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Article

Sipongi System: Navigating and fostering collaboration in Indonesia

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Abstract: The Sipongi System is essential in dealing with forest and land fires because this system provides real-time data that empowers stakeholders and communities to proactively overcome fire dangers. Its advantages are seen in its ability to provide detailed information regarding weather conditions, wind patterns, water levels in peatlands, air quality, and responsible work units. This data facilitates efficient decision-making and resource allocation for fire prevention and control. As an embodiment of Collaborative Governance, the Sipongi System actively involves various stakeholders, including government institutions, local communities, environmental organizations and the private sector. This cooperative approach fosters collective responsibility and accountability, improving fire management efforts. The Sipongi approach is critical in reducing forest and land fires in Indonesia by providing real-time data and a collaborative governance model. This results in faster response times, more effective fire prevention and better resource allocation. Although initially designed for Indonesia, the adaptable nature of the system makes it a blueprint for addressing similar challenges in other countries and regions, tailored to specific needs and environmental conditions. Qualitative research methods underlie this study, including interviews with key stakeholders and analysis of credible sources. Government officials, community leaders, environmental experts and organizational representatives were interviewed to comprehensively examine the mechanisms of the Sipongi System and its impact on forest and land fire management in Indonesia. Future research should explore the application of Sipongi Systems and collaborative governance in various contexts by conducting comparative studies across countries and ecosystems. Additionally, assessing the long-term impact and sustainability of the Sipongi System is critical to evaluating its effectiveness over time.

Keywords: forest and land fires; monitoring system; collaborative governance; Sipongi; multistakeholder; Indonesia

1. Introduction

As one of the countries with the most significant tropical rainforests in the world, Indonesia plays a crucial role in slowing climate change. Indonesia's tropical rainforests are the world's lungs (Tacconi, 2003; Wicaksono, 2018; Wicaksono and Zainal, 2022). It is anticipated that tropical rainforests will absorb greenhouse gases produced by numerous human activities and subsequently create oxygen for human respiration (Maryani, 2020; Saharjo and Yungan, 2014; Wardoyo, 2019; etc.)

In recent decades, Indonesia has had the most rapid deforestation in the world for agriculture or industrial uses; forest resources such as timber are exploited indiscriminately. In addition, forest and land fires are a yearly occurrence in Indonesia, particularly during the dry season. Human activities that convert land to agriculture burning are the primary cause of Indonesia's annual forest and land fires (Achyar et al., 2015; Astuti, 2020; Bowen et al., 2001; etc.).

The forest and land fires that occur have a tremendous negative impact, especially on health, the environment, and the economy (Purnomo et al., 2019; Rasyid, 2014; Tuhulele, 2014; Wicaksono, 2019). Forest and land fires cause a smog disaster that causes public health to be disrupted by breathing unhealthy air (Andriany et al., 2020; Greenpeace Indonesia, 2021; Saharjo et al., 2018). The polluted air causes acute respiratory infections, which are very dangerous to health. The smog from forest and land fires also releases greenhouse gases into the atmosphere. These gases are the cause of global warming (Allen et al., 2021; Arora & Mishra, 2021; Daulay & Hidayat, 2018; Deng et al., 2022; Gebara et al., 2020; Nemtinova et al., 2022; Rachmaniar et al., 2021; Runkle & Kutzbach, 2014). Forest ecosystems are also disturbed due to forest and land fires. From an economic perspective, severe forest and land fires can cause aviation activities to be disrupted. Due to unhealthy air conditions, people also find it challenging to carry out activities as usual. These negative impacts are only a tiny part of those caused by forest and land fires.

The Indonesian government remains committed to mitigating forest and land fires, recognizing them as an avoidable calamity. An example of a pioneering advancement is developing a forest and land fire monitoring system known as Sipongi (Al Fathom, 2015; Public Relations of the Ministry of Environment and Forestry, 2020). The Sipongi System is a forest and land fire monitoring system initiated by Indonesia's Ministry of Environment and Forestry. The system can be accessed through the official website at https://sipongi.menlhk.go.id or downloaded onto an Android-based mobile device. (Allawiyah, 2019; Public Relations of KLHK, 2020).

