square from the adjacent estate. These elements of vertical brightness supports legibility for pedestrians. Highlighting active routes and thresholds in this way may support the perception of security.

Overall the comparison between figure 28 and 27 demonstrate that the current lighting suggests this is a place to walk past, where as the proposal presents the space as a destination, inviting people to walk through and around the space.

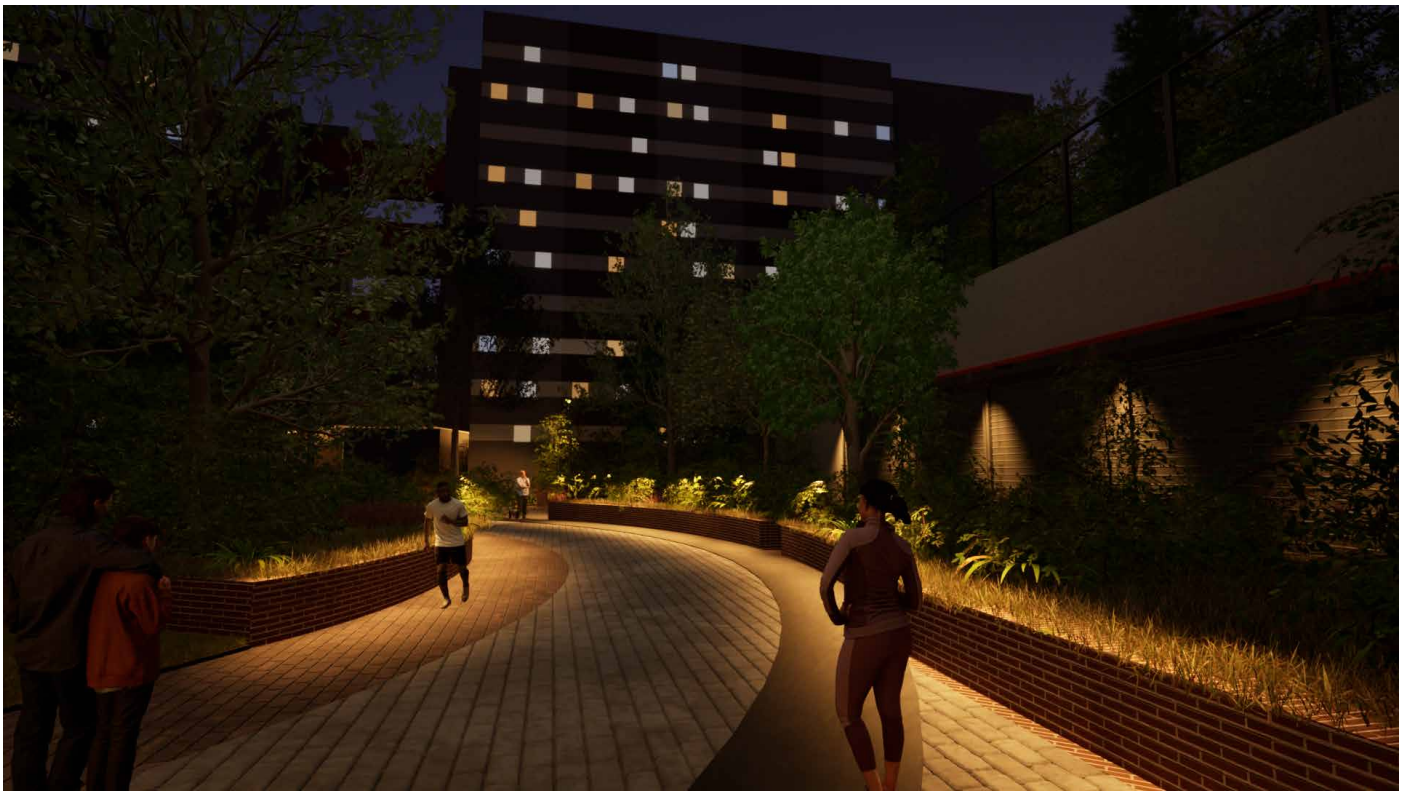

Figure 27 - New lighting design proposal for Doddington Square, self produced 2025.

