Maps of light pollution in odd places: Are night time satellite pictures making us to forget natural darkness?

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Received 26 Feb 2020, Accepted 07 May 2020

Abstract

Advances in remote sensing have proved to be highly valuable for light pollution research and awareness raising. Maps based on night-time satellite data can be used in communication campaigns aimed at improving awareness among policy makers and the general public of the extent and effects of light pollution and to justify appropriate management actions. However, visually appealing maps are also used in other communication settings. This article reviews different uses of light pollution maps and discusses the societal implications of such uses. Based on examples of light pollution maps in different communication settings not directly related to the light pollution debate, the review proposes that the relatively wide popularity of light pollution maps may strengthen impressions of an artificially illuminated night environment as the normal baseline for human experience. This contributes to the loss of experience of natural darkness, possibly leading to generational amnesia complicating the management of light pollution. Multiple uses of light pollution maps and other visualizations should be taken into account when campaigns and policies aimed at supporting sustainable lighting are planned and implemented.

Keywords: communication, framing, loss of experience, representations, shifting baseline syndrome

1 Introduction

"But first and foremost, it makes you feel so sad when all you can see is orange and grey mulch instead of complete darkness and the magnificent starry sky of the archipelago that you were expecting to see."

"Nowadays, city dwellers do not necessarily have any experience of the vastness of night sky filled with stars."

These comments emanating sadness and helplessness about decreasing opportunities to experience natural darkness and increasing light pollution were presented in an online survey charting public views of light pollution, conducted in Finland during winter 2011/2012 [1]. Such comments illustrate common sentiments among those people who are worried about the loss of opportunities to experience pristine night skies and a nocturnal environment free of artificial light [2, 3]. However, many other people pay little or no attention to the lack of natural darkness or welcome additional lighting without any further considerations for potential detrimental ecological or health effects, even though such effects are increasingly being highlighted by research [4-7]. At the same time, new energy-efficient, reasonably priced and easy-to-use lighting technologies are encouraging more wide-spread use of lighting. Installation of outdoor lighting based on light-emitting diodes (LED) is favored in lighting strategies and guidance at local, national and international level. For example, the European Commission assumes that "widescale LED usage will help to significantly reduce energy consumption" [8]. Considerations regarding the potential increase of light pollution have received little, if any, attention in these policies. Furthermore, a rebound effect may undercut the purported energy savings and reductions in greenhouse gas emissions: low-cost LEDs may lead to increased use of lighting, and new areas may become lit [9].

Artificial light undeniably brings benefits for human well-being and new technologies allow—at least in principle—more efficient minimization of the harmful effects of lighting [10]. For example, so-called intelligent lighting can automatically turn off or dim lighting in the absence of users benefitting from artificial illumination.

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A wide variety of low-tech measures are also available, such as avoiding installation of unnecessary lights, careful direction of outdoor lighting, limiting the time and area lit and selecting lamp types with optimal spectra [11]. However, despite all these opportunities, the emissions of light energy into the night environment continue to increase in most countries. Analysis of satellite data indicates that even in sparsely populated countries such as Finland, light pollution is widespread and has increased during the past decades [12, 13].

Gradual accumulation of data from remote sensing, together with advancing computing and modelling technologies allow the production of light pollution maps that can be used to monitor, assess and communicate the development of the light pollution situation. Maps based on satellite data can be useful despite problems such as calibration of the measurements over time, over-saturation caused by brightly lit areas and difficulties in interpretation caused by snow cover. The most pressing problem is the relative insensitivity of the VIIRS-DNB (Visible Infrared Imaging Radiometer Suite Day-Night Band) data to the blue peak (~0.45 μm) of the wavelength of white LEDs [14]. This makes the widely used satellite data blind to a significant fraction of the light emissions from an increasingly popular outdoor light source. Therefore, comparisons based on map data describing situation before and after LED retrofits may create a false impression of successful light pollution abatement especially if the target audience of communication is not aware of the limitations of map representations.