This article thoroughly examines collaborative governance in controlling forest and land fires in Indonesia. It commences by providing an introductory overview of the existing issues in this domain. This analysis explores the complexities inherent in this multifaceted issue, particularly emphasizing the significance of adopting a collaborative methodology. This section presents a comprehensive analysis of the architectural design and operational mechanisms of the Sipongi System, showcasing its revolutionary nature. Technological innovation is vital in Indonesia's endeavours to address the issue. In this study, we investigate the significance of the Sipongi System in fire detection, elucidating its remarkable effectiveness and wide-ranging implications. The technology above represents a promising development in the continuous battle against forest and land fires.

In the concluding section, we emphasise the notable advancements made by Indonesia in managing forest and land fires, with particular attention given to the significant contribution of the Sipongi System. This article provides evidence of Indonesia's dedication to employing cutting-edge technologies to combat forest fires effectively. We aim to offer readers a comprehensive comprehension of the joint endeavour bolstered by the Sipongi System, which Indonesia employs to tackle this pressing matter worldwide.

2. Literature review: The application of collaborative governance in managing forest and land fires in Indonesia

The Indonesian government has implemented a significant set of technical regulations known as the "Regulation of the Minister of Environment and Forestry of

the Republic of Indonesia Number P.32/Menlhk/Setjen/Kum.1/3/2016 regarding the Management of Forest and Land Fires." This law imposes a nationwide obligation that necessitates active engagement in managing forest and land fires. This law requires proactive engagement in managing forest and land fires nationwide. This call to action is directed towards several stakeholders, encompassing government agencies at all levels, the private sector (particularly those in the forestry and plantation industries), and local people directly affected by these fires' proliferation.

Indonesia's commitment to fighting forest and land fires involves many actors. This group comprises the Ministry of Environment and Forestry, the National Disaster Management Agency, TNI, Polri, local governments, and other government agencies. In addition, the private sector, especially companies operating in forestry and oil palm plantations, also plays an important role. National and local non-governmental organisations (NGOs) also contribute to this collaborative framework. Finally, local communities have organised themselves into Fire Care Communities, which operate in various regions across Indonesia. This multi-stakeholder collaboration is a joint response to Indonesia's environmental crisis, known as forest and land fires.

From a theoretical perspective, this multi-stakeholder collaboration aligns with the principles of collaborative governance. Experts in the field of public management have observed an increasing prevalence of collaborative networks among state and local governments in recent decades (Silvia, 2011). Some commentators argue that collaborative governance arrangements are on the rise, while others argue that "collaboration" often encompasses multiple approaches to working together (Lahat & Sher-Hadar, 2020).

Ansell and Gash (2008) define collaborative governance as a governing arrangement where one or more public agencies actively engage non-state stakeholders in a structured decision-making process. This process is characterised by its formality, consensus-oriented approach, and deliberative nature, with the ultimate aim of formulating or executing public policies or managing public programs and assets. In essence, it brings together diverse actors to address shared public concerns jointly. Building on Connick and Innes (2003), collaborative governance also acts as a conduit for representing all pertinent interests tied to a specific case under consideration. This comprehensive approach guarantees that all pertinent stakeholders' perspectives are acknowledged and considered.

According to Emerson et al. (2012), collaborative governance can be understood as a multifaceted system of processes and structures integral to public policy decision-making and management. This promotes productive collaboration among various public institutions, governmental levels, and public, private, and civil society sectors. The primary objective is to attain public objectives that prevailing conflicts or intricacies may hinder. Effective resolution of public problems necessitates the joint engagement of both state and non-state players from the public and commercial sectors, who possess shared concerns and work collectively.

Agranoff and McGuire (2003) present an alternative viewpoint highlighting the significance of voluntary collaboration and horizontal interactions among individuals from multiple sectors. It is emphasised that the expectations placed on governance frequently surpass the capacities and functions of public organisations. Hence, the significance lies in the interaction among many organisations, each possessing unique

skills and fulfilling distinct tasks within public activities. This collaborative method facilitates governance structures in effectively addressing the growing challenges associated with managing activities that span governmental, organisational, and sectoral boundaries. This approach serves as a mechanism for rejuvenating governance and directing attention towards the comprehensive framework of public administration.

Collaborative governance does not arise in a vacuum; instead, it is the outcome of several stakeholders' endeavours to enhance cooperation and coordination in addressing public challenges. According to Ansell and Gash (2008), this phenomenon frequently occurs due to obstacles encountered during implementation, significant regulatory costs, and the inherent complexity of political dynamics. However, it is also impacted by the need to consolidate financial and organisational resources to attain shared objectives. Moreover, it signifies the dynamic nature of governance, highlighting the proactive involvement of diverse stakeholders, including governmental entities, the business sector, and non-governmental organisations, in matters about the public sphere. Collaboration is crucial in enhancing stakeholder engagement and mitigating excessive bureaucracy inside institutions.

