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Discovering Appropriate Policy to Strengthen Indonesia's Space Science: A Discourse Network Analysis

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ABSTRACT

Changes in institutional structures, mandates stated in laws and regulations, growing community participation, and the involvement of government institutions in international space organizations have resulted in issues related to countries' contribution of roles and responsibilities, as well as the strategic value of collaboration for implementing national space science. This study presents the discourse on space science activities in Indonesia. Based on the analysis results of 92 online media articles published from 2022 to 2024, various actors spoke about space science, emphasizing more collaboration and a formulary of technical regulations to handle the country's wide area, while considering modalities that need to be strengthened and challenges that need to be addressed. Using a relationship mapping method known as discourse network analysis (DNA), in which the results were analyzed for causal-effect among them, this study has identified three gaps as the national priority needs: space security for national sovereignty, space disaster mitigation due to falling space objects, and flight safety due to space weather. This study has explained these challenges through a framework that captures the interplay of actors, policy gaps, specific sophisticated technologies, and mandates of actors.

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I. INTRODUCTION

Long before modern science emerged, human civilizations across different periods and various types of geographical location had already interpreted space-related phenomena and connected everything related to life with the dark sky, which eventually have given rise to cultures and beliefs related to celestial objects (Kaminski, 2021). Nowadays, they are are largely explained through scientific narratives (no longer based on myths) and are often featured in media headlines. Driven by global competition and international needs, countries have established space agencies and participated in collective efforts to ensure the sustainable development and utilization of outer space. For developing countries, the ever-increasing global space race poses both opportunities and challenges. The race demands strategic investments in technical skills, incentives for research and innovation, and creation of a conducive environment for realizing science and industrial advancement. Most importantly, the race requires countries to build national scientific capacites to ensure their relevance and sustainability in space domain (Afful et al., 2020).

In Indonesia, the current legal and policy landscape regarding this matter reveals important gaps. The Law Number 21 of 2013 concerning Space (UUK) only stipulates a general regulation and broad outline concerning space activities. Meanwhile, remote sensing activities has been already regulated by the Government Regulation Number 11 of 2018, which provides a more operational and technical legal basis, as well as mastery of space technology that has been already regulated by the Government Regulation Number 7 of 2023. However, apart from the latter two regulations, it is evident that space science in Indonesia—an essential foundation for the advancement of space technology, security, and sustainability—still remains without dedicated derivative regulations.

This gap becomes even more pressing in the context of international trends. Even countries with advanced space programs face challenges in public engagement and policy alignment. For instance, a study in Japan found that despite the country's strong presence of space institution through Japan Aerospace Exploration Agency (JAXA), its public remain largely unaware of the everyday benefits of space technologies (Nagashima et al., 2023). This highlights a broader issue, namely the fittest space policy should consider the morality between space development and the sustainability of space science on behalf of the survival and human welfare (Schwartz, 2014).

For Indonesia, formulating an appropriate and responsive space policy is critical—not only to stay relevant with global developments, but also to align with national needs and institutional dynamics. The post-merger of several research institutions, including the National Aeronautics and Space Agency (LAPAN) into the National Research and Innovation Agency (BRIN) in 2021, has marked a pivotal shift in space governance, necessitating a reevaluation of actor preferences and institutional roles in shaping future space policy.

To address these complexities, this study adopts Discourse Network Analysis (DNA)—a method increasingly used to map actor relationships, interests, and narratives in socio-technical transitions. DNA offers a systematic framework to analyze political discourse and stakeholder alignment. Previous studies had applied DNA in various contexts, such as by using socio-technical configuration analysis as an earlier basis to build DNA to map and analyze actors, interests, orientation, and beliefs from mass media based on three time periods of the space incidents that caused the increase of space debris (Yap et al., 2023). Besides, DNA was also applied in other needs: to investigate political debates on the sustainability transition during the coal phase-out process in Germany between pro-contra coalitions (Markard et al., 2021), to examine the effect of particular factors during the local energy transitions between rural and urban areas (Brugger & Henry, 2021), to analyze a transformative change by involving actors in transitions to implement net-zero emissions policy by adopting hydrogen as an alternative fuel (Ohlendorf et al., 2023), to examine public acceptance of adopting automated vehicles (Waltermann & Henkel, 2023), to study photovoltaic adoption in Indonesia based on sentiment analysis (Mulyani et al., 2024), and to analyze how stakeholders, their positions, and public debate affect political agenda to formulate hydrogen policy at the early stage (Belova et al., 2023). Moreover, DNA was also applied to assess public discourse regarding how Swiss policy aligned with climate change mitigation by involving multiple actors, issues, and coalitions over the last two decades (Kammerer & Ingold, 2023), and to discern the agreement or disagreement among the internal-external actors related to important issues to design agricultural policies (Ghinoi et al., 2018).