Light pollution maps have been often used in communication campaigns aimed at increasing public awareness and policy action. These campaigns have been launched in several countries and they have often focused on the aesthetic value of dark night skies, while economic, health and ecological effects have received less attention. There are some examples of campaigns that have had at least some success in terms of increased media coverage or public awareness and attitudes and in some cases the campaigns have induced the development of new guidance or local level ordinances, regional or even national laws aimed at curbing light pollution [15, 16]. For example, local level projects have been implemented to protect ecologically sensitive areas such as nesting beaches of sea turtles [17] or important sites for astronomical observations and to develop dark-sky tourist destinations [18]. However, if compared with environmental problems such as climate change or biodiversity loss, public awareness and policy actions related to light pollution remain marginal [19]. Even if compared to noise pollution, less legislative, administrative, policy and public attention has been paid to light pollution, despite the similarities between these two issues. Both are easily observable, wide-spread, energy-related issues with considerable environmental and health effects.

There is a clear need for better societal recognition of the harmful effects of and opportunities to curb light pollution. This review focuses on the roles of light pollution maps from the perspective of visual communication. More specifically, the focus is on potential unintended effects of map-based visual information. Research on visual communication is increasingly important because the possibilities in terms of producing impressive visualizations and communicating using them are rapidly improving due to developments in information and communication technologies. Maps, photographs, graphics and infographics, comic drawings, visual "memes" on social media and various other visualizations are already an essential part of societal processes that raise public attention and inform, frame issues and create emotional reactions and awareness that stimulates action—or justifies inaction [20-22]. The proliferation of online visual awareness materials may lead to attention fatigue or it may induce "slactivism" i.e. superficial advocacy restricted to digital environments. Such risks should be taken seriously, even though the available evidence suggest that digital activism is likely to catalyze off-line political and social action [23].

Despite its increasing societal relevance, visual communication remains a relatively little studied area of science communication [24-26]. This is partly explained by the lack of easily accessible digital archives of visual materials and partly by research traditions favoring the analysis of written text. This article presents a short review focusing on selected examples illustrating different uses of light pollution maps. The examples were collected by following the approach of purposeful sampling of qualitative data [27]. The aim was to identify a set of examples illustrating different contexts of communication. The materials range from science-based reporting and environmental campaigning, TV news and documentaries aimed at wide audiences, to edutainment combining education and entertainment and fiction aimed at attracting attention and generating commercial profit. The examples were collected in a northern European context characterized by the extensive infrastructure of an affluent economy, extensive use of artificial lighting and manifold opportunities to be exposed to information from multiple sources, including both electronic and print media.

The review is by no means exhaustive and further studies are needed to explore the situation in other contexts. The examples presented here are not given with the aim of providing a systematic and comprehensive overview but to concisely illustrate the variety of different types of uses and use contexts of light pollution maps. Importantly, the use of light pollution maps in education and communication campaigns specifically aimed at increasing public awareness of light pollution is excluded from this review since the aim is to analyze the usage of the maps outside the light pollution debate. This approach also aims to identify those uses that may be

considered unexpected [28]. Furthermore, different awareness-raising and education campaigns focusing on light pollution are studied elsewhere [e.g. 15, 29].

The following section presents selected examples of the use of light pollution maps, followed by a discussion proposing that light pollution maps may contribute to the processes of shifting personal and societal baselines and extinction of experience. Finally, conclusions summarizing the key implications for the use of light pollution maps are presented.