In brief, collaborative governance is complex due to diverse causes, such as constrained institutional capacity, restricted resources, the evolving nature of governance, and the necessity for intersectoral collaboration. Its role in the functioning of contemporary governments is of significant importance, as it facilitates the collaboration of diverse stakeholders in efficiently tackling intricate public issues.

Within the framework of the Forest and Land Fire Monitoring System in Indonesia, commonly called the Sipongi System, the concept of collaborative governance is a prominent illustration of tangible cooperation among institutions. The system facilitates the collaboration of at least five crucial agencies, fostering an integrated strategy for the surveillance and administration of forest and land fires. The organisations above encompass the Ministry of Environment and Forestry (KLHK), the Peat and Mangrove Restoration Agency (BRGM), the Meteorology, Climatology and Geophysics Agency (BMKG), the National Research and Innovation Agency (BRIN), and the National Disaster Management Agency (BNPB). Collectively, they establish a robust coalition committed to managing and mitigating forest and land fires in Indonesia.

Furthermore, intricate, collaborative endeavours become apparent when examining the intricate network of stakeholders involved in forest and land fire monitoring within the Sipongi System. In addition to primary institutions, other stakeholders actively participate in the ongoing endeavour to address forest and land fires. This group includes local governmental entities such as the Environment and Forestry Service and the Regional Disaster Management Agency. In addition to the above entities, the Indonesian National Army (TNI), the Indonesian National Police (POLRI), firefighters employed by the company, and local community members are actively involved in this cooperative effort. In this broad collaboration network, all participating entities have the same dedication to managing and mitigating forest and land fires in Indonesia. By collaborating, individuals and organisations can pool resources, knowledge and shared goals, resulting in a more robust and efficient approach to dealing with forest and land fire problems.

The Sipongi System describes a collaborative governance model in which various

groups collaborate to overcome complex and diverse difficulties, including government agencies, local communities, and the corporate sector. This proves Indonesia's commitment to implementing a comprehensive and integrated strategy for forest and land fires (see **Figure 1**).

