International Effort to Combat Light Pollution

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ABSTRACT

Modernity is identical to the use of lamps. However, the modernity marked by using lamps also bring adverse impacts. The negative effects caused by excessive light bear the term light pollution. Light pollution is the alteration of natural light levels at night caused by artificial light. The research question in this paper asks how the international effort combats light pollution. This research employs descriptive and literature research methods by collecting secondary data from related researches and international organizations' documents. The data were analyzed using institutional theory. The international effort to combat light pollution has a long process until it produces the Dark and Quiet Skies Initiative. As an international effort to combat light pollution, the Dark and Quiet Skies Initiative is a form of countries' shared interest and interdependency. This initiative is also a form of countries' common worldview and persistence on the light pollution issue. Moreover, it manifests the role of norms and values to restrict individual countries' actions.

Keywords: *dark and quiet skies initiative, international effort, light pollution*

Modernitas identik dengan penggunaan lampu. Namun, modernitas yang ditandai dengan penggunaan lampu juga membawa dampak negatif. Dampak negatif yang ditimbulkan oleh cahaya yang berlebihan inilah yang memunculkan istilah polusi cahaya. Polusi cahaya didefinisikan sebagai perubahan tingkat cahaya alami pada malam hari yang disebabkan oleh cahaya buatan. Penelitian ini mempertanyakan bagaimana upaya internasional untuk mengatasi polusi cahaya? Penelitian ini menggunakan metode deskriptif dan teknik penelitian kepustakaan dengan mengumpulkan data sekunder dari penelitian terkait dan dokumen organisasi internasional. Data yang telah terkumpul selanjutnya dianalisis menggunakan teori institusional. Upaya internasional untuk mengatasi polusi cahaya memiliki proses yang panjang sampai menghasilkan Inisiatif Langit Gelap dan Sunyi. Sebagai upaya internasional untuk mengatasi polusi cahaya, Inisiatif Langit Gelap dan Sunyi adalah bentuk kepentingan bersama dan saling ketergantungan di antara negara-negara. Inisiatif ini juga merupakan bentuk cara pandang yang sama terhadap dunia dan kegigihan negara-negara berkaitan dengan masalah polusi cahaya. Selain itu, inisiatif ini menunjukkan peran norma dan nilai untuk membatasi tindakan negara.

Kata-kata kunci: *inisiatif langit gelap dan sunyi, polusi cahaya, upaya internasional*

In the modern world, human tends to be productive. Many people still work and conduct many activities at night, increasing the need to use light. Many buildings in the city put some lamps to help human activities. Besides, the main street also has lamps for security reasons. Moreover, during certain celebrations like Christmas, people, stores, and public places put more lights for decoration. These phenomena show that lamps are helpful and make human life more manageable. However, too many lamps also bring a problem to the environment. It is called light pollution.

According to Taylor Stone (2017), in the research entitled "Light Pollution: A Case Study in Framing an Environmental Problem", the concept of light pollution emerged in the 1970s. Astronomers were the first group that brought the case of light pollution. They said that excessive artificial light at night could disturb stars' visibility. Besides advocation, astronomers also used anti-waste strategies to fight and mitigate excessive artificial light at night. The efforts conducted by astronomers marked the academic acceptance and adoption of the concept of light pollution. As a result, academic acceptance has become widespread, and some discourses on the adverse impacts of light pollution have emerged across various disciplines (Stone 2017, 285).

Light pollution is the alteration of natural light levels at night caused by artificial light (Falchi et al. 2011, 2714). Lamps put at the buildings or on the street are the artificial light. Meanwhile, the moon and stars are the natural light at night. According to Falchi (2011), the existence of lamps alters the moon and stars' light. There are two categories of light pollution: annoying light and excessive light. Light pollution can also be divided into indoor and outdoor light pollution. Moreover, there are five types of light pollution: light trespass, over-illumination, glare, clutter, and sky glow (Rajkhowa 2014, 861-2).

