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Artificial light at night usage patterns and their implications for human wellbeing, ecological balance, and astronomical visibility within the nighttime ecosystem of Brenton-on-Sea, Knysna

Ilonka Louw[1], Kevin Mearns[2], Logistic Makoni[3*]
[1,2,3]University of South Africa, College of Agriculture and Environmental Sciences (CAES), Department of Environmental Sciences, Corner of Christiaan de Wet Road & Pioneer Avenue, Florida, 1709, Johannesburg, South Africa; 12298786@mylife.unisa.ac.za (I.L.) mearnkf@unisa.ac.za (K.M.) logism@unisa.ac.za (L.M.).

Abstract: The purpose of this research was to investigate the usage patterns and implications of artificial light at night (ALAN) and its effects on ecological integrity, human health, and astronomical visibility within the conservation-based coastal town of Brenton-on-Sea, Knysna. In this quantitative study, survey data from [n = 49] households were obtained regarding residents' perceptions of artificial lighting and their lighting behaviors. The data reveal a dominant use of functional outdoor lighting, particularly white light, primarily driven by visibility and security needs. The findings also indicate limited awareness of ALAN's broader ecological and health impacts. Despite this, residents demonstrated a high willingness to learn more about ALAN and how to mitigate it through responsible lighting practices. The results highlight a significant disconnect between lighting behavior and ecological responsibility, providing evidence-based insights into the challenges and opportunities for sustainable lighting in similar conservation-sensitive regions. This localized insight into ALAN's real-world impacts offers a critical foundation for modeling context-specific, responsible, and sustainable lighting strategies that can be adapted across similar conservation-oriented communities globally.
Keywords: *Artificial light at night (ALAN), Brenton-on-Sea, Conservation communities, Ecological impact, Light pollution, Sustainable lighting.*

1. Introduction

In today's world, when night falls, darkness no longer emerges in its natural form. Rather, it is substituted by the artificial glow of business centers, homes, buildings, and streetlights [1]. Largely taken for granted, this illumination has increasingly become intensely rooted in modern life to the extent that a full dark sky is a rare concept [2]. The cumulative usage of Artificial Light at Night (ALAN) is one of the most prevalent yet overlooked forms of environmental change. ALAN subtly but robustly affects several aspects, such as how people experience nighttime, the functionalities of night ecosystems, humans' sleeping patterns, and the visibility of stars above [3]. In the past, people used to be diurnal beings, active during the day and resting during the night. However, due to the invention and the widespread use of electric lighting, this natural rhythm has been significantly affected [4]. Today, ALAN has become a core aspect of urban nightlife, and to an extent, rural, due to the demand for nighttime activities such as productivity, security, and entertainment [4].

ALAN supports extended commercial activities, enhanced nighttime safety, and activities, as well as lifestyle flexibility [5]. For instance, the lighted billboards, security lights in homes and on streets, and lit shopping complexes are some of the ALAN usage examples [6]. As much as this is viewed as a convenience allowing for more productivity that continues beyond natural sunlight, ALAN is, however, associated with ecological and social shortcomings that are largely overlooked. In addition, ALAN has extensive consequences beyond its intended usage. It changes the daily activities for both humans and

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* Correspondence: logism@unisa.ac.za

wildlife and disrupts the activities and behaviors of nocturnal animals [7]. ALAN also contributes to Skyglow, a concept that describes the brightening of the skies at night caused by artificial light scattering across the atmosphere, which reduces the visibility of stars. Additionally, it contributes to light pollution. Light pollution is known to impact plant development, the movement of nocturnal animals, and hormone production in humans [7]. The impact of light pollution is particularly severe in ecologically sensitive areas, as it disrupts biodiversity conservation.

Besides the global awareness and efforts to curb light pollution, many communities, especially in developing regions, remain oblivious to how their ALAN behavior affects the environment and their social structures [5]. Brenton-on-Sea, a small coastal area within the Western Heads Goukamma Conservancy in Knysna, South Africa, is one of these communities. This area is in an environmentally sensitive and biodiversity-rich zone and provides a unique case for analyzing the local behavior and consequences of ALAN. While the broader impacts of ALAN are well documented, localized research that investigates usage patterns within small, ecologically sensitive communities remains limited. There is a gap in understanding how residential lighting habits correlate with actual sky brightness and ecological vulnerability in such areas. Furthermore, little is known about public awareness of light pollution or alignment with responsible lighting practices. This study contributes to the growing field of light pollution research by focusing on the specific context of Brenton-on-Sea—a coastal community embedded within a conservation-conscious region.

