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LIGHT POLLUTION IN URBAN AREAS & BEST PRACTICE

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ABSTRACT

The surge in artificial light usage, following the invention of the first light bulb, has been exponential, resulting in the pervasive issue of light pollution. This phenomenon is primarily attributed to economic development, population growth, and urban sprawl, posing an escalated risk of health issues. The primary goal of this study is to pinpoint the adverse effects of light pollution, recognize the intrinsic value of dark skies as a precious resource, and comprehend the benefits associated with their preservation. The exploration will commence with an examination of the various types and causes of light pollution and their impacts on both animals and human health. Subsequently, attention will shift to elucidating basic standards and methodologies for measuring light pollution, encompassing the tools and techniques involved. The discussion will culminate in an exploration of strategies for planning dark skies, underscoring the crucial role of local authorities in conjunction with best practices, and presenting an overview of the current situation within the study area.

Keywords: Light Pollution, Trespass, Over Illumination, Glare, Clutter, Skyglow, Light Emitting Diode (LED), International Dark Sky Community (IDA), Bureau of Indian Standards (BIS), Etc

1. INTRODUCTION

This research endeavors to acknowledge dark skies as a valuable asset and understand the various implications of light pollution. It outlines the adverse effects of light pollution and emphasizes the role of planners in addressing this issue. The excessive or improper use of artificial outdoor lighting leads to light pollution, impacting wildlife behavior, human health, and obstructing our ability to observe stars and celestial objects. To recognize dark skies as a valuable resource and grasp the manifold benefits of managing light pollution, this study seeks to: identify the impact of light pollution on dark skies, delineate the negative effects of light pollution, and underscore the responsibility of planners in addressing the problem. Embracing darkness not only contributes to energy savings and reduced greenhouse gas emissions but also enhances tourism, improves human health, safety, and well-being, safeguards ecosystems, and preserves cultural heritage.

1.1. NEED FOR THE STUDY

The comprehension has grown that the development and widespread utilization of artificial light yield detrimental effects on human health, as well as animal and plant populations, and ecosystems, among other factors. In response to climate change and energy shortages, numerous counties, regions, and towns are initiating innovative lighting programs and concepts, giving particular attention to energy efficiency and the reduction of greenhouse gas emissions. Addressing this issue effectively requires light pollution laws to encompass considerations of socioeconomic impacts, ecological structure and function, and human health. This underscores the importance of acquiring a comprehensive understanding of the essence of night, its significance to people, and its role in natural systems.

1.2. EMERGENCE OF LIGHT POLLUTION AS AN ISSUE

"The global spread of artificial light is eroding the natural night-time environment," said first author Dr Alejandro Sánchez de Miguel, of the Environment and Sustainability Institute on Exeter's Penryn Campus in Cornwall. "This study provides clear evidence not only of how bad light pollution has become as a global problem, but also that it is continuing to get worse, and probably at a faster and faster rate."

The global prevalence of light pollution has escalated by at least 49% during the 25 years leading up to 2017, with the possibility of an even higher increase. Estimates for light-emitting diode (LED) technology, often escaping detection by current satellite sensors, suggest a potential surge in visible spectrum radiation of up to 270% globally and 400% in specific regions. Despite technological advancements, there is scant evidence to support the notion that these innovations have led to a reduction in light emissions. Parallel studies corroborate these findings , as an analysis of satellite data from 2012 to 2016 discloses a yearly rise of 2.2% in the total area illuminated by artificial light at night.

1.3. TYPES OF LIGHT POLLUTION

Over Illumination: Superfluous illumination surpassing what is essential for a particular task constitutes wasted light. Energy is squandered when empty spaces are needlessly illuminated, resulting in unnecessary energy consumption. Additionally, excessive, or bothersome lighting, which negatively affects health and induces glare, is considered a form of light pollution.

Glare: Glare is produced when light reflects off surrounding objects and scatters, leading to a visual impairment that hinders eyesight. While it does not directly impact night vision, glare poses challenges in locating and recognizing objects due to the scattered and intense nature of the reflected light.

Clutter: Poor location design is the root cause of mild confusion, a unique human-made issue. Contrasting lighting that obstructs visibility and illumination at night can be produced by business lighting or street lamp clusters. It is also capable of being potent enough to shut down an animal's inborn nocturnal system.

Skyglow: This term is employed to depict a quasi-domed zone of illumination in an urban environment. The light emitted by streetlights, signs, residences, and businesses ascends, modifying the atmospheric light quality, and is then reflected into the city from the atmosphere. This phenomenon could potentially influence the natural development of plants and impact the nocturnal navigation abilities of aircraft.

