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RESEARCH

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Do We Need a Lighting Detox for Sustainable Cities in the 21st Century?

This article looks at relearning our connection to light and dark in context of sustainability, climate change and urban lighting.

In the context of the current climate change emergency caused by greenhouse gases emitted by human activities [1] and recent natural disasters such as hurricanes, typhoons, floods, droughts, or wildfires - sustainability defined as "the quality of causing little or no damage to the environment ..." [2] should be an important aspect to be addressed by sustainable cities.

Since the establishment of the 17th Sustainable Development Goals (SDGs) [3], which includes 169 associated targets by the United Nations General Assembly in 2015, various perspectives on sustainable cities have been developed and adopted in order to achieve a better and more sustainable future for all.

However, after review, these goals appear to be limited, as they haven't taken into account the growing body of results from lighting-related research in diverse fields such as: environmental sciences, biology, medicine, and astronomy on the impact of light pollution from outdoor illumination, especially the effects caused by new LED light sources on humans, flora, and fauna.

When the 2014 Nobel Prize for Physics was awarded for the "invention of efficient blue light emitting diodes [LEDs], which enabled bright, white, energy saving light sources" [4], the general public gained the impression that this new lighting technology would contribute to a more sustainable future for cities. As municipalities around the globe quickly convert their current functional and decorative external lighting to LED in an attempt to conserve energy and save money, other key factors are overlooked.

Although, the World Economic and Social Survey 2013 addresses energy efficiency as an environmental management pillar for sustainable cites [5], nevertheless, Our Common Future, also known as the Brundtland Report, published in 1987, defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." [6] This means going beyond energy savings by addressing additional elements. Also, the Rio Declaration on Environment and Development from 1992, which was seen as a guide for future sustainable development of countries and cities in principle 4, states that "In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it." [7]

Until recently, not many people related outdoor illumination as an indirect contributor to environmental degradation and climate change, but recent studies and environmental reports link them together. For example, burning fossil fuels, which is a main contributor to global warming, has an impact on Earth's increased temperature, and the use of fossil fuels has been used to produce electricity for outdoor illumination (up to 20% of the world's electricity production is consumed by electrical light sources) [8]. Urban illumination (compared to rural areas with no outdoor lighting) directly impacts the climate change in cities, with spring seasons commencing earlier as the photoperiod of illuminated trees and plants is extended and their leaves bud prematurely [9]. Also, they do not lose their leaves in time for winter. This causes them to get weaker and less healthy, so they become an easy target for climate change flooding and pests. The health of trees and plants is important because they play a critical role in cities, counteracting air pollution by converting carbon dioxide into breathable air [10], they also reduce noise, lower the urban heat islands in cities, and they create important ecosystems for various organisms such as birds, insects, and mammals such as bats. The nighttime outdoor illumination of streets, buildings and urban parks also attracts insects and hastens their decline [11]. Many of these insects are crucial for the pollinating process, and without this process humans and ecosystems would not survive as 80% of food production requires pollination by other living organisms [12]. Exposure during the nighttime to blue-rich white light has numerous adverse effects on the environment, leading to problems with reproduction, the avoidance of suitable habitats, changes in seasonal migration routes and a reduction in numbers or even the extinction of certain species. Various animals

