SIMULATION COMMITTEE GUIDE

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Topic 1: *Light Pollution*

I. History/Context

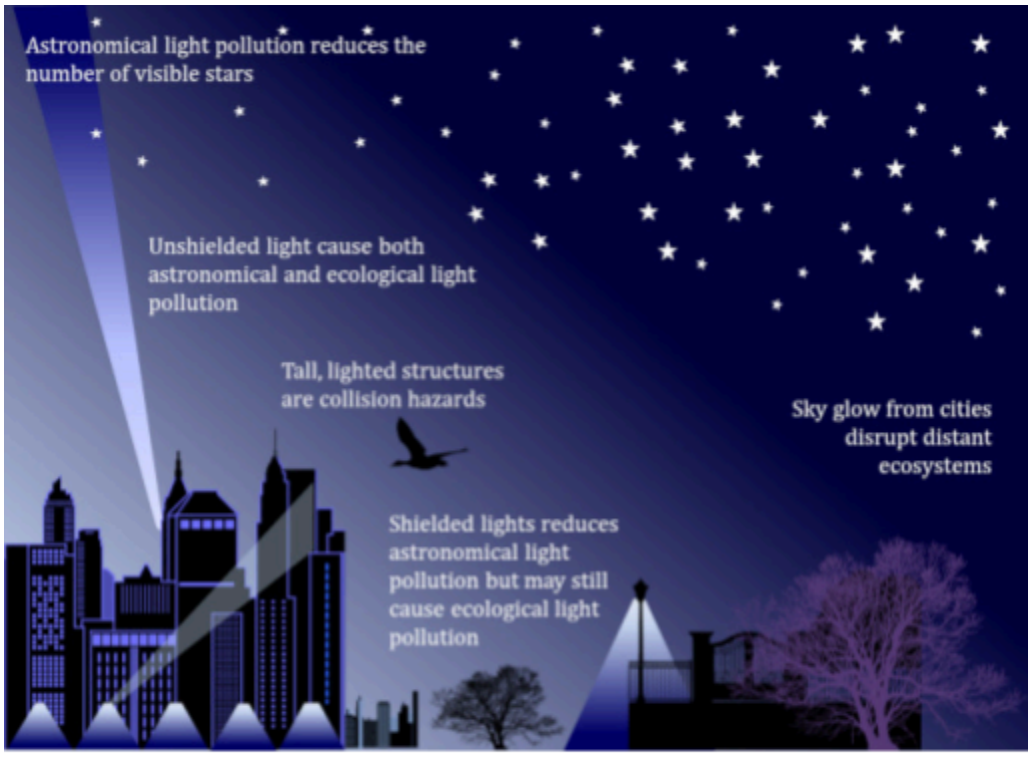

Figure 1: Light Pollution Infographic

Key concepts:

Skyglow: "Brightness of the night sky in a built-up area as a result of light pollution. "

International Dark Sky Association (IDA): " DarkSky International restores the nighttime environment and protects communities from the harmful effects of light pollution through outreach, advocacy, and conservation."

Effects of light pollution

Light pollution can have many different effects, some of which are described below:

Ecological Disruption: According to Britannica, ecological disruption is: *"an event or force, of nonbiological or biological origin, that brings about mortality to organisms and changes in their spatial patterning in the ecosystems they inhabit. Disturbance plays a significant role in shaping the structure of individual populations and the character of whole ecosystems."* (Paine, 2019). This is directly related to light pollution because when it comes to artificial light, it can cause diverse ecological consequences to multiple ecosystems and disrupt their processes.

To begin with, artificial light tends to alter natural cycles. In the first place, one of its major impacts is the way in which it suppresses the production of melatonin, which is the hormone in charge of regulating sleep in animal organisms. This not only causes insomnia and mood swings, but also various health problems. At the same time, thousands of bird species suffer from disorientation since they use the light of the moon and the stars to guide them. Additional lights external to nature may lead them to become disoriented, damaging the natural cycles or even leading them to death by exhaustion when they get confused with the daylight produced by the sun. In addition, artificial light tends to encourage many species of insects to approach the unnatural sources of light, making them easy prey for species such as bats, thus damaging the food chain from the first trophic levels.

Artificial lighting also impacts the photosynthetic processes of plants, thus affecting their growth and proper development and functioning. This may then have knock-on effects on pollinating species such as bees. Luminosity is one of the most important factors for an ecosystem to be adequate and habitable for any species; if there is not adequate luminescence, the quality of life of flora and fauna species can be negatively affected.