Light trespass: In many places, it is a criminal as well as a kind of pollution. Unwanted light intrusion occurs when it enters a person's property. It might be, for example, the light of a sign entering a neighborhood.

Sources of Light pollution.

- Residential Light Pollution.
- Vehicle and Street Light-Induced Light Pollution.
- Light Pollution Resulting from Poor Planning.
- Contributing Role of Dense Population.
- Light Pollution Arising from Night Sport Stadiums.
- Light Pollution Originating from Commercial Ads and Electronic Hoardings.

- Unregulated Use of Lights.
- Light Pollution Emitted by shopping malls, Gaming Zones, and Restaurants.
- Light Pollution in Public Spaces.

2. EFFECTS OF LIGHT POLLUTION

The effects of this issue are undiscovered and the study of light pollution is still in its infancy. The brighter night sky is one of light pollution's most evident effects, but many additional worrying implications have not yet been thoroughly investigated. One-fourth of all energy consumed worldwide goes towards lighting, and 19% of all power utilized goes towards nighttime lighting. The release of greenhouse gases as a byproduct of producing electric lighting from burning fossil fuels contributes to global warming and the loss of non-renewable resources. Other negative effects of light pollution on the environment include harm to people, vegetation, and animals. Not only does it impact nocturnal, migratory, and flying creatures, but it also harms plants.

2.1. IMPACTS ON PLANTS

Plants utilize darkness in various ways, including the assessment and response to the duration of the night. Short-day plants thrive in prolonged nights, and certain plants typically blossom during autumn when the daylight hours are shorter. Light pollution near bodies of water can hinder zooplankton from feeding on surface algae, leading to algal blooms that pose a threat to lakes. Moreover, the influence extends to nocturnal insects and flowers dependent on moths for pollination, impacting various ecosystems. Many animal species rely on trees within their ecosystems, and light pollution adversely affects these trees. The artificial illumination interferes with the trees' ability to adapt to seasonal changes. Due to ambient light pollution, birds face difficulties nesting in trees.

2.2. IMPACTS ON ANIMALS

Light pollution disrupts the natural light-dark cycle, affecting physiology, competitive behavior, predator-prey relationships, and overall animal behavior.

Threats to Birds:

Since the 19th century, light has been employed to attract both migratory and non-migratory birds. However, the reasons behind birds becoming disoriented under artificial night lights remain unclear. Experts propose that birds typically rely on the horizon as a reference point for orientation.

- In the mid-19th century, lighthouses and bird boats were initially documented, featuring static white lighting that attracted more people.
- Light beams, or rays, have been observed since the 1940s. In 1999, Bruderer et al. investigated how birds responded to both light and X-band radar. Filtering out longer wavelengths and replacing fixed beam units have reduced the number of bird fatalities.
- Oceans, with fewer artificial light sources, are more appealing to seabirds, although they can face dangers such as heat impact or oil exposure. Light used in fishing can also pose a threat to birds through hook injuries.
- The light trapping effect, causing birds to hover near light sources, depletes their energy reserves, hindering their ability to reach the next destination, reproduce, or survive the winter.
- The rise in the number and height of telecommunication and broadcasting towers contributes to deadly confrontations with migratory birds due to low visibility and the luminous matrix surrounding the tower. Recent studies indicate that using rotating or blinking red lights and white strobe lights can mitigate the impact of bird captures at illuminated towers.

2.3. THREATS TO SEA TURTLES

Artificial lighting disrupts turtle nesting, deters females from suitable sites, and increases hatchling mortality. Obstacles and human interference affect nesting success rates (50% to 80%). After nesting, turtles are drawn to urban lights, posing risks during their return to the sea.

Artificial lighting, including street lights and city skylights, disrupts newly hatched loggerhead turtles' natural orientation to the sea at night, leading them to crawl in incorrect directions. This disorientation exposes them to risks such as dehydration, predators, and elevated temperatures after sunrise.

2.4. EFFECTS ON HUMAN HEALTH AND PSYCHOLOGY

Scientific studies on the impact of heightened light levels or light pollution on human health reveal various adverse effects. These encompass exacerbated headaches, increased fatigue among workers, medically confirmed stress, compromised sexual function, and heightened anxiety. In workplaces with typical fluorescent lighting, blood pressure can elevate by approximately 8 points. Substantial evidence indicates that prolonged exposure to intense light can negatively influence sexual function. Additionally, prolonged exposure to artificial light at night, leading to a reduction in natural melatonin production, is linked in some research to an elevated risk of developing breast cancer.