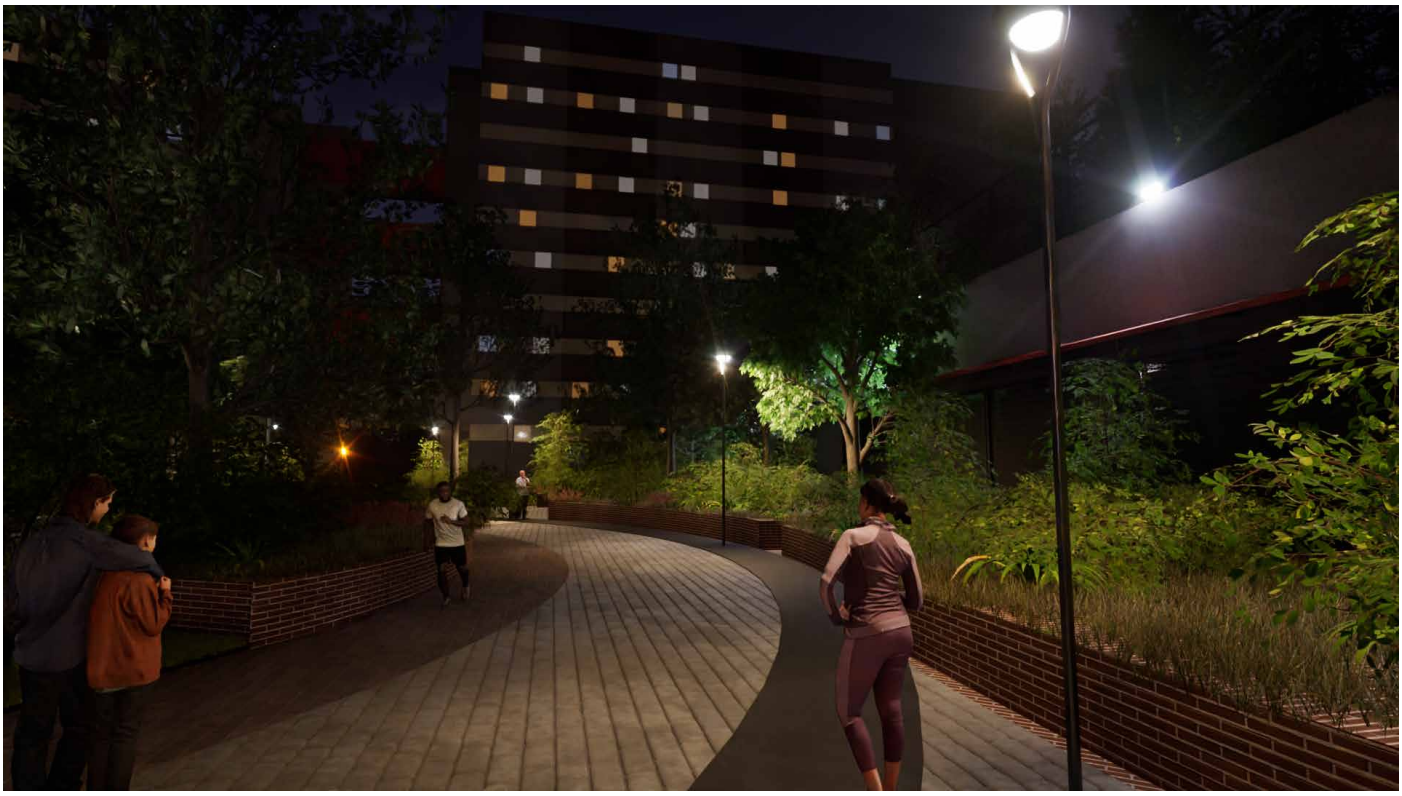

Figure 28 - Existing conditions at Doddington Square, self produced 2025.

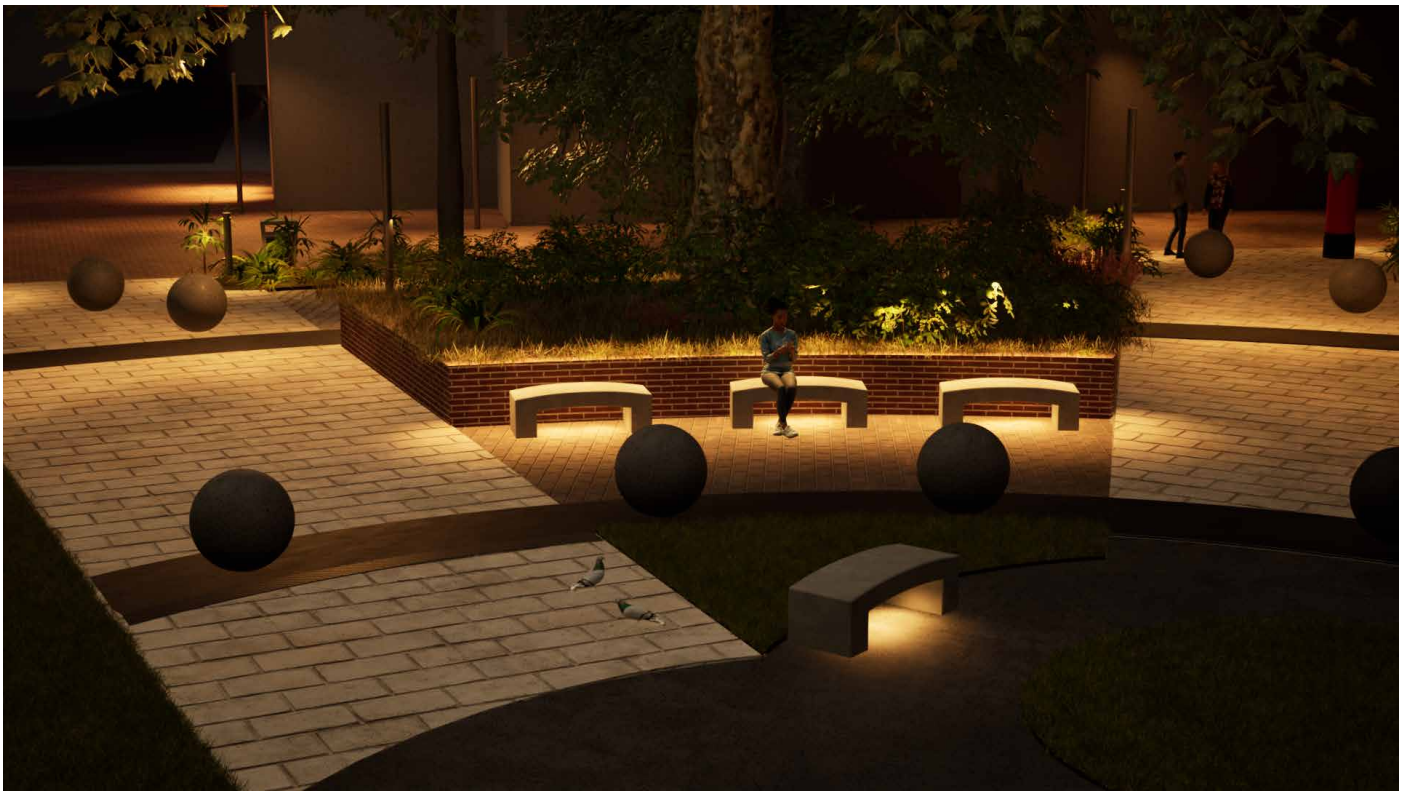

Figure 29 - New lighting design proposal for Doddington Square, self produced 2025.