A report coordinated by the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) mentioned that artificial light at night could be a pollutant that affects humans, flora, and fauna. First, related to human health, research shows a correlation between artificial light at night and elevated rates of hormonal cancer, obesity, diabetes, depression, and sleeping

difficulty. Second, glare from outdoor lighting can cause a hazard to drivers, cyclists, pedestrians, and other road users by temporarily disturbing their vision. Third, artificial light at night negatively impacts many species of flora and fauna. It disrupts the daily life and habit of nocturnal animals and disturbs animals' populations. Some animals tend to avoid light, and others gain benefits from light. The presence of artificial light brings consequences to food chains and habitat use. Fourth, the negative impact of artificial light as a pollutant is borderless. Skyglow is the condition of a brightened sky caused by artificial light scattered within the atmosphere and elevated skyglow levels hundreds of kilometers away from the location of the artificial light. This condition can affect remote and unlit ecosystems (United Nations Office for Outer Space Affairs 2021, 24).

Because of the vast impact of light pollution, it must be taken seriously. Light pollution is as important as global warming (Chepesiuk 2009, A27), and it becomes the human responsibility to reduce it. It has been explained above that the impacts of light pollution affect all living things. They are also borderless, so they need an international effort to overcome this. This research wants to analyze international efforts to overcome the impacts of light pollution. The international effort to overcome the impacts of light pollution is interesting to be analyzed because the research on it is still limited. Most of the research on reducing light pollution is based on specific countries and their national policies. So, this research will bring new insight by giving the international perspective on this matter. Light pollution is indeed an international problem, so it needs international effort to overcome.

Among the massive number of research on the national effort to reduce light pollution, three are cited here. First, a study by Schuler et al. (2018) entitled "From Global Radiance to an Increased Local Political Awareness of Light Pollution" discussed the method to analyze measurements of the Suomi NPP satellite in night vision, luminous intensity, and luminance at the community level, for light planners, politicians, decision-makers, lawmakers, and governmental agencies. The research investigates the efficiency of road lighting, the impacts of luminous flux, and a waste of light emission in Zurich, Switzerland (Schuler et al.

2018). Second, research from Daniel Silver and Gordon Hickey entitled "Managing Light Pollution through Dark Sky Areas: Learning from the World's First Dark Sky Preserve" examined stakeholders' dynamics involved in dark sky areas establishment and management in Ontario, Canada (Silver and Hickey 2020). Third, Bará et al. (2021) research entitled "Keeping Light Pollution at Bay: A Red-Lines, Target Values, Top-Down Approach" described the red-lines strategy to complement the current policy on light pollution control by using a case study based on night sky brightness at Zenith (Bará et al. 2021).

As explained above, light pollution has broad impacts on the life quality on earth, affecting humans, flora, and fauna. Moreover, the consequences can cross the national border. For example, the negative impact of skyglow can spread through the atmosphere, which does not have national boundaries. So, this research aims to analyze the international effort to combat light pollution using institutional theory. Therefore, the research question in this paper is how the international effort combats light pollution.

This research is descriptive and employs library research technique to collect the data. The data collected were secondary data on light pollution and the dark and quiet skies initiative. They were collected from research articles and documents from UNCOPUOS and International Astronomical Union. These documents were the main data resource for this research. Paul Atkinson and Amanda Coffey wrote that documents are 'social facts', in that they are produced, shared, and used in socially organized ways (Atkinson and Coffey 2004, 58). Statement from Paul Atkinson and Amanda Coffey shows the importance of documents in research. The research articles on light pollution collected for this research were published from 2011-2021. They were collected through Science Direct. Meanwhile, the documents from international organizations were collected from UNCOPUOS and International Astronomical Union's websites. After collecting the data, they were analyzed using institutional theory. This theory was chosen because it emphasizes the role of international institution and tries to see why sovereign states agree to establish international institution (Jönsson and Tallberg 2001, 4).