By exploring ALAN usage patterns and assessing residents' awareness of responsible lighting practices, the study aims to reveal the real-time implications of artificial lighting on human well-being, ecological stability, and night sky visibility. It not only addresses a critical research gap but also provides evidence-based recommendations that may inform policy and promote sustainable lighting practices in similar communities worldwide. In the absence of formalized bylaws and regulations, the lighting behaviors of residents are largely self-regulated, making it an ideal context for analyzing how ungoverned ALAN usage interplays with human experiences and ecological well-being. The main aim of this research was to investigate the ALAN habits of the Brenton-on-Sea community and their implications for human well-being, ecological balance, and astronomical visibility within the nighttime ecosystem of Brenton-on-Sea, Knysna. The study sought to provide a localized understanding of ALAN's impacts and to contribute insights toward more sustainable and environmentally conscious lighting practices in conservation-linked communities.

2. Literature

The nighttime ecosystem refers to the complex web of ecological interactions and biological processes that occur under natural darkness [8]. For millions of years, humans, flora, and fauna have evolved under a dependable day-night cycle, with darkness acting as a critical environmental cue [9]. One of the most profound evolutions of both the human and wildlife environments is the transformation of this natural night into a synthetically illuminated space. Due to the need for augmented productivity, safety, and nightlife conveniences, the global spread of ALAN has hindered the once distinct boundary between day and night [10]. As much as ALAN has undoubtedly resulted in several societal benefits, which manifest through enhanced economic activities after dark, security, improved quality of life, and increased social activities, it brings about a wide range of astronomical, ecological, and human health consequences [5]. Artificial lighting has become a critical component of contemporary society, which makes provision of illumination that makes it possible for recreational engagement, safe transportation and mobility, as well as the economic vitality of 24-hour areas [11].

ALAN plays a significant role in shaping the development of areas, supporting infrastructure, and enabling extended human activity beyond natural daylight hours [5]. Areas such as residential spaces, streets, commercial areas, public spaces, and sports venues are some of the examples where ALAN usage is applied, is prone to Gaston et al. [12]. In addition, with the emergence of the Light Emitting Diode (LED), lighting has become more efficient and widespread, yet often without regard for its necessity or ecological impact [13]. Besides the benefit of artificial lighting, the proliferation of its existence, together with limited regulations on its usage, has resulted in new forms of pollution, one that is associated with natural cycles and alteration of the ambient conditions under which life evolves [14]. Also, in some cases, outdoor lighting is needlessly bright, unshielded, or left on throughout the night, which results in inefficient energy use and unintended environmental consequences [1]. In addition, this growth of ALAN usage is associated with a wide range of societal changes, which are both beneficial and negatively consequential [15]. These benefits are particularly visible in urban areas where ALAN extends the boundaries of social and economic activity [8].

ALAN facilitates globalization by allowing people to be more productive, travel, and meet at any time, despite the time of day or night [16]. Issues such as safety and minimized fear of criminal activities, as well as the facilitation of nighttime commerce, have been associated with the increased visibility provided by ALAN [17]. Besides the numerous advantages, the ecological and health-associated downsides of ALAN are undeniable. For instance, the improper usage of outdoor lighting at night, particularly when the lights are not shielded or directed, exacerbates the growing issues of light pollution. In Figure 1, the International Dark-Sky Association [17] illustrates how shielding outdoor lights can reduce light wastage and light pollution.