2 Different uses of light pollution maps: selected examples

Examples of the public use of night-time satellite maps of light pollution are easy to find. A Google image search with the search term "light pollution" gives a long list of images, mainly of two types: visually impressive pictures of densely populated and intensively illuminated cities and map visualizations based on night-time satellite pictures showing upward flux of artificial light from a certain area, such as a city, country or continent. Notably, many of the images currently shown among the top results by Google search are NASA "Black Marble" imagery from the DMSP (Defense Meteorological Satellites Program) era, which is now considerably out of date [30]. This indicates that visually impressive but outdated maps may remain widely used if the images are in the public domain and easily accessible. Many of these maps are published on web pages discussing the extent or effects of light pollution. However, despite producing an impressive amount of hits, a simple Google search does not capture the full diversity of online usage of light pollution maps and completely misses other contexts of communication. In order to illustrate this diversity, Fig. 1. presents a review of selected examples of uses of maps of light pollution picked from communication contexts outside the light pollution debates. The review includes both online content and other communication contexts.

First, panel (a) in Fig. 1. gives an example of the use of night lighting in a cover of an online report published by Eurostat and aimed at delivering an overview of the key trends and current status of energy issues in the European Union [31]. The illustration equates night lights with a visible manifestation of energy use in Europe, although night lights are more suitable proxy indicator for energy use for the countries of the Global South [32]. The main title of the report employs an analogy of illumination as something that eradicates ignorance: "Shedding light on energy in the EU". Thus, the wording of the title and visualization of the cover create a reinterpretation of the deeply rooted narrative of enlightenment [33]. Intended or not, this is likely to create positive framings of artificial lighting. Such framings are likely to be strengthened by the expectations of economic benefits and energy savings from new lighting technologies. At the same time, the ostentatious display of light at night is still considered a sign of success and progress [33, 34]. Such framings fail to recognize light pollution as a potential health issue or an emerging environmental issue [19]. Interestingly, despite widely covering energy issues and describing various other environmental effects of energy production, the extensive report does not even mention the term light pollution. This can be interpreted as indication of how the decorative use of night-time maps disregards the informative content of carried by the maps.

Other cases of this kind of use of light pollution maps exist in energy literature. A particularly telling case is a book entitled "Keeping the lights on: Towards sustainable energy" published in 2007 [35]. The cover of this book presents a light pollution map of the world but the book itself fails to mention light pollution, even though sustainable energy is the key issue of the book. This omission frames light pollution as an acceptable form of energy waste. Such framing is nowadays even more easy to make because of energy efficiency improvements and the expansion of allegedly pollution-free renewable energy sources. Furthermore, such visual depictions of omit not only the monetary cost and environmental effects of light pollution but also negative aesthetic and safety effects.

The use of eye-catching light pollution imagery aimed at improving the visual appeal of communication is relatively common in environmental reporting aimed at larger audiences. Panel (b) in Fig. 1. gives an example of the use of light pollution maps in an animated video aimed at promoting an extensive state of the environment report published by the European Environment Agency [36]. The one-minute video includes two sequences with night-time maps of Europe as a background, illustrating the geographical focus of the report. The report consists of nearly 500 pages and it comprehensively addresses environmental issues such as noise and preservation of naturally quiet areas but does not mention light pollution [37].