Based on the aforementioned background, this study proposes three contributions to the existing literature. First, it analyzes the public debate on space science that emerged after LAPAN, as the space organizer in Indonesia, was merged into BRIN, towards three years of operation. Second, space science activities in Indonesia has been regulated only by UUK so that this study aims to strengthen it by identifying important national policy issues that need to be followed up in order to trigger derivative regulations. Third, this study strengthens the existing methodologies with an analysis of causality among the various issues by involving multi-relevant stakeholders while still considering the mandates stated in UUK.

II. ANALYTICAL FRAMEWORK

The emergence of public discourse can determine how decision-makers analyze policy preferences and the potential for cooperation among different actors (Vogeler et al., 2021). Various institutional changes, shifts in actors' interests, modalities, national needs, and sectoral capabilities are the main consideration factors in relation to what policies need to be accelerated. Furthermore, public discourse can play a very important role in politics and the policy-making process.

Several previous studies used causality analysis to disclose the causal-effect between issues and policy. This analysis can explain issues occurrence due to policies, such as the effects of supply chain on consumer prices due to the dynamism of policy, economic aspects, and cooperation (Mrabet, et al., 2024), and the effects of Islamic finance stability on oil shock prices (Raheem et al., 2024). Certainly, shift in policies and actors have an impact on how Indonesia delivers the services, research, and public enlightenment related to space science. In addition, space science events occur over time, both incidental and in daily cycles. For instance, the fall of a space object has the potential to cause a disaster so that the role of the government policy becomes a determining factor. For this reason, this study maps the space science issues in Indonesia using DNA to shape the public concerns or needs, which is then analyzed for causal-effect among them using knowledge-based and documented evidence.

By integrating this analytical approach, this study not only builds on global methodological trends, but also adapt them to Indonesia's specific institutional and policy context. This approach strengthens the bridge between international discourse and national needs—highlighting how global frameworks can influence localized strategies.

III. METHODOLOGY

DNA, a method for exploring the debate on the structure and dynamics of a policy, is a combination of content analysis and social network analysis based on political, social, cultural, and other discourses, deploying them into a network depiction (Leifeld, 2020). Political discourse is a verbal interaction between political actors, where they make normative claims about interdependent policies. Policy debates can often have consequences for the direction of decisions on the parliamentary agenda and public opinion. Political actors consist of legislators, interest groups, institutions, parties, and other organizations or individuals who make public statements about an issue.

In this regard, DNA can be conducted through deductive and inductive method, or both. In the deductive method, actors, organizations, and concepts are determined in advance as the basis for making annotations of statements from the results of content analysis obtained from discourse articles. Meanwhile, in inductive method, actors, organizations, and concepts are added dynamically based on the content that is considered appropriate to the study's issue by the coder. This study uses both methods.

The study implements DNA by initially determining the keywords based on the activities of research groups within the Space Research Center, BRIN. The keywords as seen in Table 1 became the baseline to annotate the statements in articles, which were collected from the four biggest online mass media in Indonesia, namely detik.com, antaranews.com, kompas.com, and tempo.com. The data collection obtained 92 articles, resulting in 158 statements from 36 people belonging to 18 organizations, during the publication period of January 13, 2022 to May 8, 2024. This selection of publication period was determined after the formation of BRIN following the enactment of the Presidential Regulation Number 78 of 2021 concerning the National Research and Innovation Agency.