The World Health Organization's International Agency for Research on Cancer asserts that working night shifts may contribute to an increased risk of cancer. Various studies have consistently demonstrated a correlation between night shift work and a heightened incidence of breast cancer.

2.5. EFFECTS ON ASTRONOMY

Skyglow diminishes the contrast between celestial objects such as stars and galaxies and the night sky itself, posing challenges for observing fainter entities. Consequently, new telescopes are being constructed in more remote locations to mitigate the effects of light pollution. Astronomers employ broadband "light pollution filters" or narrow-band "nebula filters" to alleviate these impacts. However, as these filters alter color perception, they are unsuitable for visually assessing the brightness of variable stars. The intrusion of scattered light into a telescope tube, entering off-axis and reflecting off surfaces other than the mirrors, can create flares across the entire field of vision when it reaches the eyepiece. This phenomenon, known as light trespass, has the potential to disrupt observations.

To mitigate glare, a common approach involves flocking the telescope tube and its accessories. Additionally, mounting a bright shield on the telescope helps reduce incoming light from angles away from the intended target. In Italy, regional lighting rules specifically identify the diffuse light effect caused by the direct link between the light source and the "optical channel" as "optical pollution."

3. DARK SKY LIGHTING BASICS

Shielding of Fixtures: Fully shielded downward lighting illuminates desirable regions while reducing glare by keeping undesired light from leaking into the surroundings and the sky above. You can buy it or retrofit it. retrofitted.

Lighting Color: Light pollution's impact on wildlife and human health is influenced by the color of the light. The International Dark-Sky Association (IDA) recommends using long-wavelength illumination with a color temperature of no less than 3000 Kelvin to minimize these negative effects.

Amount of light: Reducing outdoor lights has the potential to minimize light pollution. Optimal lighting levels are achieved by utilizing lower bulb intensities, illuminating only necessary areas, and directing light downward. Implementing timers, motion sensors, dimmers, and off switches not only helps preserve the natural darkness of the night sky but also contributes to energy savings.

4. LIGHT POLLUTION – MEASUREMENT

Handheld Devices: Affordable automatic zenith skylight meters, including the Digi Lum Luminance Meter, Mark Light Meter, and Sky Quality Meter (SQM), present cost-effective and precise solutions for monitoring light pollution across broad geographic areas and extended periods. The SQM, renowned for its versatility, offers various hardware

interface options. Operational demands are minimal compared to CCD photometry, allowing for easy installation and nearly instantaneous readings at a high frequency. Regular maintenance and calibration ensure accuracy suitable for most applications.

Photometry: Astronomers, being particularly sensitive to light pollution, employ photometry to assess the Natural Sky Brightness (NSB) across various wavelength bands. In areas where the night sky is influenced by natural light sources, astronomers can precisely identify potential threats from light pollution. Their expertise aids in evaluating and locating new observing sites with minimal light interference.

Satellite Imagery: Nocturnal images of Earth captured from space offer a vivid depiction of the spatial dispersion of light pollution. High-resolution data is provided by satellites like DMSP and VIIRS, as well as by astronauts aboard the International Space Station. Bright areas on these images indicate commercial and residential zones, whereas dark regions represent undeveloped deserts and forests.

Spectroscopy: Astronomical spectroscopy is used to study the spectra of the night sky, breaking down the light frequency and recording the signal with a camera. Artificial features such as emission lines and continuations can be identified when they are present in the spectrum.

Bortle scale: The Bortle scale is a widely utilized and straightforward tool for assessing the quality or brightness of the night sky at a particular location. Comprising nine levels, the Bortle scale ranges from Class 1, indicating pristine dark skies, to Class 9, representing the highest level of light pollution. This scale provides a convenient and standardized way to categorize and communicate the observational conditions in different areas.

5. PLANNING FOR DARK SKIES

Effectively reducing light pollution in a sustainable manner while preserving the night sky requires careful planning and community collaboration. Night sky planning necessitates the implementation of administrative codes and zoning regulations, akin to those used in other forms of land use planning. By incorporating thoughtful measures into these codes and zoning processes, communities can actively contribute to mitigating light pollution and ensuring a balance between artificial lighting needs and the preservation of the natural night environment.

5.1. OUTDOOR LIGHTING CODE

The primary objectives of many lighting laws are to diminish light pollution, promote energy efficiency, regulate outdoor lighting installations, and formulate a comprehensive public outdoor lighting strategy. The efficacy of lighting regulations becomes more pronounced as they successfully address and reduce light pollution. Various levels of government, including states (most commonly), counties, or municipalities, as well as specific development projects or districts, have the authority to implement lighting rules to achieve these goals.