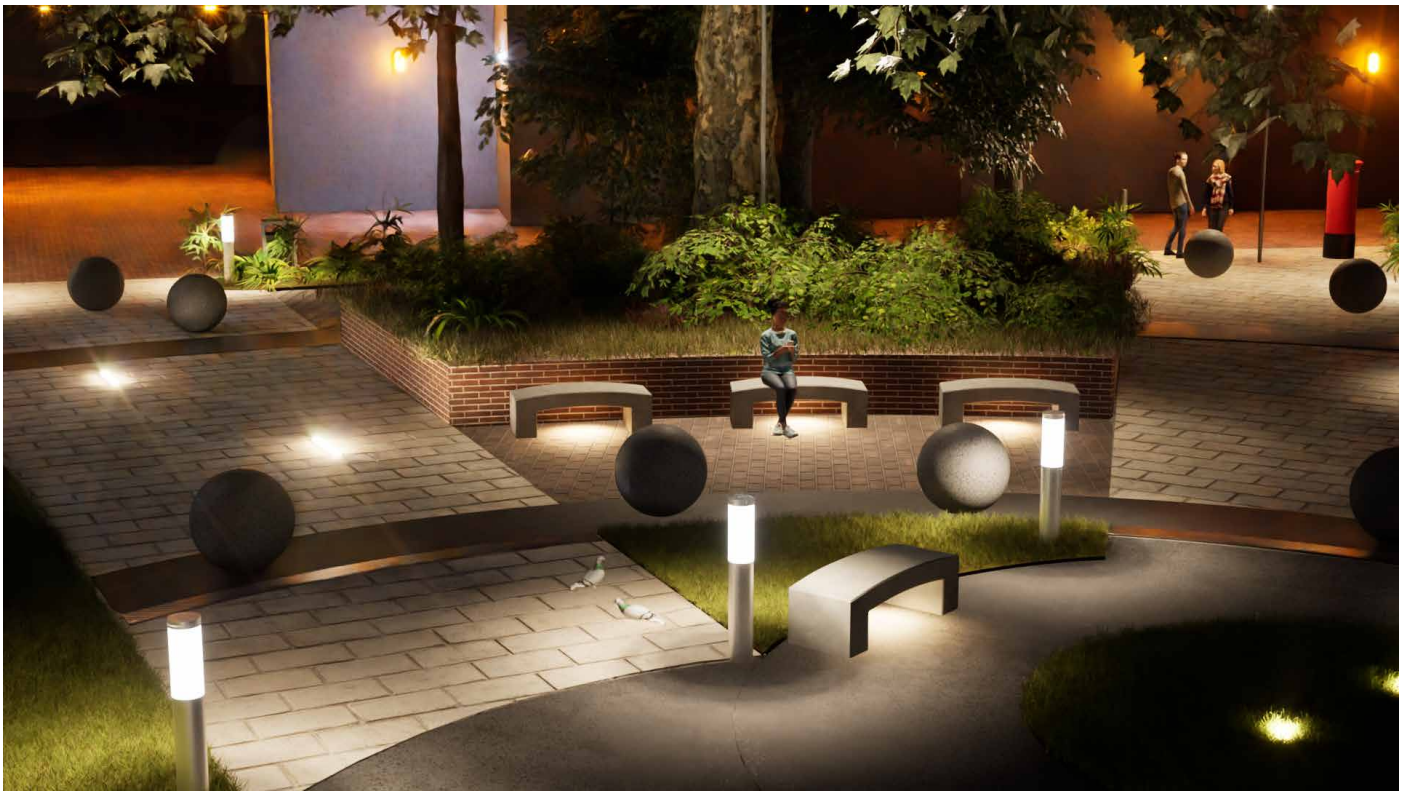

Figure 30 - Existing conditions at Doddington Square, self produced 2025.

Figure 30 demonstrates that the current lighting scheme has many elements that do not work sympathetically with each other. As well as creating high levels of brightness throughout the square these elements also contribute the visual clutter of the space. Despite the inclusion of elements that are usually conducive to relaxing atmospheres such as integrated lighting under seating, the 'busy' light field negates any calm experience of the space that these features could provide. In the design proposal, figure 29, the inclusion of a well illuminated outer walkway leaves room to provide a peaceful core in the square, where dimmed and balanced lighting may provide a sense of peacefulness and respite. The benches at the very centre are only illuminated from the integrated lighting, while the outer ring of benches also benefit from the spill of light from the hand rail lighting of the raised beds, provided variety in how people can choose to use the space. Working with the physical elements of the space allows the reduction of additional elements therefore reducing the visual clutter.

The lighting is specified as tunable white, the images depicting the new proposal present the light at 2700k, another element that provides for inviting and peaceful spaces. The lack of overhead lighting at the very centre of the square allows for a view to the sky above and the play of illumination from the interior spaces.

Cumulatively, the elements of the new proposal can be seen to provide more positive experiences of both light and darkness in Doddington square.

Positive experiences of light and darkness, qualitative assessment.

DIALux calculations were completed for both the existing lighting and the design proposal. These calculations further demonstrate the balance of light and darkness which is achieved within the new proposal Figures 31 - 34.

These calculations validate that what is shown in the visualisations can be achieved, using existing luminaires with specified optics. Visually these calculations demonstrate the hierarchy of the proposed lighting scheme, with even lighting to the perimeter of the square, a balance of higher illumination to the ring of paths around the circumference and lower levels of illumination to the core. Vertical lighting to the surrounding businesses and entrance points can also be seen. The proposal offers different experiences of light and natural darkness depending on where you choose to be within the space. The only areas that are show to be without illumination are the planting within the raised beds. The edges of this planting will be illuminated by the back spill of light from the walkway, to create a transition from the lit walkways to the relatively dim planting areas. It should be noted that these calculations do not included the contribution the of the interior illumination from the surrounding buildings which is likely to increase the ambient level of brightness across the square.

In addition to validating the experiences of light and darkness within the space these calculations also show the significant decrease of light pollution from the proposal as compared to the current lighting scheme. This was measured by calculating the Upward Flux Ratio (Ruf) which takes into account the direct upward luminous flux emitted from the luminaires as well as the light reflected upwards from the ground and surrounding surfaces. In a hypothetical ideal situation the Ruf value is 1. The larger the Ruf value the higher the degree of sky glow is (The International Commission on Illumination, 2017). The current lighting scheme produced a figure of 7.64 which is above the upper limit for Environmental Zone 2 while the proposal has reduced this by more than 70% to 2.13.

This demonstrates that the patterns that lead to high quality light are often complimentary to providing opportunities for natural darkness to be more present in outdoor environments.