Space science activities in Indonesia are regulated in Articles 11–14 of UUK. This is the basis for the initial analysis to find out whether there is a connection between the issues obtained from DNA results and the regulations in UUK. Then, the analysis results were discussed with researchers from the Center for Space Research, Aeronautics, and Space Research Organization, BRIN to

describe the interconnectedness among its sub-activities to find out how they influence each other. The causality approach is a research approach designed to determine the possibility of relationship among variables based on causal-effect connection among them (Sanusi, 2011).

Table 1. Deductive keywords of space science

Keywords
Satellite anomalies and disturbances
Early warning
Space mitigation disaster
Space disaster
National observatory
Space debris
Sky observation
Space station
International participation and cooperation
Astro-tourism
Illegal maritime actions
Space phenomenon
Flight safety

The next step was deepening the issues, then discussing it in focus group discussion (FGD) with related stakeholders, namely 1) the government—represented by BRIN, The Meteorology, Climatology, and Geophysics Agency (BMKG), The National Agency for Disaster Management (BNPB), and the Ministry of Transportation, 2) universities—represented by Bandung Institute of Technology (ITB) and Sumatra Institute of Technology (ITERA), and 3) astronomy society—represented by Langit Selatan and Indonesian Observatory and Planetarium Network (JOPI), to formulate several policy alternatives.

IV. RESULTS

This study used all keywords in Table 1 in a deductive way and added other keywords as long as they were still relevant and related to space science. Based on DNA results as seen in Figure 1, several keywords that had been proposed at the beginning, such as early warning and illegal maritime actions, did not appear in public discourse. Instead, it shows several actors who spoke about space science issues (marked in yellow), consisting of governments (red), non-government organizations (blue), universities (green), and foreign governments (black). Sky observation was the most discussed issue, namely by nine actors; followed by the issue of space phenomena, which involved seven actors; and astro-tourism, international participation, and cooperation were each raised by four actors. It is important to note that the most discussed issues are not necessarily the most important national issues, and vice versa. Even issues that did not/have not yet emerged in public discourse have the potential to become issues that need national attention, emphasizing why these issues need to be discussed more deeply with experts and relevant stakeholders.

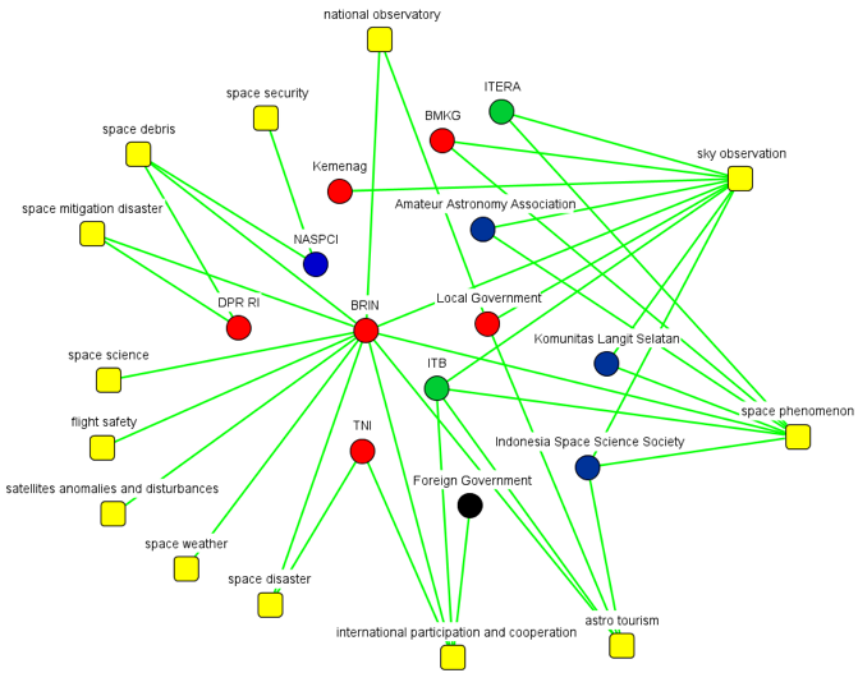

Figure 1. Issue mapping and actor involvement in space science activities based on DNA results

For instance, BNPB did not appear in the actor network regarding space disaster mitigation issue. BNPB was absent because this issue has not yet become a public concern. In addition, these results was obtained from public discourse through mass media coverage. This means the impact of disasters in Indonesia caused by falling space objects, both natural and artificial, is presumably

not as large as those of caused by natural disasters, such as earthquakes, volcanic eruptions, landslides, even floods. Furthermore, there is also no policy on the scheme and mechanism of handling falling space objects. An information obtained from researchers at the Space Research Center reveals that observing space objects that fall to earth is difficult to perform at an altitude of 100 km because there are no tools or methods to ascertain the falling duration or the falling point. In fact, determining the impact level of a disaster due to falling space objects requires certain indicators.