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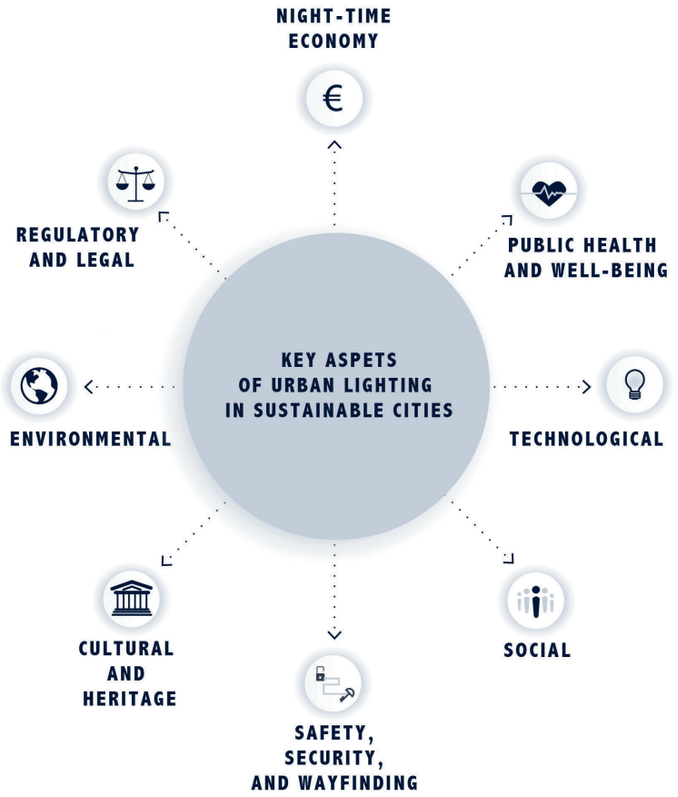

Figure 1. Eight key aspects of urban lighting in successful sustainable cities identified by online interviews performed by the author [27].

> "Sustainable cities at night means carefully balancing the benefits that artificial light provides, both socially and economically, whilst ensuring we minimise any potential damage to the planet."
>
> Mark Major, Speirs Major

like birds are attracted towards artificial lighting during migration periods, resulting in collisions with buildings and structures that can cause injury or death. Recent data indicates that around 600 species of breeding birds have been lost in European Union countries between 1980 and the present day [13]. Fish like young salmon migrate through streams, rivers, and estuaries to the ocean. These fish migrate at night cued by illumination levels, and this timing is designed to reduce predation. When attracted to illuminated urban bridges, fish become an easy target to predators such as birds and other animals, and as a consequence, their chances of survival are greatly reduced [14-15]. Nocturnal animals such as urban bats can also be negatively impacted by exterior illumination as this causes a delay or prevents the emergence from their roosts, affecting the feeding behaviour, and changing commuting and foraging routes [16]. Bats are important nighttime natural predators (insect hunters), as they make it possible to limit the use of toxic insecticides in agriculture and forests, and their presence indicates a strong, healthy, and stable natural ecosystem [17]. Also, improperly designed outdoor illumination of human settlements such as seaside condominiums, houses and hotels along beaches discourages female sea turtles from nesting, and it attracts young sea turtle hatchlings away from the sea, which decreases their chance of survival [18]. All of this can directly contribute to biodiversity loss, which is crucial for human existence and wellbeing [19-20]. The Living Planet Report, published in 2020 by The World Wildlife Fund revealed that in the last half century, vertebrate species have declined by an average of 70% [21]. It is also believed that new LED technology with high emissions of blue wavelengths of light might be the potential origin of certain chronic diseases in human beings, including cancer [22]. Today, 83% of the human population lives under light polluted skies [23], and the blue component of outdoor lighting increases light pollution much more than older lighting technology (the S/P ratio of 4000K LEDs shows they increase light pollution by 170%), completely prohibiting urban astronomy [24].

Urban lighting in sustainable cities

I have identified eight key aspects of urban lighting in sustainable cities, based on my research: Social; Safety, Security and Wayfinding; Cultural and Heritage; Environmental; Regulatory and Legal; Nighttime Economy; Public Health and Wellbeing; and Technological (Figure 2). Many of these aspects have not been taken into consideration by the UN Agenda 2030 [25]. Therefore, it is proposed that the goal SDG 11 Sustainable Cities and Communities: Make cities and human settlements inclusive, safe, resilient and sustainable [26] is updated to address these key aspects, including the mitigation proposals for the numerous adverse impacts caused by artificial lighting at night (ALAN) on public health, wellbeing, and the environment.

Social

Urban lighting should support the active use of public spaces in cities by residents and visitors during the evenings and early nights, by improving its liveability and social relationships within the urban community, regardless of gender, age, race or economic status.