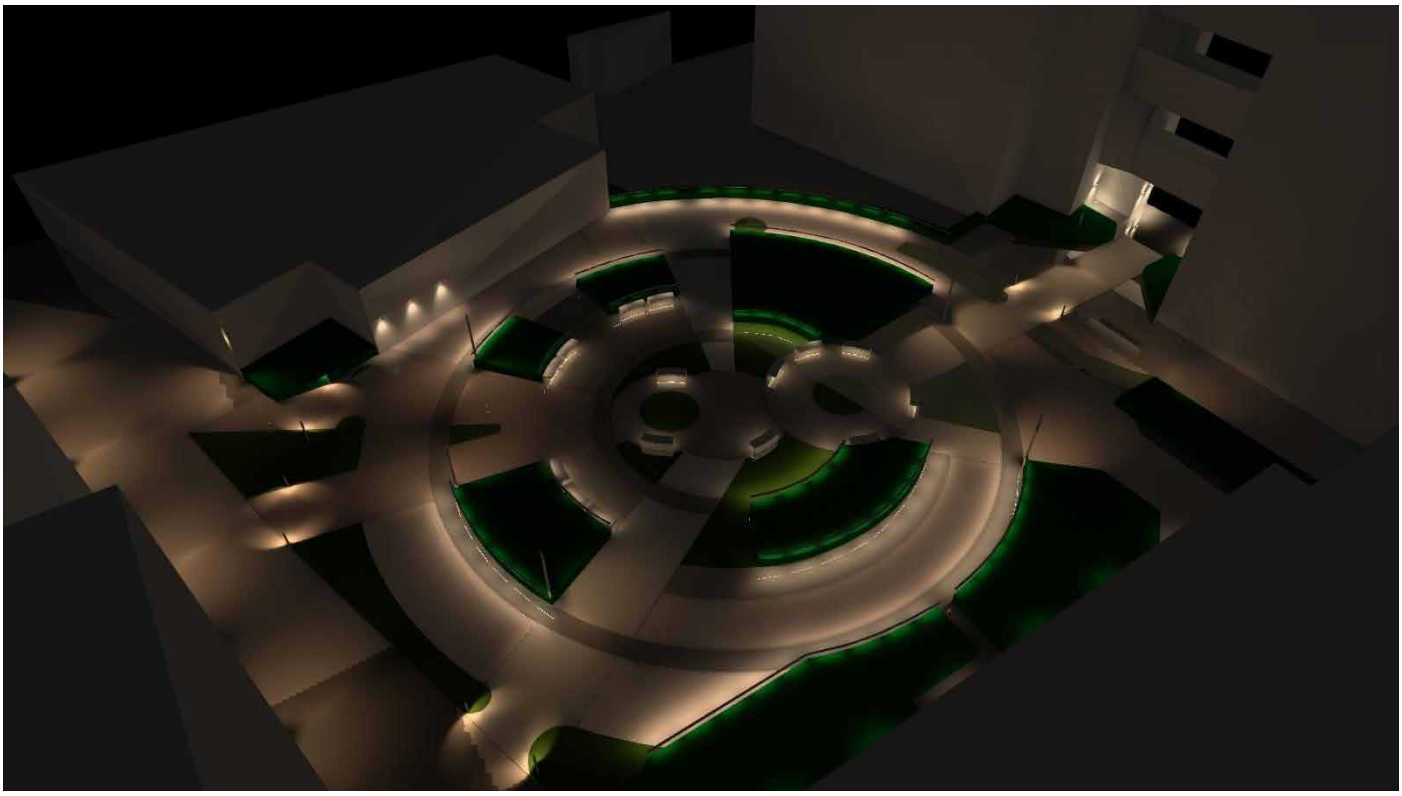

Figure 31 - DIALux Calculation of new lighting design proposal for Doddington Square, self produced 2025.