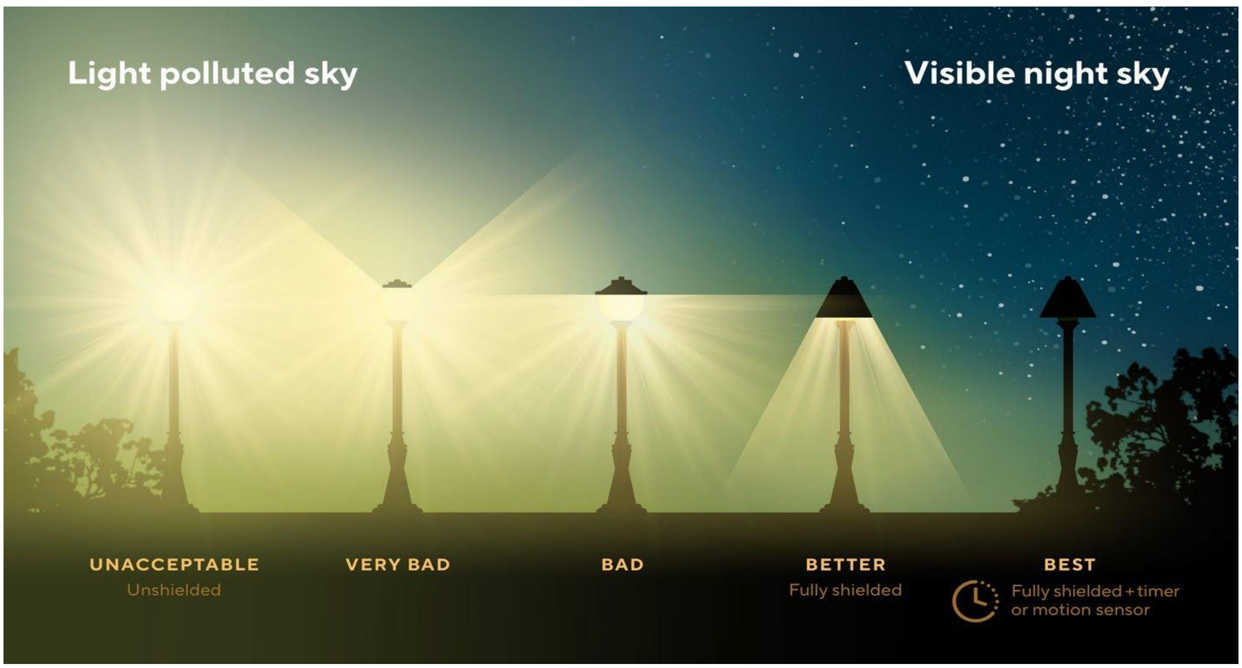

Figure 1.
An illustration of how shielding outdoor lights can reduce light wastage and light pollution.
Source: International Dark-Sky Association [18].

Figure 1 shows how unshielded outdoor lighting at night can cause avoidable light pollution, whereas fully shielded lighting is ideal [18]. Light pollution is defined as the harmful effects of excessive and inappropriate outdoor lighting, which alters the naturally occurring light levels in the environment [13]. These effects are common in both rural and urban areas as ALAN spreads, with its sources such as streetlights, stadium lights, commercial centers' lights, and residential lights all contributing to this situation [11]. It is noted that irresponsible ALAN contributes to natural balance disturbance and energy wastage. It also alters the ecosystem and disrupts critical biological processes [19]. Various forms of irresponsible ALAN contribute to this issue, such as poorly stationed lights that shine directly upward, which contribute to sky glow, or excessive clusters of light that can be visually

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disorienting [9]. This contributes to the inefficient use of energy, as well as resulting in dire consequences for both ecological and community health [20].

One of the key forms of light pollution is sky glow, which occurs when light is reflected and fragmented by atmospheric particles, creating an artificial glow over cities and surrounding areas [17]. Sky glow is particularly disastrous to astronomical observations, which require dark, unpolluted skies. As light pollution continues to rise at a rate of approximately 2% per year, the ability of astronomical researchers to conduct and produce groundbreaking research is becoming more complex, with significant implications for scientific discoveries [9]. In areas where ALAN is more prone, even rural areas that were once not affected by artificial lighting are now being affected. The impact of sky glow, therefore, goes beyond its interference with astronomical observations; it also damages the natural rhythms of both wildlife and humans [16]. For instance, the brightened night skies caused by ALAN alter the behaviors of nocturnal species, influencing everything from foraging patterns to mating rituals, with potentially catastrophic consequences for biodiversity [15].