5.2. LIGHTING ZONES

A lighting zone delineates a region where lighting codes necessitate variations in lighting standards due to distinct conditions associated with the use of lighting. There are four main approaches to accessing or defining a lighting zone.

Landuse Zoning Approach: Single-use zoning, also known as Euclidean zoning, serves as the cornerstone of land use zoning methods. This approach associates lighting regulations with different types of land use zones, including categories such as large businesses or single-family residences.

Relationship and Proximity Approach: Lighting zones can be designated based on their proximity to or association with specific resources, such as gazebos or parks. In areas near airports, overlapping lighting zones are common, often driven by concerns related to airport security.

Combined Approach: A third option involves combining a relationship or proximity strategy with land use zoning. Unlike an urban scenario where the same business area might be considered a separate illuminated area, in this approach, a commercial area near an observatory would be considered as one illuminated area.

Overlay Zoning: An overlap zone is often synonymous with a bright zone. Nested zoning is a regulatory mechanism that introduces a special zoning layer atop an existing basic zoning to designate unique conditions beyond the default zoning. In this approach, illumination zones "overlap" land use zones while maintaining their distinct characteristics.

This facilitates cross-referencing lighting regulations with other pertinent laws and ordinances, such as electrical codes, symbol codes, or planning regulations. It also allows for the integration of lighting regulations into existing ordinances or codes. The International Dark-Sky Association (IDA) recommends employing five outdoor lighting zones when formulating laws and ordinances after selecting a strategy.

LZ0: No ambient lighting - places where the natural environment is severe or adversely affected.

LZ1: Low Ambient Light – An area where lighting can negatively impact the natural environment.

LZ2: Moderate Ambient Lighting - An area where lighting is typically used for safety, security, and comfort, but is not necessarily uniform or continuous.

LZ3: Moderately bright ambient lighting - An area where lighting is generally desirable for safety, security, and comfort and is usually uniform and continuous.

LZ4: Strong ambient light - Lighting is generally considered essential for safety, security, and convenience.

See the IDA-IESNA Model Lighting Ordinance (MLO) Instruction Manual for details on the five recommended lighting zones.

5.3. LIGHTING CODE ENFORCEMENT

Strict adherence to all rules, especially those related to lighting, is essential. To effectively diminish light pollution and preserve the integrity of the night sky, it is crucial to comply with lighting restrictions. Communities should establish clear procedures and tactics for enforcing these laws, outlining how they are intended to be implemented. The choice of enforcement strategies may vary based on factors such as the community's size, resources, culture, and specific needs. The most effective implementation method will align with the community's strengths and cultural context.

Ensuring general lighting compliance often involves various measures, including:

- **Fixture redirection:** Adjusting the direction of fixtures to control the spread of light.
- **Light source shielding:** Installing shields or barriers around light sources to minimize light spill and glare.
- **Reconstruction or relocation of luminaires:** Modifying or moving lighting installations to achieve compliance with regulations.
- **Replacing luminaires with suitable alternatives:** Substituting existing fixtures with ones that meet specified lighting standards.
- **Removing the lamp:** Eliminating or reducing the output of specific lamps to achieve desired illumination levels.
- **Penalties such as fines:** Imposing monetary consequences for non-compliance to encourage adherence to lighting regulations.

6. PURPOSE OF PRESERVATION OF DARK SKIES

As beings inherently connected to light, technological advancements in recent decades have extended our work and leisure into twilight and darkness, challenging the traditional boundaries of night. However, amidst our activities, it is essential to recognize that ecosystems and wildlife operate continuously. These environments have evolved with inherent coping mechanisms, dependencies, and adaptations to the natural darkness that envelops them. A night sky free from artificial light is vital for the well-being of natural ecosystems.

Consideration of the effects of light pollution reveals its impact on various aspects of ecology. Predator-prey relationships, circadian rhythms, and species migration patterns are all influenced by the intrusion of artificial illumination. To truly comprehend our surroundings, satisfy our curiosity, appreciate our environment comprehensively, and preserve the integrity of our rich cultural heritage, natural darkness is indispensable.

Yet, in the quest to safeguard biodiversity, cherish the natural world, and preserve cultural legacies, the importance of natural darkness and the consequences of artificial light often receive less attention compared to other environmental challenges such as climate change, acid rain, invasive species, habitat destruction, and similar pressures. It is crucial to recognize and address the multifaceted impacts of artificial light on our ecosystems and cultural heritage for a more comprehensive approach to environmental conservation.