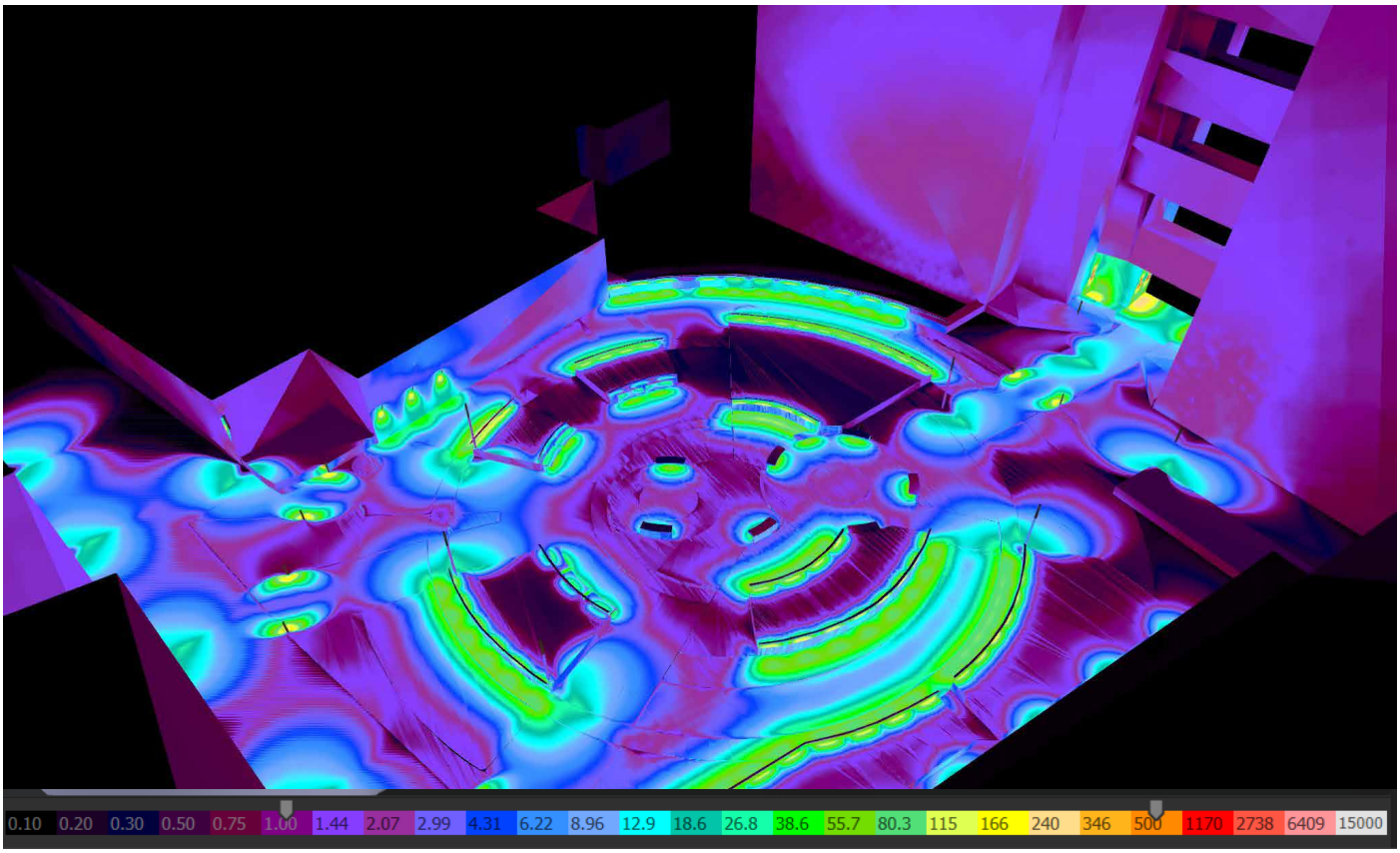

Figure 32 - False colour mapping of illuminance of new lighting design proposal for Doddington Square, self produced 2025.

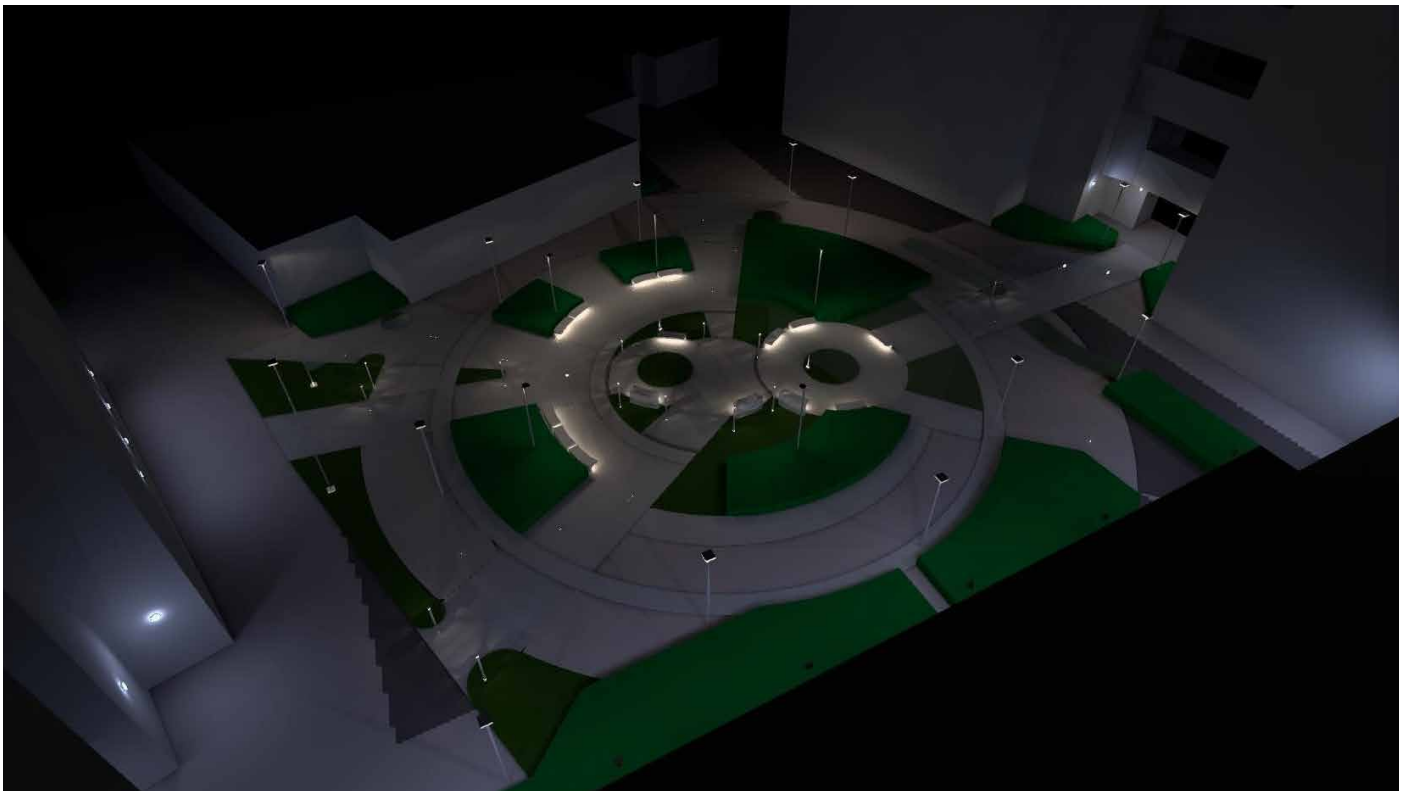

Figure 33 - DIALux Calculation of existing conditions at Doddington Square, self produced 2025.