In marine ecosystems, artificial light is particularly detrimental to food chains. This is because fish and other marine species use sunlight as a guide to find food and avoid predators, but the existence of artificial light affects their feeding patterns and makes many species more vulnerable to predation. Turtles, for example, are attracted to lights from the shore when they hatch, meaning that they head towards the land instead of the sea on hatching. Artificial light can stimulate an over-production of eggs in certain parts of coral reefs. These eggs cannot be fertilised, leading to a reduction in the growth of new coral

Melatonin suppression: According to the National Center for Complementary and Integrative Health (May 2024), Melatonin is: *"a hormone that your brain produces in response to darkness"*. Artificial light and, in turn, light pollution cause suppression of the creation of melatonin in both animal and human organisms. The creation of melatonin is triggered by darkness. Due to the existence of artificial light such as street lights, electronic devices, and bright indoor lighting, organisms are not able to complete this process, as these lights imitate sunlight and tend to confuse the body, making the brain believe that it is still daytime. For this reason, a deficit of the hormone is created, causing problems of insomnia, emotional changes or even problems in the nervous and circulatory system due to lack of sleep. It becomes more complicated for the brain to sleep and stay asleep for a long time.

Skyglow: According to the Department of Energy, skyglow is: *"an increase in the apparent brightness of the night sky that can serve to reduce visibility for astronomical observation".* For many years, astronomers have demonstrated concern about the increasing intensity of skyglow, a phenomenon caused by artificial light scattering in the atmosphere. Skyglow is demonstrated as a luminous dome above populated areas like cities, towns etc, that is noticeable mainly when looking back towards them from a darker space. This dome appears from the accumulating effect of various light sources projecting into the night sky. These sources include streetlights, parking lot lights, building security and interior lighting, landscape lighting, sports lighting, and even car headlights.

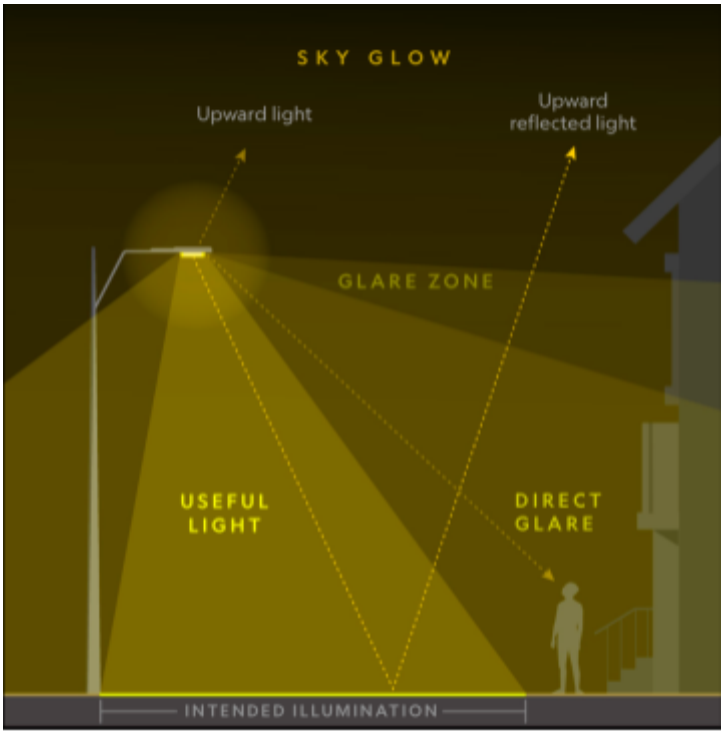

Figure 2: Skyglow Infographic

The main environmental impact of skyglow lies in its upward light component. Uplight refers to light travelling upwards from a horizontal plane. It can be both direct emissions from installations and light reflected upwards from the ground, buildings, and other surfaces. This light interacts with the atmosphere, breaking off air molecules, dust particles, pollutants, and water droplets. The scattering process brightens the night sky.

The environmental consequences of skyglow extend beyond astronomical observation. The disordering of the natural light-dark cycle caused by skyglow can have catastrophic effects on ecosystems. Disoriented nocturnal species rely on darkness for essential activities like navigation, foraging, and reproduction. Skyglow disrupts these natural cycles, impacting species' survival and possibly negatively adjusting entire ecosystems.

Concerns about light pollution

The concept of light pollution is relatively new. Throughout history, light pollution has not been considered a problem to be concerned about. This is because it had not been scientifically recognised as having a major negative impact on ecosystems worldwide. The first time it was recognised as an environmental problem was in the 20th century. However, this form of pollution actually began in

the 1870s in certain parts of the world where light bulbs were used in entire cities to replace gas, oil, and tallow lamps. These were much brighter than street lighting that had been used previously.