Likewise, the Ministry of Transportation did not appear regarding flight safety issue. This does not necessarily mean that this ministry does not play an important role in this issue, but within the time span of public discourse tracing in the mass media, the issue was not much reported. Even if we look at DNA results, BMKG only mentioned space phenomena and sky observations, even though it has Aviation Meteorology Center. On the other side, BRIN assumes its function as a space organizing institution based on the Presidential Decree Number 78 of 2021, namely by becoming a source of news regarding all public discourses on the implementation of space science, including issues of flight safety, space weather, satellite anomalies and disturbances, and space science. This makes BRIN a central body in the actor-network in various discourses for implementing national space science activities.

In addition, through Figure 1, it can also be explained that on the issue of astro-tourism, there are many discussions about the enthusiasm of the community to learn about astronomical phenomena. For this reason, several local governments have begun to empower their regional potential to increase local revenue, such as the Sermo Reservoir in Kulon Progo, and Punggu Raharjo, Lampung with its archaeoastronomy service.

The issue of space phenomena is closely related to that of sky observation, which greatly includes solar eclipses, super moons, and crescent moon sightings in determining worship period based on the Hijri Calendar. The sky observations are always carried out annually by the Ministry of Religion (*Kemenag*) to determine the fasting period during the month of Ramadan. Meanwhile, the issue concerning the National Observatory (*Obnas*) in East Nusa Tenggara Province (NTT) talks about the readiness of BRIN and NTT's regional government to make Obnas a place for collaboration among space researchers, both domestically and abroad. Obnas has a high potential to become one of the sources of reference for space research and observation, as it will be equipped with a main instrument: a 3.8-meter-diameter optical telescope, which can be stretched out by opening the 14-meter-diameter observatory dome. With the existing potential, it is certainly not surprising that NTT's regional government expects Obnas' contribution to its local revenue, and tries to utilize its buffer areas as tourist attractions.

Next, the issues of space debris, disaster mitigation, and space disasters are interrelated, as it concerns the increase in space debris, monitoring activities, and handling mechanisms when a disaster occurs due to the fall of space debris. The international participation and cooperation talks about the interest of foreign governments to collaborate in space situational awareness and Indonesia's active contribution to the International Space Environment Services (ISES). Meanwhile, the issue of space weather talks a lot about the researchers' ability to predict risks for technological resilience due to space weather phenomena, such as ionospheric density conditions that can affect satellite signals to reach earth receivers.

The next finding reveals that out of a total of 92 articles on DNA, only one Article and one actor discussed the issue of space security. This finding has become the basis of the space security as part of the territorial sovereignty and security of the Republic of Indonesia, which is also be the first focus of this study's issue. This is also regulated in Article 1 Paragraph 12 and Article 8 of UUK.

As obtained from the interview with stakeholders, the issues concerning space weather were revealed, namely flight safety, satellite anomalies and disturbances, and mitigation and space disasters. On the issue of satellite anomalies and disturbances, satellite operations in space can be affected by space environment, one of which is reflected in solar electron flux. In addition, the issue of early warning is a necessary starting point for disaster mitigating and handling due to space weather. Early warning is closely related to the mandate stated in Article 13 of UUK, namely "space weather for mitigation, anticipation, handling of national disasters, and early warning". BRIN has Space Weather Information and Forecast Services (SWIFtS) as a monitoring system that provides daily space weather information and predictions. The monitoring system, which has been integrated into that of the International Space Environment Services (ISES)

since 2016, is claimed to be the first and the only service of its kind within the Southeast Asia region. Figure 2 depicts the results of technical interviews based on causality approach. The results were complemented by evidence-based policies, also by adding UUK's mandate and related documentation, to form the basis for BRIN to formulate better policies.