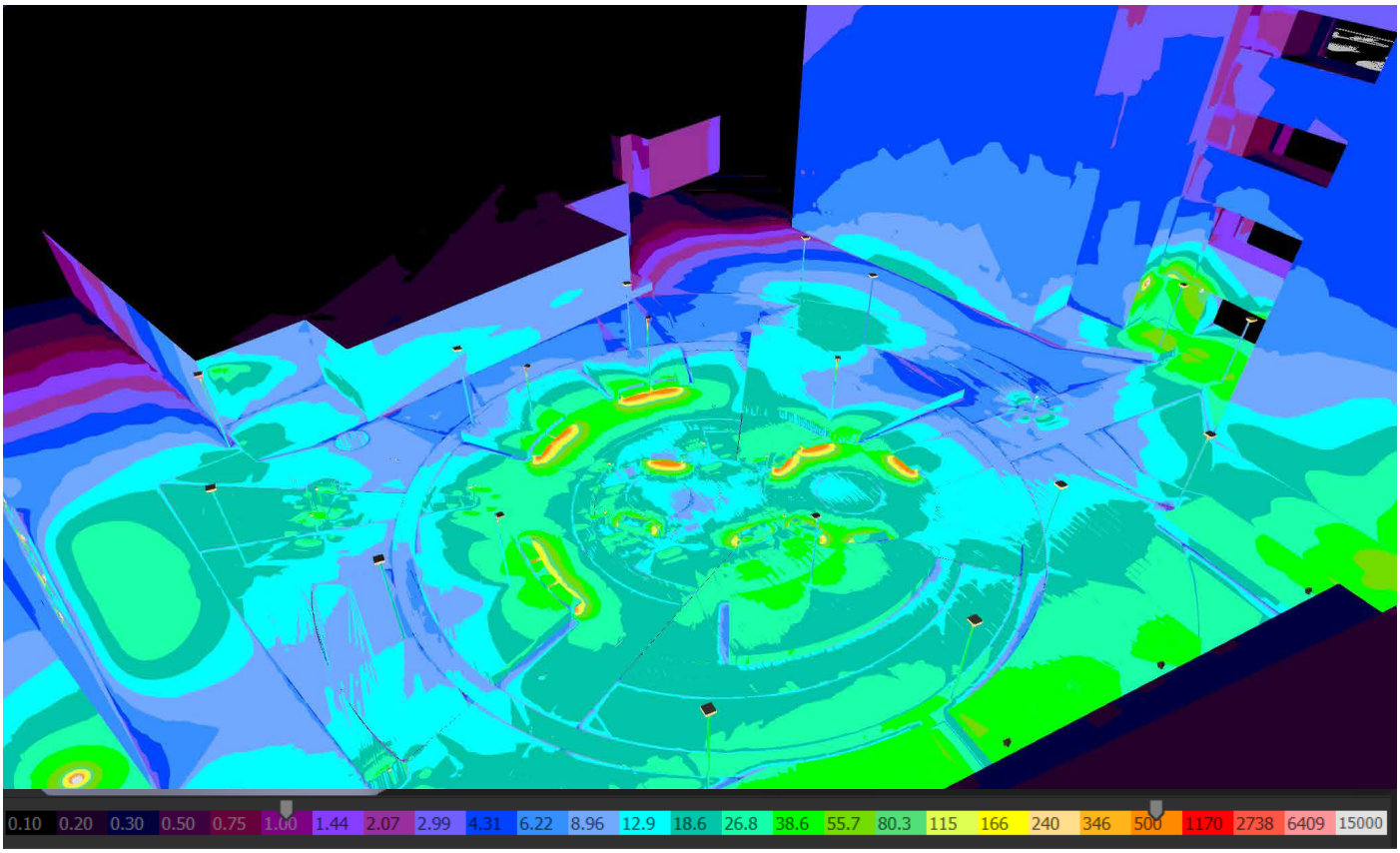

Figure 34 - False colour mapping of illuminance of existing conditions at Doddington Square, self produced 2025.

Creating the conditions for an emergent space

The result of an emergent design process, should itself allow for emergence. Design-for-emergence aims to be non-prescriptive, to allow for composability by the user as well as continued evolution in unpredictable ways. This thesis seeks to understand if lighting design can contribute to an emergent public space. The design proposal aims to achieve this in two ways. Firstly, by providing a nighttime experience of Doddington square that provides different atmospheres that may allow for people to use the square in more ways, as seen above. And secondly through integration of a control system that is intended not only to reduce energy consumption or reduce intrusive light by shifting with the astronomical clock, but also to allow for change in how a space is used as it evolves.

The control strategy that is included, asserts that the design proposal may not get it exactly right. An emergent lighting design should provide the physical infrastructure as a base, while the control strategy allows for adaptation to the real circumstances of a place. It provides room for the community to experiment to find what fits, now and at different times of year when the space is used differently, to create different atmospheres for one off events, and to adapt as the community adapts. Cities and communities are complex adaptive systems where all 'agents' (people, community, ecology, physical structure) change as they interact with each other, 'you have to move and adapt within a system that is in a constant state of movement and adaption.' (Yunkaporta, 2020).

To assess the effectiveness of this strategy to use a balance of light and darkness to create an emergent public space could only be done, in situ, with the community, over time. Because of this the presented design proposal could only be seen as the first step.

Strategies of continued engagement such as those explored in the ENLIGHTENme project could be employed, including workshops and 'walkabouts' that enable in-situ observation and discussion of local settings (Tondelli, S., Conticelli, E., Marzani, G., Kozlova, I., Slater, D., Bordonaro, E., McDaid, D., Burton-Page, M., Van Der Pol, J., & Brons, J., 2025). Importantly this is something that should be undertaken not only during the initial design process but also beyond installation. This presents lighting design as an ongoing service rather than a one-off intervention.

Acknowledgment of limitations

While it was extremely beneficial to have information that was gathered from a large group of local residents to inform the design proposal, due to the limitations of time and resources available for this project, it was not possible to engage with the local community beyond this in the ways that this thesis suggests is necessary. This allowed the design to only progress to a design proposal phase. To develop it further and maintain the view of this thesis the following stages would require a time frame and level of engagement beyond what was feasible within the scope of this thesis.

Additionally, while the nighttime experience of the square is lacking in the ways already discussed, the daytime experience of the square, was improved by the redevelopment. From the information gleaned it is evident that there was a significant contribution from local community groups in acquiring the funding and getting the redevelopment implemented. This presented significant reservations about approaching the community to point out the flaws in the lighting due to this effort, particularly when it would not be accompanied by any solutions of a route towards funding or strategy for implementing any improvements.

Discussion & future works

Introduction

This project began with an appreciation of natural darkness, its inherent values, and the risks associated with losing it. The aim was to explore the balance of light and darkness in cities, where human and others' habitats are intertwined, and these opposing needs are most in conflict. The values of darkness are expansive and range from the practical and the economic to the ecological and social. When you combine this powerful list of the values of darkness with the fact that light pollution continues to increase year on year, wasting energy, and negatively affecting ecology and human health it is clear that we need to preserve and restore natural darkness.