Regarding human health, being exposed to ALAN can have significant psychological and physiological impacts [19]. For example, the extension of daylight into the nighttime hours can distract the natural circadian rhythms that control many of the human bodily functions. If these rhythms are disturbed, the result includes, inter alia, sleeping disorders, metabolic illnesses such as cancer, diabetes, and obesity [21]. Most of these health issues manifest due to the suppression of melatonin, a natural hormone that helps regulate your sleep-wake cycle, caused by prolonged exposure to ALAN [21]. Therefore, when human systems are disturbed due to excessive exposure to light, several negative outcomes surface, such as impaired cognitive functionality and an increased risk of accidents [20]. The effects are not limited to those who work night shifts or who live in heavily lit urban areas; modern society has made ALAN an almost ubiquitous presence, impacting the health of individuals across various demographics [22].

Further, ALAN has significant ecological impacts, especially for flora and fauna that depend on natural light and dark cycles [23]. In animals, the risk involves changes in behavior, mating patterns, and feeding patterns [23]. Regarding plants, some plants, such as deciduous Platanus trees, retain their leaves much longer when exposed to ALAN, and this interferes with the trees' seasonal cycles and nutrient storage [24]. In a similar situation, nocturnal pollinators, such as moths, are often drawn toward artificial light, leaving them less able to perform their vital roles in ecosystems [5]. These disruptions have significant effects on food chains and can compromise the resilience of ecosystems in the face of environmental change. Other nocturnal animals also suffer from the impact of ALAN [10]. For instance, bats, whose scavenging behavior is vital for the balance of insect populations, are rapidly affected by the presence of outdoor light at night [5]. Other migratory birds are also drawn off course by city lights, which results in dangerous collisions with buildings or disorientation during their long journeys.

In coastal areas, artificial light is observed to confuse sea turtle hatchlings, causing them to move away from the ocean toward the light [23]. This behavior increases the risk of predation and dehydration, endangering the survival of these species [23]. The ecological impact of ALAN is particularly concerning in coastal areas such as Brenton-on-Sea in South Africa, where the natural environments are closely intersected with human settlements. The alteration of light levels in this area, especially through the widespread use of artificial lighting in residential, commercial, and public spaces, threatens not only local wildlife but also the natural beauty that attracts residents and visitors alike. The effects of ALAN on ecosystems in Brenton-on-Sea are part of a larger global trend where human activities increasingly interfere with the natural environment.

Various guidelines, however, for responsible lighting usage have been proposed over time. Organizations such as the IDA and the Illuminating Engineering Society (IES) are examples of organizations that aim to reduce light pollution while ensuring that artificial lighting serves its intended purpose. Some of the key principles for responsible ALAN include the use of targeted lighting that is shielded to prevent light from spilling into unintended areas, the use of timers and motion sensors to limit unnecessary lighting, and the adoption of warm-colored lights that reduce the amount of blue light emitted [4, 7, 18]. In addition, outdoor lighting should not be brighter than necessary to meet its purpose. Implementing these guidelines can significantly reduce light waste and help mitigate the harmful effects of ALAN on both the environment and human health [3]. For communities located where the conservation of natural environments and the need for infrastructure development and human habitation intersect, adopting responsible ALAN practices is essential in balancing the benefits of artificial lighting with the preservation of nighttime ecosystems [6]. Through limiting excessive lighting and only using light when necessary, communities can reduce the environmental footprint of ALAN and contribute to a healthier and more sustainable future [2]. As the global population continues to grow and urbanization expands, communities must adopt stricter regulations on ALAN to protect the quality of life for residents and preserve the integrity of ecosystems for future generations [25].

3. Methods

A quantitative research design was used to investigate the patterns of ALAN usage in Brenton-no-Sea and their implications for human wellbeing, ecological balance, and astronomical visibility. Figure 2 is a graphical presentation of this case study area.

Figure 2.
Map of Brenton-on-Sea, Knysna.
Source: Google Maps [26].