Reducing light pollution and safeguarding the night sky align with several compelling reasons, extending beyond environmental conservation to embrace sustainable development principles in urban planning.

Wildlife Viewing and Ecological Preservation: Ensuring wildlife viewing opportunities and preserving the ecological integrity of the natural environment.

Appreciation of Rural Vistas: Valuing the authenticity, uniqueness, and beauty of rural landscapes.

Preservation of Cultural Artifacts: Safeguarding and showcasing the authenticity of cultural artifacts, including material heritage.

Cultural Traditions and Rituals: Contributing to the preservation of customs and rituals associated with the night sky.

Preservation of Cultural Heritage: Safeguarding mythological, navigational, and astronomical cultural heritage.

Physical and Mental Health: Protection of the physical and mental health of individuals.

Energy Conservation: Encouraging energy conservation through mindful lighting practices.

Support for Astronomy: Supporting both amateur and scientific astronomy, fostering star tourism, and ensuring everyone's right to experience a clear, unpolluted night sky.

Enhanced Personal Security: Improving personal security in urban settings through glare-free illumination.

The International Union for Conservation of Nature (IUCN) recognizes the significance of nighttime for ecological protection, sustainable living, and the creation of livable cities. To bolster this acknowledgment, the IUCN World Commission on Protected Areas has established a Dark Sky Advisory Group. Collaborating with the International Dark Sky Parks Association Initiative, the organization has developed a website to encourage communities and protected areas to embrace the concept and importance of dark skies. Searching the internet for terms such as "dark sky," "starry sky," "dark sky reserve," "night ecology," "Starlight reserve," and "artificial light at night" will quickly yield a wealth of informative lighting guidance websites, detailing the effects of light pollution on both people and the environment. The Dark Sky Advisory Group does not seek to duplicate these resources but aims to support the IUCN Night Sky Initiative and offer guidance for accessing more information.

7. STEPS TO CONSERVE DARK SKIES

We all have the power to act each day and enhance the efficiency of lighting consumption. Below are six simple and cost-effective approaches to reduce light pollution.

- Implement safeguards against glare and light intrusion into the surrounding area; secure all outdoor lighting.
- Direct lights downward to effectively illuminate the desired area, ensuring no light spills onto flat surfaces.
- Opt for motion sensors for nighttime home security lighting. Activate the light only when needed, saving money, and deterring potential troublemakers more effectively.
- When purchasing lighting, focus on lumens rather than watts. Many manufacturers now include both lumens (light output) and watts (power consumption) on product packaging. By checking for lumen ratings, you can achieve optimal illumination, cost savings, and energy conservation. For instance, a 13-watt CFL bulb provides the same amount of light as a 60-watt incandescent bulb but uses eighty percent less energy and lasts four times as long.

8. LOCAL AUTHORITIES' ROLE IN REDUCING LIGHT POLLUTION

The County Council may inspect your property to ensure proper usage of lights. Some offices may have bright lights directed upward and illuminated from below. It is advisable to either remove such fixtures or, at the very least, replace them with dimmer lights and use them judiciously.

Local governments are responsible for maintaining all light fixtures, including streetlights, with the capability to be turned off or dimmed after a specified period. City councils oversee street lighting, and with the average streetlight wasting 30% of its light, it contributes significantly to light pollution. This issue can be addressed by adopting better illumination methods.

One effective solution is to replace outdated "orange" streetlights with "Full Cut Off" (FCO) lights. In FCO lights, no light reaches the horizon, ensuring that all illumination is focused on roads and pavements where it is most needed. This helps minimize light pollution and enhances the overall efficiency of street lighting.

8.1. CITY OF CALGARY

Calgary, Alberta, Canada, serves as a noteworthy example of effective implementation in this regard. In 2007, the city initiated a project to replace over 40,000 streetlights, opting for 100- and 150-watt flat lens lights instead of the previous 200- and 250-watt plate lights.

The former lanterns dispersed light both horizontally and towards the sky, contributing to light pollution. In contrast, the new fully adjustable lanterns directed all their light downward, allowing the city to maintain sufficient illumination despite the reduced lamp power.

Despite the project's cost of CAD 7.8 million, it was undertaken to streamline expenditures. The city anticipates annual energy bill savings exceeding $2 million with the adoption of the new lighting, a figure likely to increase with the rising cost of oil. Moreover, the project contributes to environmental conservation by reducing CO2 emissions by 18,000 tonnes.

The endeavor proved successful, marking the introduction of the innovative flat lens street lights in Calgary, a first in North America. Over 37,000 streetlights were upgraded, resulting in annual energy savings surpassing $1.7 million. This initiative has the capacity to provide enough electricity annually to power 3,000 households.