To understand how cities might move towards the inclusion of natural darkness it was necessary to understand why cities introduce light. The reasons are many and varied and include the fulfilment of functional, social, economic and aesthetic needs of citizens. Cities are made up of many smaller typologies of place that each need light for a balance of these different reasons. And within each typology of place there is a unique community that brings its own needs and wishes for the nightscape of their particular place.

The lens of complexity theory provided an invaluable perspective from which to explore this nuanced topic and the idea of design-for-emergence became an essential tool within the design process and a vision for the design outcome.

One of the fascinating things about complex adaptive systems, is that they are everywhere. Once you start to identify their characteristics it is apparent that the human body is a complex adaptive system, our communities, our cities and our ecology, all are complex adaptive systems. Although complex adaptive systems are challenging to describe in isolation, they are easy to understand through analogies. Through the process of exploring the patterns of complex adaptive systems another analogy emerged, that reintroducing darkness into the ecosystem as an emergent act could have many positive effects across the entire system.

There are a number of very well documented cases where a single element (often a native species that has disappeared due to human activity) is reintroduced into the complex adaptive system of an ecosystem with unimaginably broad positive impacts emerging throughout the system. The reintroduction of wolves to Yellow Stone National Park, is one of the most well know. This single intervention saw a cascade of benefits, from the re-emergence of other previously declining species to the reshaping of rivers (Fortin et al., 2005). On a much more local scale, here in

London there is the Ealing Beaver project. A busy town in north London, struggled every year with flooding at the main train station that sits in a slight dip in the road, constantly causing delays, road closers and a general nuisance. Plans were made for complicated infrastructure works, involving lots of concrete damns and an arduous maintenance schedule. Through some fortuitous timing and staunch advocacy, the concrete didn't come to pass. Instead, in a park beside a busy road and a shopping centre, a habitat was fenced off and a family of beavers were introduced. The beavers built the damns, and they maintain them. It has only been 2 years, the flooding has stopped and the ecosystem all around the beaver habitat (which the public is free to stroll through and enjoy) is thriving (Ealing Wildlife Group, 2025). It had only been 400 years since beavers were native wildlife in this place, nature didn't take much convincing to welcome them back.

Natural darkness is also something we've only recently (in an evolutionary time frame) removed from the ecosystem, what are the cascade of effects that will emerge if we find more ways to reintroduce natural darkness - in rural areas, and dark sky reserves, yes, but also, like the beavers, right in the centre of town.

This thesis asked the question if design-for-emergence could help to introduce a balance of darkness and light in urban settings and through doing so identified that if cities are to move towards the inclusion of natural darkness, a focus will need to be placed on 1.) The quality of the light they are providing and 2.) How they are engaging people in the design and evolution of their public spaces after dark.

The quality of light

This thesis used an understanding of complexity theory and how it relates to cities to place light and darkness within the complex adaptive system of shared urban spaces and the life that happens there. This reinforces the idea that lighting design is inherently context specific. It is ineffective to design with light and darkness outside of the physical, social and ecological contexts they sit within. As part of a relational network these elements (and more) are constantly shifting and adapting as they interact with each other. To design high quality lighting solutions, we must work with and from within these systems.

The current landscape of guidelines and regulations relating to light and darkness presents a gap in knowledge on how to achieve this balance as they do not always relate to the nuanced typologies of places that exist in cities. Guidelines, particularly around light pollution, are often written in a way that is broad enough to apply them to any context. In contrast, to enable lighting regulations to be communicated with specific figures as targets and limits, their context is made extremely narrow.

Applying the idea of design-for-emergence to both the process and the outcome of a lighting design case study aimed to explore how to bridge this gap. Rather than designing an end result design-for-emergence aims to design the building blocks or create the conditions to allow users to define and evolve any number of outcomes. When looking at design-for-emergence in the process of this case study, the view was taken that guidelines and regulations could be seen as the building blocks of a lighting scheme. That light (and how it interacts with natural darkness) is one of the building blocks that allow atmospheres to emerge in a space and that atmospheres provide the conditions that influence how people will feel in, and use, a place.

The designer is the 'user' of guidelines and regulations, and can combine these building blocks to create a site-specific palette of guidance for a project relating to the specific context. By going through this process in the case study it became clear that it was necessary to cast a wider net to find relevant guidance. Current research, along with regulations and masterplanning documents were referenced to find the patterns of how light could be used to foster the desired atmospheres.

Many of the patterns for providing quality light in this context, align with the guidance for how to preserve natural darkness, demonstrating that these are not contradictory factors, but in fact complimentary. Providing positive experiences of light, also makes room for positive experiences of natural darkness.

This project is just a single example of this concept. If this process was repeated many times across many projects where light and darkness were considered within the physical, social and ecological context, it may be possible to see the patterns emerge further, and as a profession, to grow, a more refined palette of guidelines that do relate to the nuanced typologies of places that exist in our cities.

The elements from the guidelines, regulations and research that were used in this case study tended to be 'rules of thumb' more than specific figures, as context specific figures are not known. Again, if this process was repeated many times and the results recorded it may also be possible to see patterns in the numerical data, which could support the creation of numerical ranges to be included in future regulations that better represent how the light we introduce to our cityscapes shapes our experience of these places at night.

Engaging people with light

The intent of this thesis was not only to employ emergence in the design process but also to produce an emergent space, where positive experiences of light and darkness create the conditions for life to emerge and continue to evolve in a shared public place.

If we want the interventions we take in our public spaces to have meaning they have to be taken with the community who lives in and uses these places. The viewpoint of light and darkness as part of the complex adaptive system of our cities and communities also reinforces the need to engage with the local contextual knowledge of the people who live in a place. Before any site-specific guidelines are draw up the social context and the vision of the local community must be explored, as this is what makes each site, specific.

Public light has not been something people generally feel they have much control over, it is the remit of municipalities, or alternately a display of commerce and capital. When something is presented as unchangeable, we can be inclined not to think about if, or how we would like to change it. It will take time and intention to continue the work of projects such as ENLIGHTENme that aim to bring an awareness to the public about light, and how these elements impact our places. To evolve a shared vocabulary for what we might like to see achieved with light, to move away from the notion that more light is safer and move towards an understanding that site-specific light is safer, as well more beautiful, more conducive to supporting social cohesion and a piece in the puzzle of protecting and restoring our ecology.