Brenton-on-Sea is a coastal settlement located along the Garden Route in the Western Cape Province, within the Western Heads Goukama Conservancy [27]. This settlement is renowned for its geographic significance, endangered species, and ecological sensitivity. In addition, Brenton-on-Sea is composed of a blend of natural biodiversity and cultural significance [28]. The Knysna Sand Fynbos and the Brenton Blue Butterfly are some of the key highlights of this settlement's biodiversity [29]. This ecology and socio-cultural blend makes this location an ideal case study for examining the intersection of human activity and nighttime environmental impact in this context. The understanding of ALAN is significant, given the area's vulnerability to light pollution as well as its potential impacts on both ecological and human systems. A structured questionnaire was designed to collect data for this research. The questions sought to gain insights into the residents' knowledge of light pollution, the purpose behind their use of ALAN, their outdoor lighting behaviors, and their willingness to adopt more responsible lighting practices. A two-stage sampling method was employed to target the study participants. First, initial participants were targeted through convenience sampling, taking advantage of the ease of access within the small community. Second, a snowball sampling method was used, which allowed the study to reach broader networks of residents through referrals [from the initially targeted populations]. This was seen as a practical approach in a close-knit area where trust and familiarity can augment participation. Eventually, data were collected from (n=49) households in Brenton-on-Sea. The collected data were processed and analyzed using SPSS to identify patterns, correlations, and insights that informed the study's discussion and conclusions.

4. Results

There was evidence of a high understanding of the term 'light pollution' from the study respondents. The results are presented in Table 1.

Table 1.
Familiarity with Light pollution.

Are you familiar with the term light pollution?	Total (%)
Yes	67
No	18
Vaguely	14

This result shows that most community members have some level of familiarity and understanding of the concept of light pollution. While a majority indicated a clear understanding, a notable proportion only had vague or no understanding of the term. This indicates a foundational awareness within the community but also suggests a need for more comprehensive education on the concept and its implications. In relation to these results, the respondents were asked to indicate their level of awareness of the impact of ALAN. The results are displayed in Table 2.

Table 2.
Level of awareness of the impacts of ALAN.

Impact on ecological health	Total (%)
Yes	41
No	37
Vaguely	22
Impact on human wellbeing	
No	43
Yes	39
Vaguely	18
Impact on astronomical observations	
Yes	65
No	27
Vaguely	8

The results reveal varying levels of understanding across different domains. For instance, there was a high awareness regarding the artificial lighting effects on night sky visibility [astronomical observations], but a significantly lower awareness level on the effects on ecological and human aspects. This uneven awareness suggests that many residents perceive ALAN primarily as a visibility issue, rather than recognizing its broader environmental and health implications. This limited understanding is reflected in the community's lighting practices, such as the widespread installation of outdoor lights for functional purposes, as indicated in Table 3.

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Table 3.
Outdoor lights installation.

Do you have the following outdoor lights installed against your building/property?	Total (%)
Lights installed against the house walls	86
Solar lights	39
Lights installed in the garden	35
Lights along pathways/driveways	22
Fairy lights	14
String lights	6

Note: Multiple response questions

The data provided in Table 3 implies that outdoor lighting is widespread throughout Brenton-on-Sea. Much of the lighting is shown to be installed directly on properties. The results also show that the community utilizes both functional [to a greater extent] and decorative [to a lesser extent] lighting. These patterns highlight how lighting decisions are driven both by utility and, to some degree, aesthetic preference. Their reasons for using lights are reflected in Table 4.

Table 4.
Reasons for using lights.

Please indicate why you have installed outdoor lights	Total (%)
To light pathways/steps/driveways and to see where one is going	69
For security purposes	43
For its aesthetic appeal	16
Other:	8

Note: Multiple response questions.

Practical reasons for outdoor lighting were largely cited by the respondents, with safety and visibility after dark being the key reasons. In addition, security was also prominently cited, showing how lighting is closely related to perceptions of personal safety. Decorative or aesthetic motivations were present but played a secondary role. This prioritization reflects a functional orientation toward lighting rather than an environmentally conscious one. Table 5 provides a broader insight into the community's outdoor lighting behaviors, offering a clearer understanding of usage patterns, control mechanisms, and timing practices.

Table 5.
Outdoor lighting behaviors.