Between 2002 and 2010, the City of Calgary realized significant savings and reductions following its comprehensive upgrade efforts:

- **Energy Savings:** The city achieved substantial energy savings through its upgrades, contributing to a more efficient and sustainable lighting system.
- **Cost Reductions:** Financially, the city experienced cost reductions because of the upgrades. This indicates a positive impact on the budget and efficient allocation of resources.
- **Environmental Impact:** The upgrades resulted in a reduction of the city's environmental footprint. This likely includes a decrease in carbon emissions and other environmental pollutants.
- **Operational Efficiency:** The overall efficiency of the city's lighting infrastructure improved, leading to enhanced operational performance and potentially reducing maintenance costs.
- **Innovation and Modernization:** The upgrade initiative reflects the city's commitment to innovation and modernization, aligning its infrastructure with contemporary standards and practices.
- Energy savings of 107,000 MWh.
- Reduction of 124,000 tons of CO2.
- Saved US$11 million by reducing energy consumption.

These achievements between 2002 and 2010 showcase the City of Calgary's dedication to sustainability, cost-effectiveness, and the well-being of both its residents and the environment.

Taking a further step in 2011, the City of Calgary introduced 310W lighting fixtures as a replacement for the existing 400W fixtures. Additionally, a pilot project was initiated to curtail streetlight energy consumption in non-residential areas, demonstrating a commitment to ongoing energy efficiency improvements.

While local authorities in Ireland may face certain limitations, adopting a strategy like Calgary is recommended. The replacement of faulty streetlights with Full Cut Off (FCO) designs is encouraged, contributing to reduced light pollution and enhanced energy efficiency. Furthermore, a proactive approach involves the installation of FCO lighting in all new buildings, promoting sustainable practices from the outset.

On the planning front, it is crucial for local governments to explicitly outline in their development plans and planning regulations the necessity of environmentally friendly facilities. This includes the incorporation of specific details regarding exterior lighting plans in new developments, ensuring compliance with minimal standards for

environmentally responsible lighting practices. Such measures contribute to a more sustainable and ecologically conscious urban development.

9. BEST PRACTICE – FLAGSTAFF

Thanks to innovative and exceptional leadership, the City of Flagstaff and the Northern Arizona region have garnered global recognition for their commitment to preserving the night sky. Over the span of more than 50 years, their visionary policies and implementation efforts have cultivated a flourishing astronomical industry. Notable establishments such as the Lowell Observatory, the United States Naval Observatory, the Naval Prototype Optical Interferometer, the National Undergraduate Research Observatory, the US Geological Survey Astrogeology Centre, and the Discovery Channel Telescope have become integral parts of this astronomical hub. This journey began with the inception of Regulation 400 in 1958, specifically addressing reflectors.

The support from the public for safeguarding the night sky, essential for both amateur and professional space exploration, has evolved into a fundamental element of the local and regional identity. Both cities and counties took a significant step in 1989 by enacting local codes that restrict the amount of light per acre in outdoor lighting installations. These regulations have since undergone frequent modifications and tightening.

On October 24, 2001, Flagstaff achieved the distinction of being recognized as the world's first international night sky city. This recognition stems from its pioneering efforts in preserving the natural wonders of the night sky while prioritizing public and financial safety. The region's hard-earned reputation and accomplishments are regarded as a crucial asset, emphasizing the need for further reinforcement rather than compromising its significant economic and cultural heritage.

An annual event, the "Flagstaff Star Party," serves as a dark-sky experience attracting attendees from the Southwest and around the world. This event aims to introduce those impacted by light pollution to the enchanting dark skies of Flagstaff. Amateur and professional astronomers in the region set up around 30 telescopes, allowing people to marvel at the wonders of the night sky.

To maintain its status as one of the world's premier astronomical sites, the region actively addresses evolving challenges. Preserving the naturally dark night sky is recognized as a lasting expression of social value, contributing significantly to economic and tourist attractions. Ongoing concerns include managing artificial light, combating air pollution, and addressing illuminated signs and buildings, both in proximity and around substantial scientific equipment. These efforts are essential to ensure the continued success and global standing of the region as a haven for astronomical observation.