By engaging people directly in the development of their space, understanding the atmospheres that are desired and using the balance of light and darkness to support these atmospheres we can create nighttime experiences of shared public places that are non-prescriptive, and allow for emergence through use.

Design-for-emergence

The final insight that complexity theory provides in this thesis is that complex adaptive systems are dynamic and always in a state of change and evolution as the different elements interact with each other. Emergent public places are not static, they change and evolve, as different people move in, community priorities shift, and any number of other variables interact. Light, unlike most other construction materials in the public realm, does not have to be static. The fact that more advanced control systems for city lighting are becoming ubiquitous allows for light to evolve with a place.

Communities may continue to have input on and affect the nightscape of their shared public spaces. There is room to try things out, to play with the space and find out what makes it work for that community at that time and change if change is wanted. This should incentivise municipalities to think about lighting as an ongoing service, not a one-off installation. By allowing a community to control the nighttime experience of their shared public spaces, these places might evolve to meet the wishes of that community – to provide an inviting place to walk and play, a peaceful place to rest, or somewhere that can facilitate events and activities, it may even allow these places to emerge as the 'heart of the community,' that they are always intended to be.

A vision of supporting cities to move towards the inclusion of natural darkness, is unlikely to come to fruition through a solely top down or regulatory approach. Instead, we should trust that if communities are given the opportunity to experience and play with light and darkness in context, that the inherent qualities of natural darkness will present themselves. Through this appreciation, a balance of light and darkness could be achieved in our cities that is conducive to the creation of vibrant shared public places and the preservation of our ecology.

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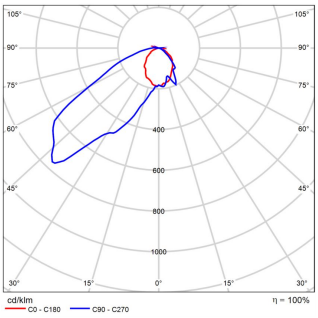
Appendix

Luminaire specification

DW Windsor - GAR 1200 12LED

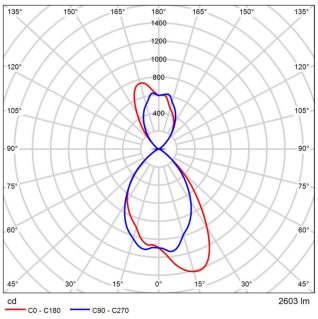
Article No.	Garda 1200 - 12LED-16W-3k- Asymmetric
P	16.0 W
Φ_{Lamp}	821 lm
$\Phi_{Luminaire}$	821 lm
η	99.99 %
Luminous efficacy	51.3 lm/W
CCT	3000 K
CRI	100



Polar LDC

FAGERHULT - Rondo G3 wall twin wide 830 CLO

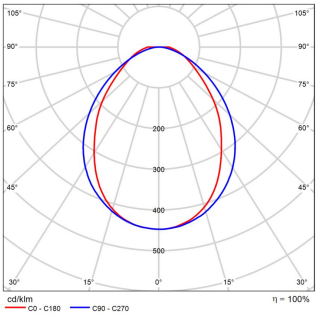
Article No.	308040
P	28.0 W
Φ_{Lamp}	–
$\Phi_{Luminaire}$	2603 lm
η	–
Luminous efficacy	93.0 lm/W
CCT	3000 K
CRI	80



Polar LDC

LED Linear - XOOLINE IQ White HYDRA HD12 W922-W940 DH-C004 IP40 1000

Article No.	W922-W940
P	12.0 W
Φ_{Lamp}	1033 lm
$\Phi_{Luminaire}$	1034 lm
η	100.12 %
Luminous efficacy	86.2 lm/W
CCT	2900 K
CRI	95

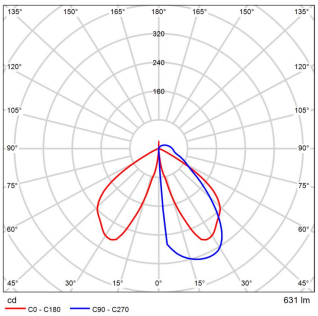


Polar LDC

Appendix

Louis Poulsen - Flindt Bollard 800mm Alu LED 2700K 12W CLO

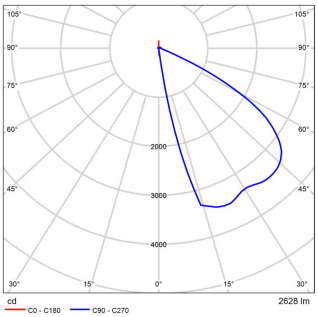
Article No.	91608-1011
P	12.0 W
Φ_{Lamp}	–
$\Phi_{Luminaire}$	631 lm
η	–
Luminous efficacy	52.6 lm/W
CCT	2700 K
CRI	80



Polar LDC

Louis Poulsen - Flindt Plaza Aluc LED 2700K 33W 60D pos.30

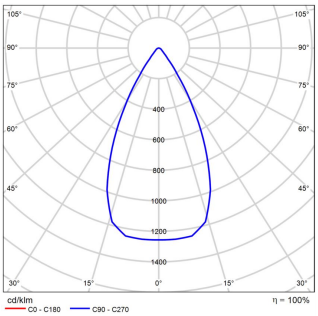
Article No.	91813-1038
P	33.0 W
Φ_{Lamp}	–
$\Phi_{Luminaire}$	2628 lm
η	–
Luminous efficacy	79.6 lm/W
CCT	2700 K
CRI	80



Polar LDC

Mike Stoane Lighting - MSL_Frog Type X_9.8mm Xicato XOB_90CRI_3000K_1513lm_Wide Flood

P	11.9 W
Φ_{Lamp}	1041 lm
$\Phi_{Luminaire}$	1041 lm
η	100.00 %
Luminous efficacy	87.5 lm/W
CCT	3044 K
CRI	97



Polar LDC

Glare evaluation according to RUG