Given that space weather has a significant influence on the potential for space disasters, awareness for mitigation is in line with the mandate stated in Article 14 of UUK regarding the provision of special information. This special information is divided into two clusters (Figure 2). The first cluster, refers to Article 14 Letter A of the Space Law, consists of flight safety issues and satellite interference anomalies. The second cluster, a mandate stated in Article 14 Letter B of UUK, consists of disaster mitigation issues and space disasters.

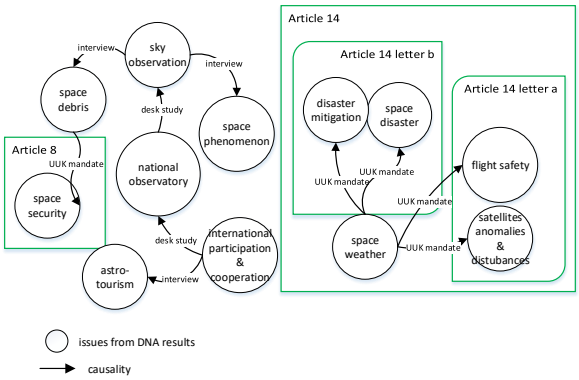

Figure 2. Clustering of space science activity issues based on causality approach

The next causality issue is international cooperation. Indonesia's participation in the development of space weather research is quite active. Not only ISES; through BRIN, Indonesia has always participated in the Asia Oceania Space Weather Alliance (AOSWA) since its establishment in 2010. The existence of Obnas, along with other observatories in Indonesia, has positively shaped Indonesia's ability to conduct sky observations to explain space phenomena for educational and research needs, also sky patrols for surveillance and sovereignty. However, based on Obnas program, as conveyed by head of the Space Research Center, the potential for cooperation is still being explored to develop the national observatories as a global work platform for the needs of astrophysics programs, space weather, space debris, calendar systems for determining prayer periods, and interdisciplinary studies. In fact, global cooperation is necessary if Indonesia has a desire to develop astro-tourism by utilizing its advantageous geographical location on the equator, as done by Chile, Bolivia, and Peru.

Next, based on interview results with Langit Selatan as a community that specializes in space observation and is active in space education to the public and universities, the potential for astro-tourism in Indonesia is highly promising, as it is widely known that Indonesia's public enthusiasm regarding space phenomena is very high. For example, when a solar eclipse occurs, people flock to visit planetariums or observatories owned by universities. According to the representative of Langit Selatan, the government needs to be present in providing an understanding to the public regarding space phenomena and their impact on human life, also to counter hoaxes that are developing in society.

Although it is clear that the development of space science research and activities has grown a lot, there are still many policy gaps in Indonesia that need to be addressed. Based on DNA results, the causality analysis of the issues, and interviews with many experts and stakeholders, three main focus issues were identified: 1) space security for sovereignty based on the mandate stated in Article 8 of UUK, 2) special information on space weather based on the mandate stated in UUK's Article 14 a and b regarding space weather advisory for flight safety, and 3) information on disaster mitigation and handling due to space weather. This was the material discussed in the FGD to formulate alternative policies to strengthen space science activities in Indonesia.

A. Space Security for Sovereignty

Launching space activities have become commonplace for countries that master space technology to continue to seek benefits for human life. However, concerns began to emerge when several countries began to demonstrate their capabilities to create weapons, such as anti-satellite systems, reconnaissance satellites, and even the use of nuclear power in space. The militarization of space continues to be exhibited by countries that master space technology, such as the United States, Russia, China, India, France, and others.

From China's perspective, space security occupies a strategic position. They consider space to be a crucial battlefield in future wars. In 2020, the United States formed a new unit known as the United States Space Force. It is responsible for training and equipping troops for tasks in achieving superiority and readiness in space domain, offensive and defensive control, satellite

operations, support for space operations and services, support for nuclear command, and detection of space nuclear explosions and missiles for defense operations. The attitudes of these developed countries regarding space security are often at odds with the activities they carry out in space. They express support that space security needs to be viewed as a shared concern. However, restrictions on the advancement of space technology, such as the use of weapons and nuclear power, are considered counterproductive matters so that they become a subject of continuous assessment.