Are any of your outdoor lights on timers?	**Total (%)**
No	69
Yes	27
Unsure	4
Please indicate what time your outdoor lights are switched ON	
At night (once the sky is completely dark)	41
No fixed routine (whenever it feels appropriate)	35
At dusk (just after sunset, when the sky is still slightly lit	22
Please indicate the time your outdoor lights are switched OFF	
No fixed routine (whenever it feels appropriate)	29
At dawn (just before sunrise when the sky starts to lighten)	27
When we go to sleep	24
After sunrise (once the sun has risen)	12
Are any of your outdoor lights on motion sensors?	
Yes	55
No	45
Do you have completely unshielded lights on your property?	
None of my lights is completely unshielded	57
Some of my lights are completely unshielded	24
Most of my lights are completely unshielded	2
All of my lights are completely unshielded	16
Do you have fully shielded lights on a timer/motion sensor?	
None of my lights are fully shielded and are on a timer/motion sensor	71
Some of my lights are fully shielded and on a timer/motion sensor	20
Most of my lights are fully shielded and on a timer/motion sensor	4
All of my lights are fully shielded and on a timer/motion sensor	4
What is the color of the light emitted by your outdoor lights?	
White	63
Amber	37
Orange	10
Blue	2

These results [in Table 5] reveal that there is a high level of unstructured lighting behavior by the residents of Brenton-on-Sea. Most of the lights remain on throughout the night in the absence of automation, such as timers or motion sensors. Despite a small proportion of residents using motion-activated lights, the results show a high rate of manual control, which follows inconsistent on-off routines. Additionally, the results indicate that fully shielded lighting and energy-saving controls are not widely adopted, suggesting significant potential for improvement in responsible lighting practices. Furthermore, the dominant use of white light implies a preference for brighter, cooler-toned lighting, driven by availability and visibility. However, the relatively limited use of warmer colors like amber and orange, which are known to be less disruptive to ecosystems, points to a potential gap in awareness regarding the environmental and health impacts of different light spectra. Data regarding light trespass is presented in Table 6.

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Table 6.
Neighboring lights.

Do any of your neighbors' lights shine onto your property?	**Total (%)**
No	65
Yes	33
Unsure	2
Do any neighboring lights shine directly into your house?	
No	76
Yes	22
Unsure	2
Do any streetlights shine directly onto your property?	
Yes	65
No	33
Unsure	2

The results in Table 6 regarding the issue of light trespass, where lights from neighbors or public infrastructure intrude into private property, were raised by a considerable number of participants. Specifically, streetlights were largely indicated as a source of light pollution affecting personal space. These insights highlight how ALAN extends beyond individual choices to include community and infrastructural influences. Lastly, the respondents were asked to indicate their level of interest in learning more about AAN and how to mitigate it. The results are presented in Table 7.

Table 7.
Level of interest in ALAN.

Would you be interested in finding out more about ALAN and how to mitigate it?	**Total (%)**
Yes	53
Not sure yet	29
No	28

Encouragingly, more than half of the respondents expressed interest in learning more about ALAN and ways to reduce its impact. This interest suggests a community openness to change and provides a foundation for future awareness campaigns and educational initiatives aimed at promoting sustainable lighting practices.

5. Discussion

The results of this research show the nuanced interplay between community lighting behaviors and the health of the nighttime ecosystems. These results offer significant empirical insights into the usage patterns of ALAN within a context that is both ecologically sensitive and largely unregulated. The implications extend beyond local concerns, speaking to global challenges around sustainable lighting, urban development, biodiversity loss, and human wellbeing.

5.1. Lighting in the Absence of Formal Regulation

Due to its lack of local lighting regulation, as shown in the results, Brenton-on-Sea presents a unique case in the understanding of ALAN. This result shows that lighting practices are largely shaped by individual preferences and decisions in place of formal policies. This [unregulated ALAN] is argued in existing literature to be one of the defining features of modern environmental change, though it is scantily addressed with the same urgency as other pollutants [11]. These unregulated lighting practices in Brenton-on-Sea are emblematic of broader global patterns in which communities, often in oblivion, contribute to light pollution because of their practices that prioritize safety and security, convenience, and aesthetic choices without the consideration of ecological stewardship. Despite most of the participants indicating that they were aware of the term 'light pollution', there was a noticeable disconnect between general familiarity and a deeper understanding of ALAN's diverse impacts. This finding mirrors [18] research indicates that the limited understanding of ALAN and its many consequences, particularly regarding ecosystem functionality, circadian biology, and astronomical visibility, is common across the globe. The partial awareness seen in the Brenton-on-Sea study highlights the need for localized educational interventions that move beyond surface-level terminology to promote nuanced understanding and pragmatic application of responsible lighting practices.