Figure 3: Levels of light pollution (DarkSky)

In the 1970s, astronomers began to communicate the serious and profound effects that artificial lighting was having on nature. It was also becoming quite complicated to observe the stars with the existing technology of the time. In the 1980s the IDA (International Dark-Sky Association) was created. This is a non-profit organisation that aims to preserve and protect the night sky, creating awareness among world citizens about the importance of darkness and trying to use as little artificial light as possible. Its director, Amanda Gormley, stated: *"We lose something essential; we lose a part of ourselves when we lose access to the night sky. We lose that sense of stillness and awe that should be right over our heads every night."*

Additionally, governments of countries such as Spain created organisations such as IDAE (The Institute for Energy Diversification and Saving 2004) when they realised

that this problem was seriously affecting their ecosystems and economy. Some countries, such as France, South Korea, and Chile have created laws to combat light pollution.

II. Current Situation

Figure 4: Satellite map of light pollution (National Geographic)

Light pollution at different regions:

According to National Geographic, *"Some of the most light-polluted countries in the world are Singapore, Qatar, and Kuwait."* and, *"More than 80 percent of the world's population, and 99 percent of Americans and Europeans, live under sky glow."* While sky glow may seem "attractive", it is crucial to highlight that this phenomenon, caused by anthropogenic activities, is one of the most invasive and harmful forms of light pollution.

Additionally, an article published in 2017 by the University of Hong Kong notes that the city's sky was *"1200 times brighter than a normal dark sky"* and *"30 times higher than other countrysides"*, attributed to the presence of over 130,000 streetlights, not to mention domestic and commercial lighting.(Lau Sum et al., 2014)

In Spain, particularly in Madrid, serious impacts are also being felt. An article from 2019 on the website EL PAIS states that *"scientific studies have drawn attention to the problem with striking images that capture the light pollution emitted by Spain's major cities"*, indicating that Europe is facing a severe issue of this type of contamination. (El País, 2019)

Moreover, in the United States, cities like New York also suffer from high levels of light pollution. According to a report from 2015 on adubon.com, the local government became aware of the high mortality rate of migrating birds in the city. In response, a measure was implemented to turn off most lights to allow the birds to migrate at night without becoming disoriented. The New York city government stated that, *""This is a simple step to help protect these migrating birds that make their home in New York's forests, lakes and rivers,"* the Governor stated. (Palus, 2015) This initiative had a very positive effect on environmental health; however, no further similar measures have been taken in the future, as this project appears to have been forgotten.

Regarding Africa, it has been found that dark skies can significantly contribute to environmental development, which in turn bolsters the economy. This is primarily due to the practice of keeping lights off in areas dominated by nature such as safari regions. As a result, much of the local fauna, and consequently the flora, benefits, as the integrity of the animals is preserved from the effects of light pollution. Therefore, tourism remains an essential component of the economy and is not adversely affected by this type of pollution.

In addition, Shanghai is well known for its excessive light pollution; however, an article published by Dialogue Earth in 2022 highlights the government's concerns

regarding the impact of light pollution on bird migration. Although they have not yet fully implemented the proposed plans, they are beginning to engage in dialogues aimed at promoting the practice of turning off lights to protect the surrounding wildlife. Additionally, it is believed that Shangai will be the first city in China to establish regulations aimed at reducing light pollution, which represents a significant advance.

According to Adrew Farnsworth, an ornithologist at Cornell University, *"Turning off lights during migration season is the easiest and most effective solution"* and he further noted that *"It is not only beneficial to bird migration, but to the health of residents. It also reduces energy consumption and carbon footprint. Any city around the world should do the same, whether it's New York or Shanghai."* (Huang, 2022)

Impacts of Light Pollution

Economic: The economic sector can also be negatively affected by light pollution due to wastage. About 30 percent of outdoor lighting worldwide is wasted as a result of poor planning and lack of control. This not only means additional costs for the government, but also for many private sector companies and households worldwide. It also means more environmental costs for governments because in the vast majority of countries, electricity relies on non-renewable sources such as fossil fuels, which increases greenhouse gas emissions and in turn climate change. Therefore, in areas such as citizen health, environmental damage, and climate change mitigation, light pollution means additional costs for governments. The International Dark-Sky Association, estimates that about ⅓ of the lighting is wasted annually and in

Figure 5: Economic waste from light pollution (Kiwi Energy)

terms of monetary resources this would be equal to about 2.2 billion dollars each year.