United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) has Long-Term Sustainability Guidelines, which is considered a valuable contribution to space security. However, without direct action and good faith negotiations on issues directly related to space security, it is unlikely that real progress will materialize to maintain stability (Blount, 2019). Moreover, based on the guidelines' status, they are voluntary and not legally binding under international law, as stated in the report of the Committee on the Peaceful Uses of Outer Space Annex II, June 12–21, 2019.

Space is indeed dual-use for both civilian and military purposes. In its 2020 vision, the United States has set two themes that can be interpreted as their principles of dominance: 1) dominating space dimension in military operations to protect American interests and investments, and 2) integrating space power into war capabilities that can encompass the entire spectrum of conflict (Sudjatmiko, 2017).

Thus, considering these trends, developing Space Situational Awareness (SSA) capability is inevitable because space is the next field of exploration for future generations and national sovereignty. There are various concepts of SSA. For instance, the Aerospace Corporation defines SSA as the knowledge, characterization, and practice of tracking space objects and their operational environments. SSA data is used to predict conjunctions between objects and warn space operators of potential hazards, allowing them to carefully perform manoeuvres to avoid collisions. Meanwhile, according to the EU Satellite Center, SSA refers to a knowledge about the space environment, including the location and function of space objects and space weather phenomena. Relatedly, according to the Space Foundation, SSA refers to a knowledge to track objects in orbit and predict where they will be at any given time. From these various concepts, SSA can be defined as a comprehensive capability—in the form of knowledge, analysis, and decision-making—that is essential to deal with various possible threats for ensuring space security and maintaining order (Wang et al., 2022).

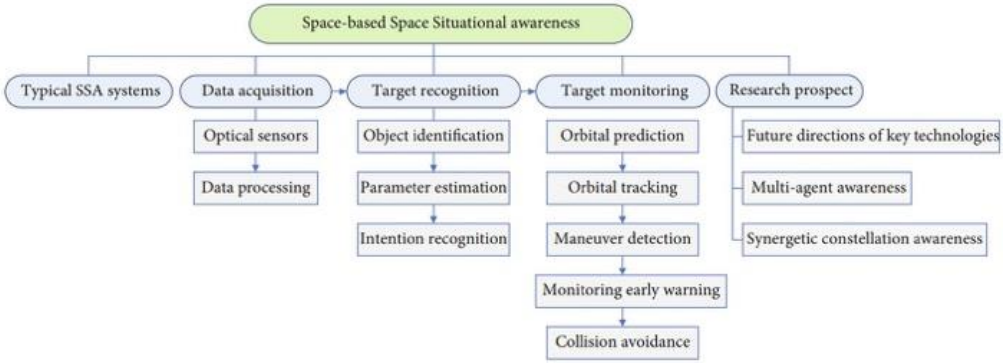

Figure 3. Key technological concept in mastering SSA (Wang et. al., 2022)

Building strong SSA capabilities necessitates adequate human resources, equipment, and infrastructure guided by scientific knowledge obtained from qualified research results. Figure 3 depicts a broad overview of the capabilities that must be possessed for developing SSA capabilities. Indonesia has the potential to play a significant role in this case. The FGD results with Indonesian Observatory and Planetarium Network (JOPI) reveal that Indonesia has more than 60 observatories spread across various locations, owned by government, universities, and high school levels. This is certainly can be viewed as a strong modality that needs to be encouraged through collaboration to cover the country's vast area. With the wide distribution of observatories at various points within Indonesia, BRIN should be able to maximize the role of the community, universities, the Indonesian Air Force (TNI-AU) and related institutions to collectively build SSA capabilities so that they are able to maintain space security, educate the public, and provide

mitigation or early warning of space disasters. This is also part of the development activities of space management as mandated by Article 41 and Article 42 of UUK. Unfortunately, there is no regulatory mechanism for maximizing this modality. This mechanism certainly requires a conductor and regulations to be able to run seamlessly. Therefore, BRIN needs to coordinate the entire observatory network and strengthen them to meet adequate device specification, use the correct scientific methods, and improve observers' capabilities. At the end, the resulting regulations should be reliable to navigate operational activities of space science data services in Indonesia and have to be considered worthy as the future actionable policy.