Safety, Security and Wayfinding

Urban lighting should provide safety and visual reassurance in cities for elderly residents and visitors, supporting their orientation and wayfinding by guiding them around outdoor environments and public spaces with the help of appropriate lighting.

Cultural and Heritage

Decorative urban lighting should facilitate appreciation for the cultural value of the built heritage via the sensitive illumination of buildings façades, monument, structures, and artefacts to give them identities after dark.

Environmental

Urban lighting should respect not only human needs but also the natural environment including flora and fauna by reducing light pollution, and questioning what kind of urban illumination is needed, as well as where it is needed and when. It is also important to preserve humanity's right to have visibility of the dark night sky and celestial bodies as an ancestral global common, and to also enable continual professional and amateur nighttime observations.

Regulatory and Legal

Urban lighting should be properly regulated in the form of soft and hard laws, and it should also be monitored in order to counteract artificial light pollution and its negative impact.

> "Light pollution is the most visible indication of a city's commitment to sustainability. To be considered "sustainable", cities must also take steps to use light at night more responsibly."
>
> Ruskin Hartley, International Dark-Sky Association

Nighttime Economy
Urban lighting should support nocturnal activities including tourism, retail and hospitality.

Public Health and Wellbeing
Properly designed urban lighting should take into consideration public health and wellbeing by avoiding over illumination, light trespass into the windows, balconies and gardens of residential properties, and glare, all of which can desynchronise circadian rhythms, resulting in insomnia and hormonal imbalance.

Technological
Urban lighting should save energy by using energy efficient light sources, along with luminaires that integrate proper optical design, have an appropriate light spectrum, and employ smart lighting control systems. Also, it should include aspects such as a circular economy, and the re-use and recycling of lighting equipment. Moreover, urban lighting should apply other forms of natural and inexhaustible energy such as solar energy to power the outdoor illumination of our cities.

Lighting Detox required

Currently, there seem to be an uncoordinated explosion of vividly coloured and bright outdoor illumination on building façades, in parks, and in the streetscape of many cities around the world. Many urban planners and architects appear to have discovered the new design possibilities of this new medium, overlooking the importance of thinking holistically about environmental aspects. And some lighting professionals may be unaware of the negative impact their urban illumination can cause, if not properly designed, which necessitates a serious rethink of their design approach. Unfortunately, the new knowledge of the impact of artificial lighting on humans, flora, and fauna is rarely available to them, the reason being that researchers work in isolation and do not share the findings of their scientific work with those who design cities and the lighting. However, some luminaire manufacturers recognise the importance of collaborating with researchers and lighting professionals and the need to develop new tools, as well as lighting solutions to support the safety and wellbeing of humans, flora, and fauna. Yet this process to develop appropriate solutions is not immediate. And although responsible lighting advocates are informed and knowledgeable about the various challenges, they are rarely invited to be part of the design process. Although city representatives are aware that they need to make choices that are beneficial in a long run, not only for people, but also for nature and animals, the process to coordinate all the stakeholders involved can often be overwhelming and complex.

With the recent climate change emergency and environmental degradation, it is now urgent to apply different than traditional, people-centred development approaches. To protect the future of humanity, planet Earth, and to transform our world into a healthier environment, a new paradigm shift in the form of Lighting Detox (Detoxing from too much applied light in our urban and natural environments) is urgently required.

In December 2021, the UN Human Rights Council recognised for the first time, that having a clean, healthy and sustainable environment is a human right [28]. So, other targets could possibly be included into the Sustainable Development Goals, such as protecting access to dark skies and reducing light pollution in order to preserve this common ancestral heritage shared by humanity, as well as helping safeguard the health and wellbeing of humans, flora, and fauna by the application of responsible outdoor lighting at night (ROLAN) or no exterior lighting in Urban Natural Areas, such as parks and open spaces in any city, which are not only essential for humans, but for many other species too.

> "The quest for brightness seems never ending. It is like a drug we are craving. A lighting detox for all cities seems to be necessary."
>
> Kristin Bredal, Director, Zenisk

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