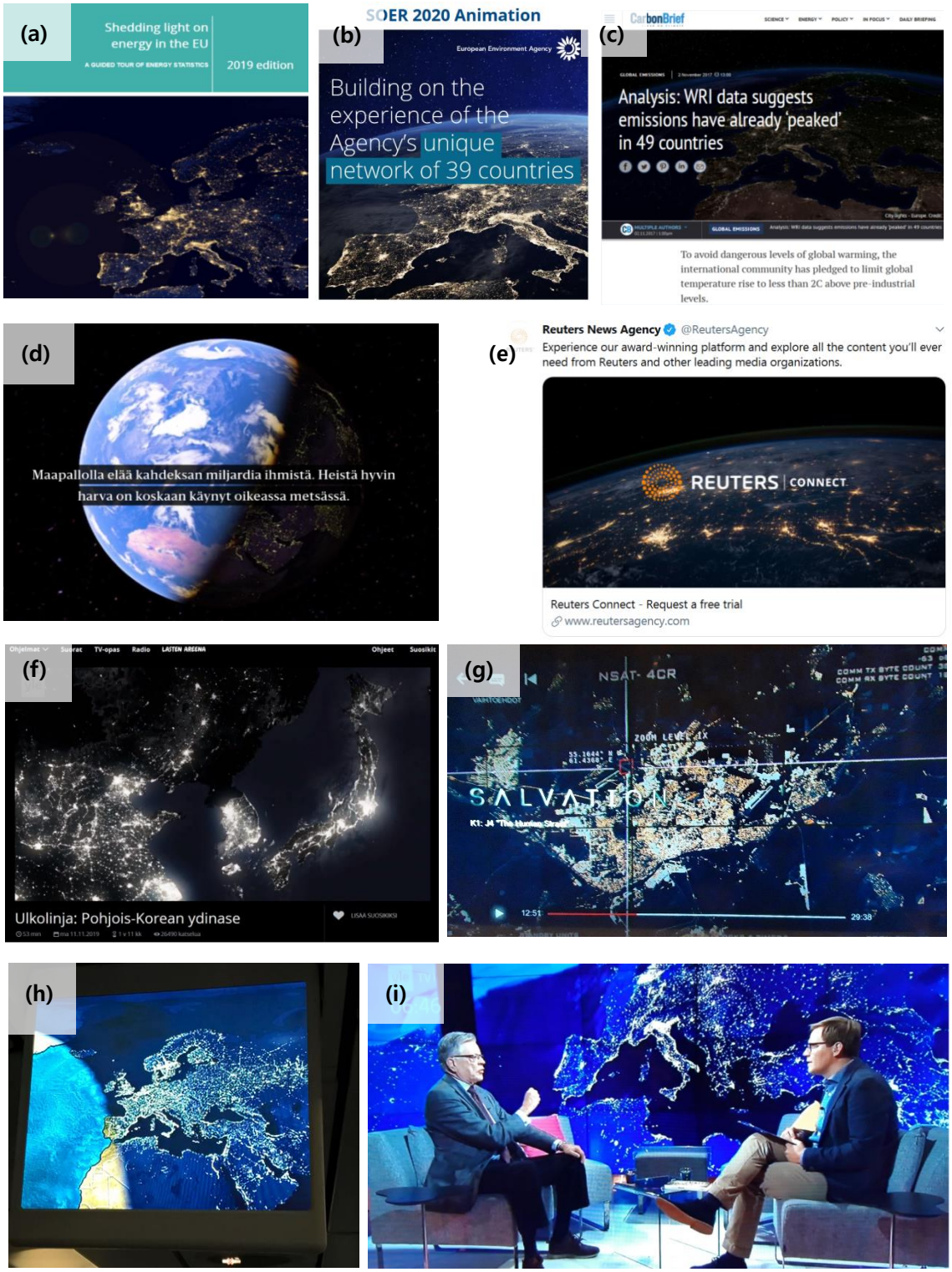

Fig. 1: Examples (panels a–i) of representations of light pollution maps in different contexts. See text for the detailed discussion. Images courtesy of the author.

Panel (c) in Fig. 1. gives another example of the use of a light pollution map in the context of contemporary environmental reporting and communication. The web page of the Carbon Brief project aims to support climate policies and to raise awareness of the results of climate science. The web page uses the image of night-time Earth as a background when informing the reader about trends in greenhouse gas emissions. No direct reference to the climate effects of energy production and consumption related to light pollution is provided. Instead, the light pollution map is apparently used to symbolize the planetary environmental and climate impact of humankind.

This resembles the usage of the photographs of the daytime images of the "Blue Marble", i.e. the Earth seen from outer space, the first such examples of this being those taken from the Apollo space missions in the late 1960s and early 1970s. These images have served as powerful metaphorical symbols of the fragility of ecosystems since then [38]. Released at a time of heightened public scrutiny of environmental issues they helped to catalyze the modern environmental movement even though they do not show any identifiable sign of human activities.