9.1. ORDINANCE NO. 440

An ordinance delineating regulation for floodlights in the City of Flagstaff, Arizona, prohibits the use of specific commercial floodlights within the city limits. The ordinance prescribes fines, judgments, and the declaration of an emergency in case of violations. The Mayor of the City of Flagstaff and the General Assembly decree the following:

- It is declared that any individual employed within the city of Flagstaff must prevent the installation or adjustment of any light, arc lamp, beacon, or lighting device designed to project light beyond a radius of more than half (1/2) mile into the sky within the city limits.
- The provisions of this law do not apply to emergency lamps, street lamps, or public street lamps.
- Nothing in this code shall be interpreted to prohibit the use of short-open wide-angle fixtures that cannot project a beam longer than half (1/2) mile.
- Violation of any provision in these regulations constitutes a misdemeanor, and the offender may be fined up to $300 or imprisoned for a period not exceeding (90) days, or both.

- This law, enacted immediately for the protection and welfare of the public, is declared an emergency, taking effect upon publication in accordance with the law.
- This ordinance, approved and passed by Flagstaff's Mayor and City Council, was enacted on April 15, 1958.

9.2. STREET LIGHTING FOR ENHANCING DARK SKIES (SLEDS)

1) Project purpose statement:

Through a comprehensive analysis of the impact of various lighting systems on nocturnal conditions, this project assesses the control or enhancement of the dark night, considering both visual brightness and spectral width. The evaluation extends to technologies and strategies aimed at enhancing the existing street lighting infrastructure within the city. The overarching goal of this initiative is to formulate and implement a novel street lighting system that aligns with the Flagstaff community's values, emphasizing the preservation of dark skies, sustainability, and safety.

The project recognizes the delicate balance required to meet the city's commitment to maintaining dark skies, promoting environmental sustainability, and ensuring the safety of residents. By addressing the aging street lighting infrastructure, the project seeks to introduce innovative solutions that contribute to the harmonious coexistence of urban development and the natural environment, fostering a community that values and prioritizes both its unique celestial views and the well-being of its residents.

2) Project Background:

The main aim of the Street Lighting for Enhancing Dark Skies (SLEDS) project is to fix the current issues with streetlights in Flagstaff. The project will look at how streetlights affect the dark sky, safety, and maintenance. By focusing on these areas, the goal is to make street lighting better so that it works well, keeps people safe, and aligns with Flagstaff's commitment to preserving its unique dark sky environment. Overall, the project wants to create a street lighting system that not only works well but also helps Flagstaff achieve its goals of being sustainable, safe, and keeping its special views of the night sky.

9.3. LOW PRESSURE SODIUM

The SLEDS project is the result of years of collaboration between the city and local observatories (US Naval Observatory - Flagstaff Station and Lowell Observatory), starting in May 2012. The traditional lighting system, High-Pressure Sodium (LPS), has been the city's choice since 1989. However, it has become more expensive over time, making quality changes challenging. The city is also dealing with issues related to the size and weight of the LPS fixtures, especially when it comes to their installation on light poles and post arms.

9.4. FUNDING

To secure funding for the SLEDS project, an Interim Agreement (IGA) was approved with the Arizona Department of Transportation (ADOT) in June 2015. The agreement included $100,000 (FY16) for hiring a team of consultants (ultimately Monrad Engineering), $200,000 (FY16) for testing to support the consultant team's work, and $370,000 (FY18) for the initial phase of the Lighting Change project. All funding was provided through the Flagstaff Metropolitan Planning Organization (FMPO), Surface Transportation Program (STP) grant.

9.7. LIGHT EMITTING DIODE TECHNOLOGY (LED)

The SLEDS project has allowed Flagstaff to showcase innovative lighting solutions using LED technology to other cities. This approach not only addresses concerns about preserving dark skies but also fulfills the city's safety and security requirements. By setting astronomical targets for effective and dark skies, Flagstaff is at the forefront of innovation and best practices in lighting applications. This initiative is encouraging the industry to embrace technological changes that help prevent light pollution and contribute to maintaining the natural darkness of the night sky.

10. LIGHT POLLUTION HYDERABAD

A research paper authored by Professor Siba Prasad Mishra from the Department of Civil Engineering at Centurion University of Technology and Management in Bhubaneshwar reveals that Hyderabad, India, has the highest light intensity in the country, measuring 7,790 µcd/m2 (a unit of luminous intensity per square meter).

The study also applies the Bortle scale, which assesses the darkness of the night sky, indicating that two specific locations in Hyderabad, namely Charminar and HITECH City along with its surrounding area, exhibited a high level of light pollution, scoring between 8 and 9 on the scale. This data is derived from a pollution board survey conducted between 2012 and 2019.

1) Charminar

The area around Charminar in Hyderabad has transformed into a lively commercial center. This region boasts a rich mix of historical architecture and a thriving business environment. The grand mosque and palaces from the city's past rulers stand as prominent landmarks in the midst of this dynamic atmosphere.