5.2. Light as a Disruptor of the Ecology and Natural Cycles

In coastal areas, the ecosystem is known to be rich and highly sensitive to even subtle alterations in light levels [9]. The emergence and growth of ALAN in these areas have been increasingly disrupting the natural light-dark cycles that are crucial for many species [12]. This research's context is particularly relevant considering evidence from the International Dark-Sky Association [9], which highlights that even subtle ALAN has profound consequences for coastal species. For example, the disorientation of sea turtle hatchlings due to ALAN is a well-documented issue in coastal areas. Besides Brenton-on-Sea not currently being reported as a nesting site for turtles, the vulnerability of coastal ecosystems to light pollution is a relevant parallel, especially considering the community's proximity to marine-protected areas and biodiversity corridors. The existence of decorative and unshielded lighting, which are largely not on automation [presented in the results], reflects what [5] cautions against: non-essential lighting that contributes to environmental degradation without delivering proportional benefits. The results of this research show that unshielded and overly bright lighting causes sky glow and stray light into nighttime ecosystems, significantly masking natural cues that many organisms rely on for orientation, migration, foraging, and reproduction.

5.3. Human Wellbeing and the Circadian Disruption Paradigm

The results show that lighting behaviors in Brenton-on-Sea lack routine and control, indicating regulatory gaps regarding ALAN usage. The implications of these behaviors, while not explicitly stated by participants, align with what [20] identifies as high-risk ALAN exposure environments, such as settings where outdoor lighting is unpredictable, non-directional, and persistent throughout the night. These conditions are conducive to circadian disruption and contribute to the phenomenon of "light trespass," where individuals are subjected to light in their private spaces, often without consent. Similarly, Ścieżor [19] and Voigt et al. [21] underline that prolonged exposure to artificial light, especially at inappropriate times and in inappropriate intensities or wavelengths, interferes with melatonin production and the body's sleep-wake cycle. Such interference can result in several health complications, such as insomnia, cancer, fatigue, and related chronic illnesses. Ścieżor [19] add that ALAN is currently a ubiquitous part of modern life, affecting even rural and semi-rural areas and populations beyond night shift workers or urban dwellers. The Brenton-on-Sea findings support this assertion: the lack of strong regulatory oversight has created conditions where ALAN becomes a normalized feature of the nighttime landscape, with residents potentially unaware of its cumulative health effects.

5.4. Astronomical Visibility and Sky Glow

International Dark-Sky Association [11] indicates that sky glow is increasing and significantly threatening both professional observatories and public engagement with astronomy. Besides the residents of Brenton-on-Sea showing an awareness of ALAN, the dominance of white lighting and the relative rarity of shielded lighting practices imply that the community is inadvertently contributing to the growing concern of sky glow. According to Gaston et al. [12], white light, especially that emitted by blue-rich LEDs, disperses more into the atmosphere than longer-wavelength amber lighting. In Brenton-on-Sea, where natural aesthetics, stargazing, and eco-tourism are part of the cultural and economic fabric, conserving the astronomical visibility of the area benefits both scientific elements and community assets. Accordingly, Helm et al. [29] emphasize that preserving the visibility of the night sky is an environmental justice issue as much as it is a scientific one, particularly for communities seeking to retain their connection to the natural world.

5.5. Cultural Perceptions of ALAN and Readiness for Change

Besides the residents demonstrating a mixed understanding of the ALAN concept and its impacts, there is an untapped readiness for change, which was portrayed in their expression of interest in learning more about this concept. This finding mirrors the International Union for Conservation of Nature [13] research indicates that once communities become aware of light pollution's consequences, they are often willing to change their behaviors if provided with accessible alternatives and pragmatic guidance. This presents an opportunity in Brenton-on-Sea to introduce community-based initiatives to mitigate ALAN. These include, among others, training workshops on shielded lighting, local lighting guidelines, and collaborations and partnerships with both the government and ecological organizations. In a similar study, Smyth et al. [3] highlight that empowering communities to self-regulate through education and participatory planning can be more effective than top-down enforcement, especially in smaller or semi-rural areas. The results also show that sustainable technologies are partially present and underutilized. This is, though, an indication from a few respondents that they make use of motion sensor lights and solar lighting. Enhancing the use of these technologies through incentives or community campaigns could foster a shift toward more ecologically sensitive lighting practices without sacrificing safety or aesthetic preferences.