An example shown in panel (d) of Fig 1. illustrates the use of light pollution maps in news coverage focusing on the state of old-growth forests in Finland. The most widely read newspaper in Finland, Helsingin Sanomat, published a feature story filling four pages of the print version and complemented by the online version with additional visual material. The example comes from the online version, which included a dynamic opening visualization starting from a view of the planet Earth and automatically zooming into a close-up of a boreal forest ecosystem [39]. The screenshot presented in panel (d) of Fig. 1. states that "The Earth is inhabited by eight billion humans. Very few of them have ever visited real forest". In the background is a visualization of Earth, showing both undisturbed daytime Earth and night-time Earth filled with artificial lights.

The examples in panels (c) and (d) suggest that while the early daytime planetary photography highlighted the ecosystems in a context of wilderness and pristine nature, the more recent images of the globe at night highlight the pervasive planetary presence of humans in the context of the Anthropocene. It should be noted that the use of the images of the Earth with lights visible on the night side can be either a deliberate choice of the content creators or a subconscious choice influenced by social expectations. These choices are also influenced by the increased availability of stock imagery of the Earth at night.

Panel (e) of Fig 1. originates from a Twitter advertisement [40]. It is marketing material from a news agency, aimed at attracting attention and new customers. Connotations of global coverage, high connectiveness and intensive information flows are created with the use of an image of a brightly illuminated globe. The wording emphasizing the capacity to "connect" supports framing created by the image, where lights create an impression of a global network.

Quite the opposite connotations are created with the map presented in panel (f) of Fig 1. This is from a TV-documentary focusing on one of the most oppressive policy regimes in the world. The TV documentary "North Korea vs USA: A Nuclear Chicken Game" scrutinizes the political tactics of the non-democratic ruler of the Democratic People's Republic of Korea, Kim Jong-un [41]. The opening sequence of the documentary shows North Korea concretely as a dark spot on the map, contrasted with brightly illuminated neighboring country South Korea. The lack of artificial light here symbolizes the technological and economic backwardness of the country. It also denotes the lack of basic civil rights of the population. In academic literature, light pollution maps of North Korea have been used as proxy indicators aiming to compensate for missing or unreliable official indicators of the societal progress of the country [42].

An example of the usage of light pollution maps in fiction is presented in panel (g) of Fig. 1. The image is from science fiction series "Salvation" (CBS, 2017–2018) where an outer space object is at risk of hitting Earth and causing an extinction-level catastrophe. A city-level night-time map serves as the background in a scene where strategies for avoiding the impact and the looming catastrophe are pondered. Science fiction often uses cityscapes with intense artificial illumination to symbolize technological progress while unilluminated cityscapes or scenes showing lights shutting down block by block illustrate the risks of technological breakdown and catastrophes threatening the survival of certain group of people or the whole of humanity. Through these representations, constantly illuminated spaces are framed as the normal or desired state, while the lack of lighting symbolizes abnormality and danger. Such framings regenerate the deeply rooted cultural connotations of natural darkness as untamed, unsafe or evil [43].

Panel (h) in Fig 1. illustrates so-called "infotainment" use of light pollution maps in the context of free-time and travelling. It is a view from the screen in an airplane cabin, showing the transition between night and day in relation to the route the airplane is flying. This example illustrates the how map-based visualizations of light pollution can be used both to inform and entertain without any direct connection to environmental or energy issues. Notably, the map contrasts nighttime scenery dominated by artificial light with a daytime view of natural scenery lacking all signs of human influence or built infrastructure. This may create an impression of artificial light as a normal or natural part of the circadian cycle. Additionally, the map representation exaggerates the intensity of light pollution and is likely to create an impression of night-time lights almost equaling the intensity of sunlight. This is in part a matter of necessity to make the shapes in the night map visible, but it can be argued that the map could include e.g. country boundaries that help to position the plane at any given moment while on the night side of the Earth.