As mentioned before, artificial light tends to negatively alter sleep patterns and melatonin production. Lack of quality sleep predisposes people to suffer from serious diseases, thus governments in the long run will also be paying the consequences of this. In the great majority of cases, environmental affectations also end up being economic affectations in the long term. Light pollution affects agriculture and fishing due to the obstruction of natural cycles and the decrease of diversity and population.

Efficient lighting may also positively affect the economy. This is because it benefits aspects such as increased public safety, since having visibility on the streets or roads creates a safer environment in terms of theft or road safety. It also helps to extend working hours, which allows companies to create more shifts for employees and thus have greater production ranges. As far as tourism is concerned, night lighting is of great benefit. This is because in many cities of the world such as Las Vegas, much of the tourism depends on the nightlife that is offered. It is important to find a sensible balance between efficiency and pollution.

Scientific: Skyglow has had serious effects on the science of astronomy. It limits the ability of scientists and astronomers to observe the stars correctly since it obscures celestial objects, making astronomical research impossible. In a study reported in Science journal citizens scientists were asked about the visibility of stars. They reported that between 2011 and 2022 they were able to see fewer and fewer stars, which related to a 7-10% increase in sky brightness every year. (Kyba et al., 2023)

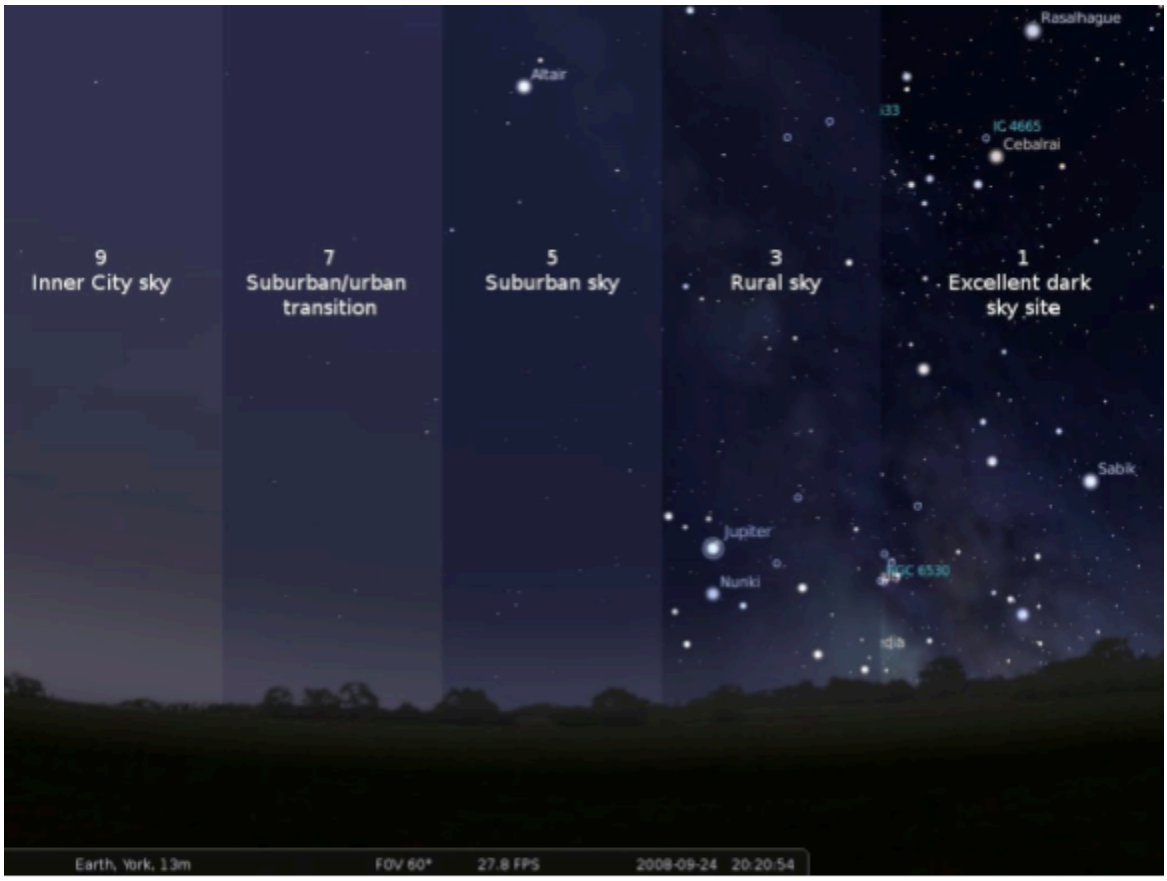

Figure 6: Stars that can be seen in different parts of the planet (JMU)

What have some countries done to solve this issue?