Institutional Theory

Institution is defined as related complexes of rules and norms identifiable in space and time (Keohane in Schimmelfennig 2015, 94). This definition shows that institution is an independent actor; it has its own rules and norms; it can also be identified in a certain time and space. In International Relations, there are two types of institutions: international regimes and international organizations. More specifically, international organization as an institution can shape actors' behavior in ways that cannot be fully explained by the constellations of power and preferences from which they may have originated. Moreover, international organization can redistribute power and change actors' preferences. Since it can shape actors' behavior and preferences from their originals and redistribute power, international organization is seen as an independent actor which pursues its purposes independently from its member states (Schimmelfennig 2015, 95).

The definition of institution above is suitable to be used for this research. It is because the Dark and Quiet Skies Initiative is an initiative of two institutions, the International Astronomical Union (IAU) and UNCOPUOS. The emergence of this initiative shows that ITU and UNCOPUOS, as international organizations, can act as independent actors which pursue their purposes. Based on the abovementioned definition, this research chooses institutional theory as an analysis tool because this research focuses on analyzing a product of international organizations, namely the Dark and Quiet Skies Initiative. Institutional theory has three perspectives to analyze the Dark and Quiet Skies Initiative, as explained in the next paragraph.

According to Christer Jönsson and Jonas Tallberg in their paper entitled "Institutional Theory in International Relations", institution can be seen using three different perspectives. There are rational choice institutionalism, historical institutionalism, and normative institutionalism. Rational choice institutionalism assumes that states with self-interest are central actors in the political process. International institutions' establishment results from interdependence, strategic interaction, and collective action or contracting dilemmas. The emergence and

the existence of international institutions depend on the interest and interdependence among countries. International institutions can survive if they can fulfill the needs of the countries which have built them. Historical institutionalism represents a cultural approach. It means that the behavior of individual states is not entirely strategic but bounded by their worldviews. Historical institutionalism focuses on the contingencies of history, the path dependency, and the persistence of institutions more than the strategic ratio based on self-interest. Normative institutionalism redirects attention from rationality and means-ends efficiency to the role of norms and values. It focuses on how the institution constrains individual states' choices (Jönsson and Tallberg 2001, 5-6).

Those three perspectives are used to analyze the Dark and Quiet Skies Initiative to better understand this initiative as the product of international organizations. Each perspective has different focuses on how they see international organization as an institution. Consequently, analyzing the product of international organizations is more comprehensive when those three perspectives are used. Furthermore, there are no dominant perspectives among those three because they complement each other. Therefore, the analysis using those three perspectives can give a complete understanding of the Dark and Quiet Skies Initiative as a product of international organizations.

The Benefits of Dark Skies

The document entitled "Report of the Scientific and Technical Subcommittee on its fifty-ninth session, held in Vienna from 7 to 18 February 2022" mentioned that the sky's darkness must be preserved to make astronomical observation becomes possible. Moreover, the document mentioned that astronomical observation from space and Earth-based installations supported the ability to understand the universe, enabled deep space navigation and exploration, and provided early warning detection of near-Earth objects (United Nations Committee on the Peaceful Uses of Outer Space 2022, 37). Therefore, other than posing the threat of light

pollution, they tried to elaborate on the advantages of dark skies.

Dark and Quiet Skies Initiative

In the research entitled "Light Pollution and Impact of Light Pollution", Rajkhowa (2014) mentioned that light pollution can affect humans, animals, and plants. However, the first noticeable impact of light pollution is on astronomy in the form of the bright night sky. The bright night sky can disturb astronomers who observe the stars, galaxies, and other phenomena in the sky. Besides, light pollution also creates energy waste.

Light pollution can affect human health. It can be in the form of headaches, fatigue, stress, decreased sexual function, and increased anxiety. For example, daily exposure to high lighting for an extended period can lead to diminished sexual function. In addition, too much artificial light exposure at night can increase breast cancer risk due to the suppression of the production of melatonin hormone.

Light pollution may affect some animals. For birds, light pollution can lead to disorientation when they migrate. Light pollution, which can disturb birds during migration, can exist in lighthouses, light beams, light-induced fisheries, city lights, and towers. For sea turtles, light pollution can affect female turtles' when they search locations for nesting. It can also disturb hatchlings to find the sea. For fish, artificial light can disrupt their natural behavior. Artificial light attracts certain fish species. It is often misused by anglers or industrial fisheries to catch more fish.