Panel (i) of Fig. 1. is taken from the morning TV news show of the Finnish Broadcasting Company, where the editor interviews the author of a recently published non-fiction book about the state of western civilization and discusses the possible impeachment process of the president of the United States [44]. This discussion does not

touch on light pollution, energy issues or environmental problems in any way. Nevertheless, in the background there is a night-time map showing Europe, northern Africa and the eastern Atlantic. No obvious reason for the selection of this imaginary could be identified, apart from grabbing the attention of the audience. The example indicates that the light pollution maps can be used as visual decorations regardless of the topic of the debate.

3 Discussion: Towards the extinction of natural nocturnal experience?

The review of the uses of light pollution maps presented above is by no means comprehensive. However, together with insights and examples from elsewhere (such as literature focusing on the use of light pollution maps as proxy indicators of other environmental effects, economic and societal development and human well-being [45-47]) it is sufficient to suggest that light pollution maps are used across various communication contexts in addition to discussions focusing solely on light pollution assessment and management.

The relatively wide popularity of light pollution maps can be explained both by internal and external factors. Internal factors include the visual appeal of light pollution maps as well as the improved availability and quality of data suitable for producing the images. External factors include, importantly, the increasingly visual communication culture creating demand for such images [22]. Advanced data and image processing tools allow for more cost-efficient production of map versions suitable for multiple purposes across different communication contexts. Internet-based image repositories make the maps widely, easily and in many cases freely available to potential users.

In addition to multiple communication contexts, there are multiple purposes for the use of light pollution maps. Visualizations are commonly used to attract attention or make messages more appealing or convincing in advertising, the news industry or personal interaction on social media [22, 24]. As indicated by the examples presented above, map-based visualizations can be used to inform or entertain, strengthen or criticize certain factual statement or emotive appeals, to build a commercial brand, support a certain policy stance or simply decorate an empty space. Because of this heterogeneity the audiences of communication may not be aware that the maps are representations of the human influence on night environment.

A key function of the use of maps in communication processes is to frame the message in certain way. Map-based visualizations have considerable power to frame certain states of affairs as normal, acceptable or even desirable. This is partly because maps may be comprehended as realistic and truthful mirrors of the reality even though they are, by definition, simplified representations that hide and arrange elements in a certain way. Maps can also deliver incorrect impressions, exaggerate or belittle, or they can even be used for purposeful lying [48]. Therefore, critical reading of framings suggested by maps is a necessity for fact-based awareness building and well-informed decisions.

Here, framing is understood widely as a communication process that highlights some pieces of information and makes them more salient, accessible and applicable to an audience [49, 50]. As indicated by the examples presented above and supported by studies of cultural history, humanities and social sciences [33, 51-53], positive impressions and connotations connected with artificial light and lighting can serve as powerful framing devices. To take a global-level example, the “Black Marble” image of illuminated night-time Earth shining in a vast darkness of dark space creates a framing highlighting human technological advancement and human planetary dominance. This is in contrast with earlier allegorical representations of “Blue Marble” or “Spaceship Earth” [38, 54] based on images of daytime earth and highlighting the natural ecosystems and interconnectedness of humanity and nature. The positive framings of artificial light as human achievement partly explain why the “Black Marble” has largely failed to capture public attention as a symbol of environmental degradation in a way the earlier “Blue Marble” image did. Furthermore, the “Black Marble” representation underscores apparently severe economic inequalities among nations [30]. This highlights the need for sensitiveness towards the potential inadvertent messages and interpretations created by the maps.

Humans living in technologically advanced modern societies that are increasingly information-intensive, digitalized and mediated perceive their environment largely through representations delivered by electronic communication applications and platforms. Furthermore, because of continuing urbanization, direct sensing of the environment—such as seeing, touching, hearing or smelling—occurs often in the context of built infrastructures not providing opportunities for direct observations and experiences of natural darkness [13]. These missing opportunities can be seen as an example of the process of shifting baseline syndrome of the nocturnal environment [9, 43].