Charminar is surrounded by two bustling bazaars, namely Charminar Bazaar and Laad Bazaar. These areas, along with the broader surroundings, contribute significantly to light pollution in the region. Beyond Charminar, the surrounding areas like Afzulgunj, Koti, Begum Bazaar, Sultan Bazaar, Abids Market, Moazzam Jahi Market, Nampally Market, Madina Market, Shahran Market, and more, form major commercial hubs. Here, one can find a diverse array of products, ranging from clothing, accessories, and jewelry to kitchen items, furniture, construction materials, electronics, automobiles, and much more. These commercial activities make up nearly 70% of the Municipal Corporation of Hyderabad (MCH) and contribute to intensive light pollution, brightening the night sky.

One of the main reasons for the lively night scene in the area is the presence of street food stalls in these spots, which keep the area vibrant and active 24 hours a day. The combination of commerce, diverse markets, and a bustling street food culture makes this area a central part of Hyderabad's nightlife.

2) Hi-Tech City

HITECH City in Hyderabad experiences high illumination intensity primarily due to its status as an IT hub and the presence of various commercial activities. The area is home to numerous multinational companies such as Google, Deloitte, Amazon, Microsoft, TCS, Qualcomm, Dell, Oracle, and more. These companies, along with commercial spaces like IKEA, Sharath City Mall, Inorbit, shopping malls, pubs, clubs, drive-ins, clothing stores, and studios, contribute significantly to light pollution in the city.

Recreational spaces like Shilparamam, Biodiversity Park, Durgam Cheruvu, Birds View Park, and others add to the overall vibrancy of the area. Additionally, the existence of a 24/7 street with food stalls at DLF caters to the needs of night shift workers.

While these spaces are essential strengths of HITECH City, they also contribute to light pollution. Many establishments tend to over-illuminate their buildings as a way to showcase their presence. The result is excessive lighting that not only affects the night sky but also impacts the overall ambiance of the area.

Furthermore, the area's high land value is indicative of its economic significance. However, the street lights in the region are noted for providing glare to passersby, and the fixtures may not adhere to the standards set by The Bureau of Indian Standards (BIS). These factors collectively contribute to the challenges of managing light pollution in HITECH City.

3) Street Lighting National Programme (SLNP) – Hyderabad

The Energy Efficiency Services Ltd (EESL), a division of the Power Ministry, has collaborated with the Greater Hyderabad Municipal Corporation (GHMC) for the implementation of the Street Lighting National Project (SLNP). Under this initiative, the GHMC street lighting project is expected to cost around Rs. 270 crores, and EESL will cover the entire cost. The repayment of this expense will be facilitated through projected savings over a seven-year period.

Currently, GHMC has 3.5 lakh street lighting poles, and this number will be increased to 4.5 lakh, ensuring 33 lighting posts per kilometer. The transition to LED street lighting is estimated to result in a saving of 200 million kWh of electricity per year for GHMC. The annual expenditure for GHMC on operating and maintaining the existing conventional lighting system is Rs. 210 crores. EESL has communicated to the Telangana civic authority that the switch to LED lighting will lead to a 50% reduction in costs compared to the current system. Over the seven-year period, GHMC is expected to save Rs. 1200 crore. The Correlated Color Temperature (CCT) of the LEDs provided in the specified area is 5700 kelvins.

11. CONCLUSION

The significance of the night-time environment has grown in recent decades, influenced by social and cultural changes. Various factors, such as the blurring of distinctions between day and night, evolving life rhythms due to social practices, demographic shifts, and new urban living patterns, have contributed to this shift. Advances in lighting technology have enabled people to engage in social, cultural, or political activities well into the night or simply enjoy personal time alone.

In response to these changes, there is a renewed focus on night and darkness in urban planning. Cities are increasingly considering light planning as a way to create a distinctive artistic image. When planning for the night, including cultural, economic, and environmental policies becomes crucial. Despite the current lack of awareness in many nations, the impacts of light pollution are expected to worsen over time.

The primary goal of this essay is to raise awareness about the detrimental effects of light pollution, emphasize the value of dark skies as a precious resource and part of our heritage, and recognize the numerous benefits that arise from preserving dark skies. There is a responsibility to protect the environment and cultural heritage for future generations. The essay advocates for the pursuit of dark skies, not only for tourism and leisure opportunities but also for environmental preservation. It suggests that local authorities and planners should take proactive measures in this regard.

CONFLICT OF INTERESTS

None.

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None.

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