6. Implications

The case of Brenton-on-Sea reinforces the need for holistic techniques for nighttime lighting that promote a balance among safety and security, functionality, and environmental integrity. As portrayed in the literature reviewed for this research, practical and clear guidelines and principles for responsible use are proposed by organizations such as IDA and IES. For example, International Dark-Sky Association [11] encourages the use of only the needed light, the mitigation of blue light, and promotes proper outdoor light shielding. Brenton-on-Sea, together with relatable regions, stands to benefit immensely from implementing these principles, especially given their ecological proximity to sensitive coastal and forested zones. In addition, the results show that the unmonitored spread of ALAN represents a silent encroachment upon human and ecological health. However, the mitigation of irresponsible ALAN largely requires behavioral rather than infrastructural overhaul. For example, the use of motion sensor lights and timers, as well as shielding, is crucial for promoting measurable improvements in both ecological and human outcomes of ALAN usage. Through aligning local lighting behaviors with international best practices, Brenton-on-Sea can serve as a model for similar regions experiencing similar challenges. The findings from this study thus contribute to the growing body of evidence calling for context-sensitive, community-based lighting policies that uphold both modern conveniences and ecological responsibility.

In addition, this research set out to investigate ALAN usage and its implications for ecological integrity, human health, and astronomical observations. Through a localized, community-based lens, the research has revealed a complex interplay between human behavior, technological choices, environmental awareness, and the unintended consequences of unregulated lighting practices. The findings of this research reveal that despite a moderate level of understanding of the ALAN concept, the associated consequences, particularly on human health and ecological systems, are not fully comprehended by the Brenton-on-Sea community. The absence of formal regulations on ALAN usage in the small town has resulted in hazardous lighting behaviors that are highly individualized, often guided by utility, security, or aesthetic appeal rather than environmental consideration.

Importantly, the findings of this study mirror global research on the subject matter; ALAN, when used irresponsibly in the absence of structured regulations, changes the natural rhythms and contributes to the growing set of ecological and public health problems [3, 8, 12, 23]. Therefore, from a practical perspective, this research underscores the urgent need for context-specific and community-based ALAN guidelines that are useful for the promotion of safer energy-conserving and ecologically friendly practices that do not compromise the residents' needs for security and visibility. Theoretically, this research makes a meaningful contribution to a growing body of literature that argues for a more nuanced understanding of ALAN, not just as a technological or infrastructural issue, but as a socio-environmental phenomenon shaped by habits, perceptions, and place-based values.

7. Conclusion

This research underscores the complex dynamics of ALAN within Brenton-on-Sea, where unmonitored lighting behaviors subtly, yet significantly, impact the well-being of communities, the ecological integrity, and the visibility of the night sky. The limitations of this research were, however, acknowledged. Particularly, this study made use of self-reported data with a geographic focus on Brenton-on-Sea. Additionally, the research focused on perceived impact, which leaves room for further studies to explore actual ecological and social measurements of ALAN in the town and/or similar regions. Future research should also combine ecological field data, such as information regarding nocturnal species behaviors and sky brightness, with social metrics to deepen understanding. A comparative analysis across communities with varying regulatory environments would be beneficial, as it can provide practical insights into how governance influences lighting behavior and outcomes. Moreover, participatory action research involving residents in lighting interventions could help test practical, context-sensitive solutions. Ultimately, this research highlights the importance of responsible ALAN in conservation-like communities. It further emphasizes the hidden consequences of ALAN and the untapped potential for awareness-driven change. In an era when natural nighttime ecosystems are increasingly endangered, this research takes a critical step toward restoring natural night rhythms—not just for stargazing and astronomical activities, but also for ecosystems, public health, and the collective rhythm of life that depends on it.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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