Shifting baseline syndrome refers to the changing human perceptions of the state of certain systems due to loss of experience of past conditions [55-57]. Simply put, people who routinely face information and experiences of artificially illuminated spaces tend to consider illumination as a normal and typical state of the environment and

ignore that such lighting levels in most outdoor places were extraordinary just a few generations ago. The relatively widespread use of light pollution maps is one part of this process.

From an environmentally-oriented socio-psychological perspective, shifting baseline syndrome has been also labeled environmental generational amnesia, asserting that the present generation is unable to recognize how degraded the ecosystem has become because of long-term environmental pressures and resulting gradual changes [58, 59]. Generational amnesia is a particularly relevant concept for light pollution since typical city dwellers in the Global North have lacked access to natural nighttime darkness for many decades, even a century or more. In the cities of developing economies of the Global South the conspicuous and profligate consumption of artificial light at night is typically of more recent origin. In both cases the baseline of unnaturally bright night can continuously shift towards more intensively illuminated nights.

Likewise, research into biodiversity has addressed a similar process with the notion of extinction of experience, focusing on the decrease of quantity and quality of interaction between people and nature [60, 61]. This extinction of experience results from rapid urbanization and depleting biodiversity as well as decreased time spent outdoors. Awareness of this extinction of experience can be induced by communication campaigns or by blackouts temporarily switching lights off. As noted by Le Gallic and Pritchard, crises demonstrate the limits of progress narratives of supposedly linear, permanent shifts from darkness to light [34]. Awareness can also be indirectly created by exceptional circumstances such as the stay-at-home orders imposed by governments around the world due to the COVID-19 pandemic. Amateur astronomy and stargazing are one option for pastime for people confined at home, potentially making people to realize that they live under light pollution.

In the case of light pollution, these concepts describe the two processes by which the environment depleted of natural darkness becomes perceived as the normal state. On the one hand, they point out the development leading to disappearance of the perception of natural darkness, focusing attention on darkness as valuable natural resource [51]. On the other hand, they point out the normalization of increasingly intensive illumination through various processes making people unaware of relatively gradual environmental changes. Even though the concepts take individuals as the starting point of analysis, they note that the question is not only about personal-level perceptions but also about socially shared knowledge and expectations that influence policy processes, planning priorities and technical solutions. As noted by Appelt [62], what was once perceived as bright today can't either be used in a functional way or even less meet current standardization regulations.

If beliefs about the normalness of illuminated night prevail among the general public, it is likely that controversies and conflicts will arise when measures aimed to curb light pollution are planned and implemented. Criticism based on safety and security concerns is particularly common as an argument against switching off public outdoor lighting. Because of cultural and social preferences, proposals aiming at overnight dimming may induce public demands for more, not less light [63]. For example, fears related to nighttime crime in urban outdoor spaces can lead to demands for more light, instead of other solutions such as greater nighttime social control. However, available evidence shows that if carefully planned, switching off or part-time or dimming of street or road lights does not lead to increased crime or accident rates [64, 65]. There is no correlation between crime and the luminous intensity of communities [66]. However, the facts do not speak for themselves. All communication carries a risk of misunderstandings and evidence can be easily sidelined if it contradicts with personal beliefs, opinions or perceptions. As noted by Stone [67], the policies aimed at addressing the shifting baseline syndrome related to lighting risk omitting or overriding the concerns and preferences of citizens by presenting top-down paternalistic solutions not taking the perceptions, attitudes and values of citizens seriously. Anticipating, forestalling and solving these conflicts requires sensitivity to different lighting situations and understanding of systemic interactions involving a wide variety of issues such as available technological options, administrative hierarchies and power structures, social relations and personal valuations and perceptions related to lighting [63, 68, 69].