B. Special Information on Space Weather Advisory for Flight Safety

Technological advancement is increasingly penetrating the daily life through the emergence of sophisticated terms, such as e-commerce, big data, and Internet of Things (IoT). Moreover, GPS is widely applied in smartphones, even reaching the transportation navigation system sector, such as in vehicles and drones. From an operational perspective, space weather observations can be conducted either in land, air, or space, based on the relevancy at the moment to detect and predict the impacts of certain phenomena on flight safety, such as high-frequency radio communications, satellite communications, global navigation satellite system (GNSS)-based navigation and surveillance, and radiation exposure. Regarding the latter, it may contain high-energy charged particles, X-rays, and/or Gamma rays, all of which can be highly detrimental to aircraft passengers' bodies.

The issue of space weather advisory for flight safety was discussed further with BMKG and the Ministry of Transportation. BMKG has been providing periodic data for space weather advisory for flight safety. The data are collected from Australia, Canada, France, and Japan (ACFJ) as one of the International Civil Aviation Organization (ICAO) five space weather centers. The findings reveal that these space weather centers have a two-week rotation system. What should Indonesia do to continuously receive space weather advisory updates for flight safety, even when the ACFJ is not on duty? On the other hand, BRIN—represented by the Space Research Center—has Space Weather Information and Forecast Services (SWIFtS), which provides space weather data as Indonesia's active participation in the International Space Environment Services (ISES). SWIFtS data makes it possible to provide space weather advisories for flight safety if needed. However, there is no national coordination regarding these roles and tasks because the Ministry of Transportation is still revising its regulations. Nonetheless, with the capabilities of BRIN and BMKG and the authority of the Ministry of Transportation, it is necessary to establish technical policies on space weather advisory for flight safety.

C. Special Information on Disaster Mitigation, Anticipation, and Handling due to Space Weather

On February 15, 2013, the largest air explosion occurred from an altitude of 29.7 km above the city of Chelyabinsk, Russia due to an asteroid collision, causing a natural disaster in an area with a population of more than one million people (Popova et al., 2013). The asteroid collisions or asteroids falling directly to the earth can bring a massive impact. With today's technological modernization, the effects of asteroid collision waves, such as those that occurred in Chelyabinsk, can disrupt electronic equipment, sensors, and others. Furthermore, the direct asteroid fall can also result in dust and smoke covering the atmosphere so that it has the potential to block sunlight, decreasing ambient temperatures. This can endanger the survival of living things in the affected area.

The issues of space debris and disaster mitigation had become part of the public discourse, but there was little discussion about falling space objects and their handling. Thus, a deeper and more specific exploration was carried out again to explore public discourse within the same period regarding falling space objects, as shown in Figure 4. The fall of a celestial object is indeed a rare phenomenon. Even though an incident of this kind occurred in August 2022, it has not yet become a concern, for both public and BNPB. The DNA results on handling of falling space objects were then further confirmed with relevant stakeholders and BNPB to be discussed in detail about the national regulations on disaster management. The findings also imply that the mandate stated in UUK's Article 14b is synchronous with the Government Regulation Number 21 of 2018 and BNPB Regulation Number 5 of 2018 concerning early warning and disaster mitigation of outer space object events. However, there is no national coordination through standard operation procedure (SOP), because handling falling space objects is not a simple thing, as it requires coordination activities, starting from monitoring,

prediction, early warning, and evacuation if necessary to handle when the objects collide with the earth's surface.