Light pollution affects plants' metabolism, development, and life programs. Light pollution can also affect the ecosystem. First, light pollution disturbs nocturnal animals' ability to navigate. One of the animals which should navigate at night is insects. If their ability to navigate is disturbed by light pollution, they cannot help the pollination of night-blooming flowers. It will lead to species decline because certain plants cannot reproduce. Light pollution also hinders trees from adjusting to seasonal alterations (Rajkhowa

2014, 862-865).

Besides, the Committee on the Peaceful Uses of Outer Space (2017) mentioned that recent decades have greatly improved astronomy research. For example, for the data collection capabilities, i.e., telescopes (for the UV, optical, and IR wavelengths), antennae (for the radio frequencies), and more recently, detectors for neutrino and gravitational wave events. These modern infrastructures need a lot of money for investment, so they must be secured. It is essential to make those infrastructures operate optimally for a certain period. Protecting the environment around the infrastructure is necessary to maintain their performance.

One of the environmental problems is the extensive illumination of urban areas. Consequently, it leads to the deprivation of the vision of the night sky. In response, a resolution in defense of the night sky and the right to starlight was approved at the 27th International Astronomical Union (IAU) General Assembly in 2009. Then, IAU submitted a proposal at the 54th session of the Scientific and Technical Subcommittee (STSC) in 2017. The proposal was made available in a conference room paper (CRP) as an initiative under the Committee on the Peaceful Uses of Outer Space (COPUOS) to protect environmental observing conditions for large astronomical observatories and world citizens (United Nations Committee on the Peaceful Uses of Outer Space 2017, 1-3). Also, in 2017, COPUOS agreed to work with IAU to hold a conference on light pollution (United Nations General Assembly 2021, 1).

The initiative to protect the dark and quiet sky originated with two days off-campus meetings at Kuffner Observatory during the 2018 IAU General Assembly in Vienna. The first day of the meeting discussed, among other technical issues, recommended standards for site protection for optical and radio observatories, measurement and modeling of artificial light at night, and heritage and dark sky sites. The second day of the meeting focused on mitigating light pollution and radio interference through site protection and education. Then, a conference on Dark and Quiet Skies for Science and Society was planned to be held in October 2020. However, due to the Covid-19 pandemic, the conference was postponed until October 2021. The conference was intended

to develop a set of policy recommendations for consideration and approval by COPUOS, first through its Scientific and Technical Committee, then by the entire United Nations General Assembly (International Astronomical Union 2021, 1-2).

Due to the covid-19 pandemic, the planned conference was postponed until October 2021, and an online workshop was held on 5-9 October 2020. This workshop discussed initial findings and draft recommendations. The recommendations were submitted at the 58th session of the STSC meeting in April 2021 in the form of CRP entitled "Recommendations to Keep Dark and Quiet Skies for Science and Society". This CRP explained the issues faced by astronomy. The Scientific and Technical Subcommittee was invited to give comments on the recommendations mentioned in the CRP. After that, the comments were reviewed during the Scientific and Technical Subcommittee session in April 2021. After the session, the CRP was revised and presented during the COPUOS meeting in August 2021 (United Nations Committee on the Peaceful Uses of Outer Space 2021, 1).

The CRP mentioned three types of artificial interference that may disturb the visibility of the night sky and astronomical science. The three types of artificial interference are satellite constellations; artificial emission of light during the night, also known as artificial light at night (ALAN); and radio astronomy. So then, those three types of artificial interference affect five sectors. They are satellite constellations, citizens' right to enjoy the vision of the starry sky, the protection of dark sky oases and astronomical observatory sites, the environment in general, especially biological life and human health, and radio astronomy (United Nations Committee on the Peaceful Uses of Outer Space 2021, 2-4).