Intergovernmental Organisations (IGOs) such as the European Union have developed and implemented diverse legislations and strategies to ensure that minimum rates of light pollution are present in each member state. Measures include: setting technical standards; producing awareness-raising manuals or

Figure 7: Polluting vs non-polluting streetlamps (Astro Backyard)

guidelines; financing research projects; and allocating dark-sky areas. For example, in 2019, the EU revised its Green Public Procurement Criteria for Road Lighting and traffic signals, known as the GPP, to Implement strategies to address light pollution, reduce energy usage in outdoor lighting systems, and to ensure the long-lasting performance of lighting fixtures. Member states have implemented several measures for street lighting such as activating sensors and timers, which reduce illumination levels and are only used when it is mandatory instead of having the street light turned on all the time.

Figure 8: Singapore night-time light pollution (Roamscapes)

An example of extreme light pollution can be seen in Singapore. According to the BBC, *"In Singapore, the entire population lives under this extreme level of artificial night-time brightness, and it is a problem affecting many other parts of the world."* (Morelle, 2016) Singapore has also been rated the most light-polluted country in the world. This is because Singapore has a very high population density as the country is located on a small island - the amount of people who inhabit the country is very dense compared to the amount of available territory. This amount of population translates to a high number of light resources needed for different aspects like homes, offices, businesses, public spaces, streets, and more. Also, countries such as Singapore prioritise their security and visibility rather than the environmental impact this might lead to. This is the reason why they have many public spaces utilising artificial light, which not only affect Singapore but also the rest of the world. In addition, in this country, there is a lack of awareness about light pollution and the consequences each citizen might have for producing this type of contamination are limited.

Africa tends to have the lowest levels of light pollution. For example, countries such as Chad present the lowest light pollution rates around the world. One of the main reasons is that these countries have limited infrastructure, which directly leads to a less extensive electricity supply for its citizens compared to other nations. Much of the population lives in rural areas, further minimising the amount of artificial illumination, as urban areas tend to have more light pollution. In addition, some African countries have limited industrial activity, which tends to cause a lot of light pollution. However, as more people migrate to large cities, the level of light pollution in these areas rises.

An example of how light pollution has decreased in one region of the world is in Arizona, USA. This state is well-known for being a great destination for those who love astronomy. However, at the end of the 20th century, the state was losing the visits of the majority of tourists and astronomers who came to Arizona to see the stars. Even though the state had perfect weather, mountainous geography and good management of the countryside, light pollution meant that visitors could not see the stars as they had been able to in the past. For this reason the government decided to implement diverse measures to make sure the rates of light pollution were reduced, as it was not only harming nature, but also the economic sector by affecting scientific investigations and tourism. Some of these measures were:

Figure 9: Tucson, Arizon reduced light pollution by changing street lighting to LED lamps

- using outdoor lighting only when necessary (in the streets and houses of the state)

- implementing a sensor system in which light is only turned on when it is strictly necessary
- changing the types of bulbs used for street lighting.

After a few months of implementing these changes stars were more visible for tourists and there was an environment development regarding light pollution.

Another example regarding light pollution initiatives, is in Zion National Park in the US. Around 2023, in this place a transition from their old shuttle buses to a new fleet of electric vehicles started to happen. Among various designs for the new buses, one is centred on preserving dark skies. The design of the bus features the message “TURN OFF THE LIGHTS / INTERNATIONAL DARK SKY PARK DAY.” The right side displays a full-length image of stars and a telescope, along with the phrase “SEE THE STARS / INTERNATIONAL DARK SKY PARK DAY.”

There are various organisations around the world that are working to tackle the problem of light pollution. DarkSky, The Starlight Initiative and the International Astronomical Union are just a few of these institutions.

III. Key points of the debate

- Causes of light pollution
- Effects of light pollution on the environment
- Effects of light pollution on the economy
- Aid to ecosystems affected by light pollution
- Public awareness about light pollution
- Solutions for light pollution
- Economic penalties for places with high levels light pollution

IV. Guiding questions

1. What are the main causes of light pollution in your country?
2. What are the environmental implications of light pollution in your country?
3. How does light pollution affect local communities in your country?
4. What solutions are currently proposed and/or are in place to mitigate light pollution in your country?
5. How effective have these measures been?
6. How can public awareness positively impact the light pollution issue?

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