In addition to the experience of the normalness of artificial illumination, light pollution management is hampered by lack of knowledge of the harmful well-being and health effects and ecological effects of outdoor light pollution. Despite the rapidly accumulating evidence, many remain unaware and some remain skeptical of the harm caused by the intrusion of artificial light into the nocturnal environment. Awareness of the ecological and health effects may be low even among amateur astronomers, who are typically well aware of the effects of light pollution on the night skies [1]. Skepticism can also be strong among lighting professionals, as implied in an editorial of the journal Lighting Research & Technology in 2019 stating that "there are the environmental enthusiasts who are developing a narrative that light at night is not just masking the night sky but also damaging biodiversity and harming the environment" [70]. However, despite their different perspectives, light pollution experts and lighting professionals generally share the definition of light pollution as a serious problem and agree on potential solutions [71].

To summarize, the main driving forces of the extinction of the naturally nocturnal experience is the increasing use of artificial lighting and the rapid development of lighting technologies. Other driving forces include the relative low price of energy used for lighting, continuing urbanization, increasing night-time mobility and lifestyles favoring night-time social activity, as well as increasing time spent in inside spaces that are partially or totally unaffected by the natural circadian cycles of dark and light. Light pollution maps can play a dual role in the extinction of the experience process. First, as highlighted here, the maps can normalize the impressions of the normality of constantly illuminated outdoor spaces. Second, as indicated by various education and communication campaigns and literature focusing on eradicating light pollution, maps can also be used to remind of or reintroduce natural darkness. Recognition of both roles of light pollution maps is needed for successful development and adoption of more sustainable lighting.

4 Conclusions and recommendations for future research

"Night-time is a globally shared experience across countries and cultures" argues Acuto [72]. He makes a call for the comprehensive science of the night that would be needed for global sustainable development. Such calls have been voiced by several other scholars as well [73, 74]. However, the assumption about the widely shared experience of night time undisturbed by artificial light has become questionable.

The main argument from this review is that the light pollution maps are used in various communication contexts outside the debate focusing on light pollution and that these uses contribute—at least to some extent—to the extinction of human experience of natural darkness. Users of night-time maps should be aware of framings and connotations delivered through the maps. Obviously, map representations are not the only thing that is making us to forget about natural darkness. However, since visualizations are important part of building meanings in contemporary societies, visually appealing night-time imagery will unavoidably be used outside the light pollution debate.

The results of this review should not be read as a warning against the use of light pollution maps. On the contrary, the use of night-time satellite maps should be encouraged. Recognizing the variety of uses and potential unintended effects of light pollution maps can help communication campaigns aiming to advance public understanding of light pollution. However, assessing such unintended effects of communication is notoriously difficult [28]. If used as indicators of the loss of natural darkness, the maps can increase public and policy awareness of the harmful effects of light pollution. However, as shown by this study, night-time maps do not automatically convey a message of light pollution as a negative or harmful environmental change, and they may instead frame illuminated night as a normal or desired living environment for all species. This neutral or positive framing leaves potential detrimental effects of artificial light unnoticed. Whether the light pollution is perceived as "the good, the bad, or the ugly" [75] is clearly a question that cannot be determined by physical measurements alone.

This review has highlighted that light pollution maps have several roles in communication, both helping and hurting efforts aimed to raise awareness of light pollution. Further studies are needed to quantitatively chart the extent of the use of light pollution maps within and outside light pollution debates and to analyze the societal effects of these uses. Likewise, better understanding other types of images, textual and verbal representations and storylines framing the non-illuminated and illuminated night could help to avoid conflicts related to light pollution management. An interesting future research topic is the potential impact of so-called echo chambers or filter bubbles of social media on the use of night-time images and on perception of nocturnal environments. This review focused on examples derived from the North European context and discussed light pollution mainly from the perspective of affluent and urbanized Global North. Comparative insights taking into account the different contexts of rural areas and Global South are needed to draw a more complete picture.

Acknowledgements

The Finnish Environment Institute supported this review. I warmly thank the reviewers for insightful and helpful comments.

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