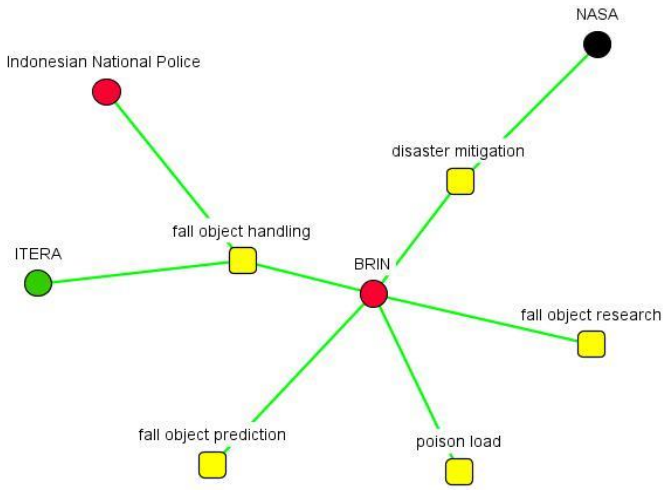

Figure 4. Public discourse results on falling space objects

V. DISCUSSION

This section delivers several thoughts after conducting an in-depth study of public discourse to explore what stakeholders need, the shift in space activities and policies, government agencies, and causality analysis among various issues. Based on this study's results and to remain align with the mandates stated in UUK, the issue of space security takes the first place to be followed up.

Space activities possess a dual-use nature, serving both civilian and military purposes. Civilian programs traditionally involve international cooperation, while military/defense-related space activities are typically managed nationally or through selective partnerships, often by ad hoc arrangements (Papadimitriou et al., 2019). International cooperation—either competitive or not—will only take shape if it supports national interests. This is particularly significant, as all key actors stress the need for greater collaboration in areas often constrained by national industrial and economic priorities (Racionero-Garcia & Shaikh, 2024).

Developing an SSA information and observation system requires comprehensive real-time data. For this reason, referring to what European Space Agency (ESA) has done, BRIN also needs to maximize the role of other infrastructure nationally. The ground-based observation instruments used by ESA are not its own, as it utilize infrastructure owned by other organizations, outside its regional area. ESA's SSA program focuses on information obtained from three observation segments: 1) through Space Weather (SWE) observations to monitor and predict the state of sun and the interplanetary and planetary environment, including the earth's magnetosphere, ionosphere, and thermosphere, which can affect space infrastructure that can potentially endanger human health and safety; 2) through Near-Earth Objects (NEO) to detect natural objects, such as asteroids, that can potentially impact the earth and cause damage; and 3) through Space Surveillance and Tracking (SST) to monitor active and inactive satellites, discarded launch stages, and fragmentation debris orbiting the earth.

This study's framework has revealed the public preferences and urgency, despite there were no policies or collaboration among the parties to bridge them. Nonetheless, this study has contributed to strengthen the space science activities in Indonesia, as they by far have been regulated only by UUK, which is too general. Comprehensive derivative regulations must be followed up and stipulated to maintain the order of ministries and the mandates of government agencies. Moreover, the government should give more consideration to the territorial sovereignty regarding outer space utilization and protect citizens from the possibility of unwanted outer space incidents following the aims of UUK.

VI. CONCLUSION

BRIN as a new space government agency in Indonesia and a superbody in research, which combines all resources from all ministries, should be capable to provide the necessary technological research and development activities on space science and collaborate with related parties. One of the measures is by creating a cross-national community in processing data and its software to ensure interoperability and data exchange formats so that there will be a data catalogue containing information of all objects detected in an orbit.

Most importantly, this study promotes the National Space Science One Data Policy. This notion emerged due to the need to build SSA capabilities to maintain space security to anticipate the possibility of falling space objects by considering the modalities of observatory distribution in various locations in Indonesia. BRIN needs to take the lead in formulating this suggested policy together with related ministries, universities with a strong space background, and the astronomy communities. In practices, BRIN should regulate the establishment of policies concerning national sky observation networks, schemes, and mechanisms in obtaining, storing, processing, and distributing data, also standardization of observation scientific methods.

Moreover, regulations for handling falling space objects do not yet exist to help mitigate risks or disasters in Indonesia. If the falling space objects are man-made, such as nuclear-powered satellite fragments, rocket debris, or others belonging to a foreign country that can cause a detrimental impact on the affected community, it is necessary to analyze the legal aspects of space debris as regulated in international agreements to be used as material for a lawsuit for compensation. BNPB should be more concerned about this possible case. Besides, this measure requires collaboration and clear assignment of tasks from each related ministry.

Last but not least, future studies are expected to focus on developing a structured scheme and mechanism for SSA network collaboration, regulated through a national technical policy that clearly outlines roles and responsibilities across research areas, operational, and international cooperation dimensions.

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