In 2021, the conference on Dark and Quiet Skies for Science and Society was held online on 3-7 October 2021. The conference report was submitted on document A/AC.105/1255 of the United Nations General Assembly. This document also reported the conference's objectives, attendance details, presentations and discussions, conclusions and observations. The conference focused on technical and policy actions associated with the recommendations, particularly identifying which stakeholders

and partners would need to collaborate to implement satisfactory solutions for preserving dark and quiet skies. The conference's program consisted of presentations from working groups of the scientific organizing committee, talks by invited speakers, and contributions selected through a call for abstracts in the form of poster presentations and round-table discussions. In addition, the conference discussed various aspects of artificial light at night, the impact of satellite constellations, and radio astronomy (United Nations General Assembly 2021, 13-14).

Moreover, some countries that attended the conference suggested a new agenda item to be discussed at the STSC meeting in 2022. They proposed the wording of "General exchange of views on the effect of satellites upon astronomy" as the new agenda item at STSC 2022 (United Nations, 2021). At the beginning of the STSC session on 7 February 2022, under the discussion of the "Adoption of the Agenda", a new agenda item entitled "Dark and Quiet Skies" was accepted as the agenda for the STSC meeting. The discussion on the agenda of "Dark and Quiet Skies" during 2022's STSC meeting explored the views regarding this matter from member states and permanent observers. Besides the discussion during the main session of the STSC meeting, a symposium on Dark and Quiet Skies was held on 15 February 2022. This symposium was organized by the Office of Outer Space Affairs (OOSA).

Dark and Quiet Skies Initiative and Institutional Theory

As the international effort to combat light pollution, the Dark and Quiet Skies Initiative can be analyzed using institutional theory. As explained above, this initiative has a long history. It was started in 2009 by a resolution to defend the night sky and the right to starlight made by ITU. However, ITU members did not stop in 2009. They continued to another forum, UNCOPUOS, primarily through its Scientific and Legal Subcommittee (STSC), by submitting a CRP. Members of UNCOPUOS gave positive responses until it became an agenda item at the STSC meeting in 2022.

From the rational choice institutionalism perspective, the Dark and Quiet Skies initiative shows the interdependence and collective action among ITU and UNCOPUOS members. Rational choice institutionalism sees states as individual actors with self-interest. When a lot of countries have common self-interest, they become interdependent. The interdependence makes them create the international initiative. In the Dark and Quiet Skies Initiative context, countries share a common self-interest in combating light pollution. This initiative is a collective action by countries through two international institutions, ITU and UNCOPUOS. This initiative is still running. It started as a new agenda item at the STSC meeting in 2022. It will be discussed during the STSC meeting as a permanent agenda item in the following years. According to the rational choice institutionalism perspective, this initiative is still running because it still suits countries' interests.

The historical institutionalism perspective sees that countries' behavior is determined by their worldview. For example, in 2017, the United Nations Committee on the Peaceful Uses of Outer Space talked about the massive improvement in astronomy research on the "Dark and Quiet Skies" proposal. Besides the massive improvement in astronomy research, this document discussed the side impact of the research on the environment. The side impact is the over-illumination of the urban areas. UNCOPUOS produced this document, and UNCOPUOS consists of more than 100 member states. From the historical institutionalism perspective, this document was made because UNCOPUOS member states have a common worldview. It is the common view on the side impact of the massive improvement in astronomy research.

The historical institutionalism perspective also focuses on the persistence of the institution. The above explanation of the history of the Dark and Quiet Skies Initiative proves that ITU and UNCOPUOS are persistent in fighting to realize an international effort to combat light pollution. It can be seen from the effort that started in 2009 until 2022. For example, the effort at the UNCOPUOS shows the persistence of member countries. This committee uses a consensus mechanism to make decisions on certain issues. Consensus is a decision-making method in which a group deliberates to reach a unanimous decision. In the context

of COPUOS and its two subcommittees, they use a no-objection procedure. The chair observes the agreement achieved by the member states, and when the chair does not see any objections, the chair makes a decision. By applying this method, the consensus is achieved and used by COPUOS and its subcommittees (Sugiyono 2011, 259). It is believed that if a country has any objection to the dark and quiet skies matter, this will not be an initiative and a new agenda item of the STSC meeting. The consensus agreed by UNCOPUOS members also shows the dependency among countries. The historical institutionalism perspective also pays attention to dependency.

The normative institutionalism perspective pays attention to the role of norms and values. It focuses on the ways institutions constrain individual countries' choices. As explained in the previous paragraph, the consensus method used at the UNCOPUOS can be seen as an institutional norm that constrains individual countries' choices. It does not matter how strong a country's desire is; if another country rejects its idea or proposal, then that idea or proposal cannot be accepted. Because of this mechanism, UNCOPUOS and its two subcommittees' meetings become the arena for countries to pursue others to follow their desires. Therefore, it is important to get a consensus without any objections from this committee. This rule works as a norm to constrain countries' attitudes. Because of this rule, countries cannot use voting, for example, to win on specific issues. Instead, they must try to influence others to agree with them or give no objections during the meeting.

Besides norms, the normative institutionalism perspective also sees the role of values. Protecting the environment from the impacts of light pollution is a value shared by countries. This shared value moves them to work hard on this issue. It is stated clearly from the first international resolution made by ITU in 2009 that the purpose of the resolution is to defend the night sky and the right to starlight. The effort does not stop there. In 2017, ITU submitted a proposal to the UNCOPUOS with the same purpose. The discussion and effort on protecting the environment from light pollution's impacts were continued by an international conference initiated by ITU and Spain. The recommendation from that conference was brought to the STSC meeting, and finally, Dark

and Quiet Skies became a new agenda item at the STSC meeting in 2022. Seeing the long and consistent effort from 2009 until 2022 and the possibility that this initiative will be continued proves that protecting the environment from the impacts of light pollution is still relevant for countries. Countries share this value and agree that protecting the environment will be useful for the continuation of astronomical science and the benefit of human life. It is because astronomy is one of humanity's oldest science which has brought massive improvements to human life (United Nations Office for Outer Space Affairs 2021, 12).

Conclusion

Based on the explanation above, light pollution generally brings many adverse effects. Since it has a lot of negative effects, light pollution must be reduced. Reducing light pollution can be in the form of reducing sky glow, glare, light trespass, and clutter. Five possible solutions to reduce light pollution are utilizing light sources of minimum intensity necessary to accomplish the light's purpose, turning lights off using a timer or occupancy sensor or manually when not needed, improving lighting fixtures so that they direct their light more accurately towards where it is required, and with fewer side effects, adjusting the type of lights used, so that the light waves emitted are those that are less likely to cause severe light pollution problems, and evaluating existing lighting plans, and re-designing some or all of the plans depending on whether existing light is actually needed (Rajkhowa 2014, 866). Besides those possible general solutions to reduce light pollution, the international community has initiated more specific actions to combat light pollution.

The international effort to combat light pollution was started in 2009. ITU and UNCOPUOS member states show their commitment and consistency in fighting for this issue. The consistency of some countries to resolve continued by submitting a CRP until online workshops and conferences, which produced recommendations submitted to the United Nations General Assembly, showed that the problem of light pollution has caught the attention of many

countries. Based on the analysis above, the Dark and Quiet Skies Initiative, as the international effort to combat light pollution, is a form of countries' interdependency. Countries with their self-interest might come to a particular shared interest. If they do so, they initiate an international initiative or effort to fulfill their shared interest. This initiative is also a common worldview among countries and their persistence in combating light pollution. From the normative institutionalism perspective, this initiative manifests norms and values to limit individual countries' choices.

The Dark and Quiet Skies initiative should be maintained as a new international effort. The discussion under the Dark and Quiet Skies agenda item at the STSC meeting can be a hope to continue the fruitful discussion to combat light pollution at the international level. The discussion was started at the STSC meeting in 2022 and will be continued in future years. The continued discussion is believed to bring more relevant items in combating light pollution and preserving the natural light in the sky at the international level. The development of this issue at the STSC meeting and countries' national policy related to light pollution to match the agreement at the STSC meeting can be studied in the future. Since it is an ongoing issue, the observation of the development of this issue will enrich the research on light pollution in the International Relations discipline. International Relations scholars still need to analyze the progress and development of international efforts to combat light pollution. In this conclusion, it is no less important to offer solutions to minimize the problem of light pollution.

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