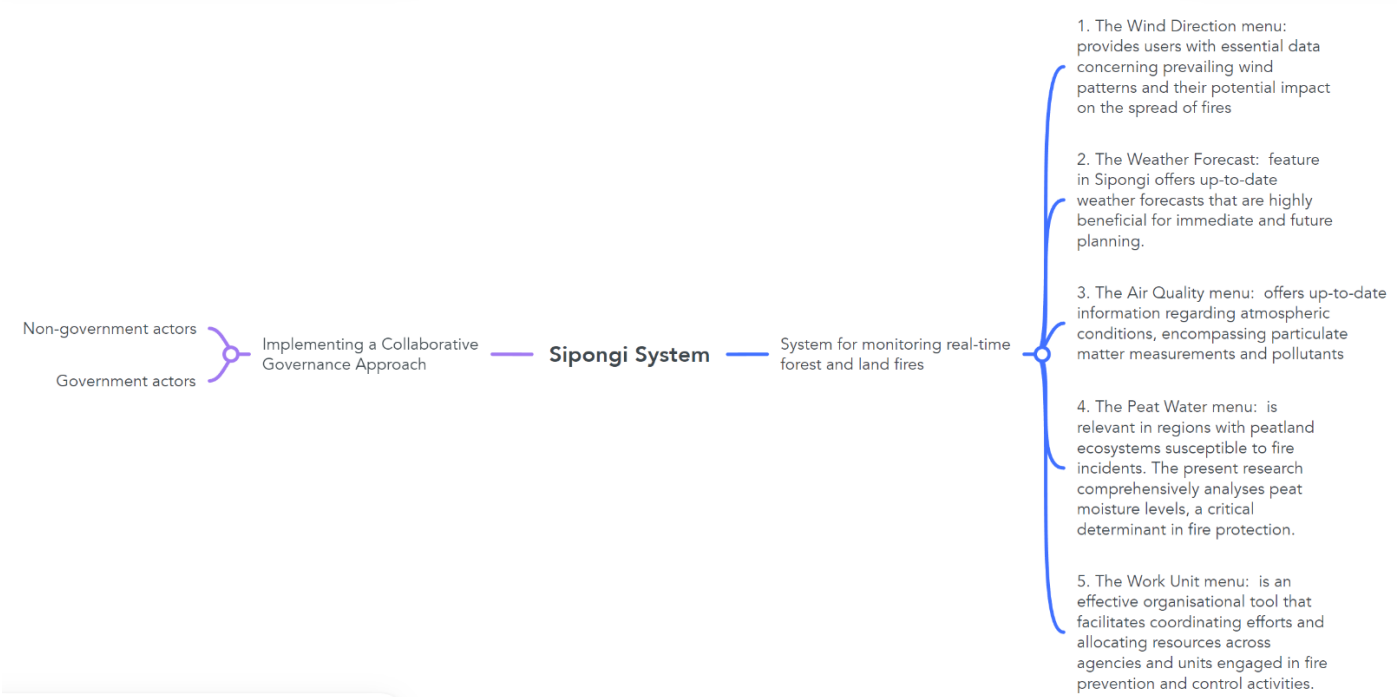

Figure 1. Study of the research.

3. Methodology

This research uses a qualitative methodology based on the work of Guion et al. (2002), Leech and Onwuegbuzie (2007), and Yin (1989). The methodology used in this research includes a variety of data collection techniques, which include in-depth interviews, participant observation, evaluation of relevant documents, surveys, audio recordings, and examination of objective evidence. Several scholars have contributed to the field of academic research on this topic, including Gerring (2004), Meyer (2001), Vanwynsberghe and Khan (2007), Woodside and Wilson (2003), and Yin (1989).

We interviewed two representing environmental non-governmental organisations (NGOs), three from the Ministry of Environment and Forestry, one from the Peat and Mangrove Restoration Agency, and two from the Provincial Environment and Forestry Agency.

In addition to primary data, the research also used secondary data from various government sources, including official reports that are regularly distributed and available to the general public. The sources used in this study included a variety of materials such as government records, press releases, media reports, and field observations made by the research team. The researchers carefully synthesised data from multiple sources to reach a complete conclusion (Hussein, 2018; Oppermann, 2000; Renz et al., 2018).

4. Findings

4.1. Forest and land fires in Indonesia

Historical records bear witness to the severity of Indonesia's forest and land fires during the tumultuous year of 1997/1998, as documented by Duncan et al. (2003); Levine (1999); Tacconi (2003); etc. The scale of this catastrophe is truly staggering, with over 12 million hectares of Indonesian land consumed by flames during this period. The resulting smog disaster threatened human health and inflicted substantial material losses, as underscored by Tacconi (2003).

Regrettably, this devastation marked the onset of an ongoing crisis as forest and land fires continued to ravage the region year after year. The government's perceived lack of commitment to controlling these recurring conflagrations during the dry season has only exacerbated the situation. A complex interplay of factors, beginning with the El Niño phenomenon and further exacerbated by opportunistic human activities seeking inexpensive agricultural land, serves as the primary catalyst for these unrelenting fires (Bowen et al., 2001; Budiman et al., 2020; Cahyono et al., 2015; etc.).

Land clearance for the establishment of oil palm plantations stands out as a prominent culprit behind Indonesia's recurring forest and land fires, a suspicion well-founded and substantiated by research findings (Ervayenri et al., 2016; Mead et al., 2018; Puspitaloka et al., 2020; etc.). Opportunistic oil palm entrepreneurs and unscrupulous communities exploit the dry season to their advantage, employing the cost-effective method of land clearance through deliberate burning. This approach, undoubtedly more economical than heavy machinery, all too often leads to the emergence of palm tree plantations in the wake of forest and land fires, further entrenching the cycle of environmental degradation.

Figure 2 provides a comprehensive overview of the forest and land fires that have consistently plagued Indonesia from 1997 to 2021. The data underscores the alarming recurrence of fires, with at least three distinct events where the affected area exceeded 1 million hectares. These critical events occurred in 1997/1998, 2015, and 2019, serving as a reminder of the environmental challenges the country is facing. This data does not include data on forest and land fires in 2009–2012 (written 0) because we could not find official data regarding the total area burned in those years.

The unending cycle of fires and the resulting haze emissions have had a profound impact, turning Indonesia. This country should be at the forefront of climate change prevention efforts and a significant contributor to exacerbating global warming. The losses from forest and land fires and the resulting haze have further exacerbated the global climate crisis, underscoring the urgency to address and mitigate this recurring disaster. Indonesia's role in combating climate change has evolved into a critical imperative, calling for concerted efforts to curb the devastating impacts of the annual forest and ground fires.

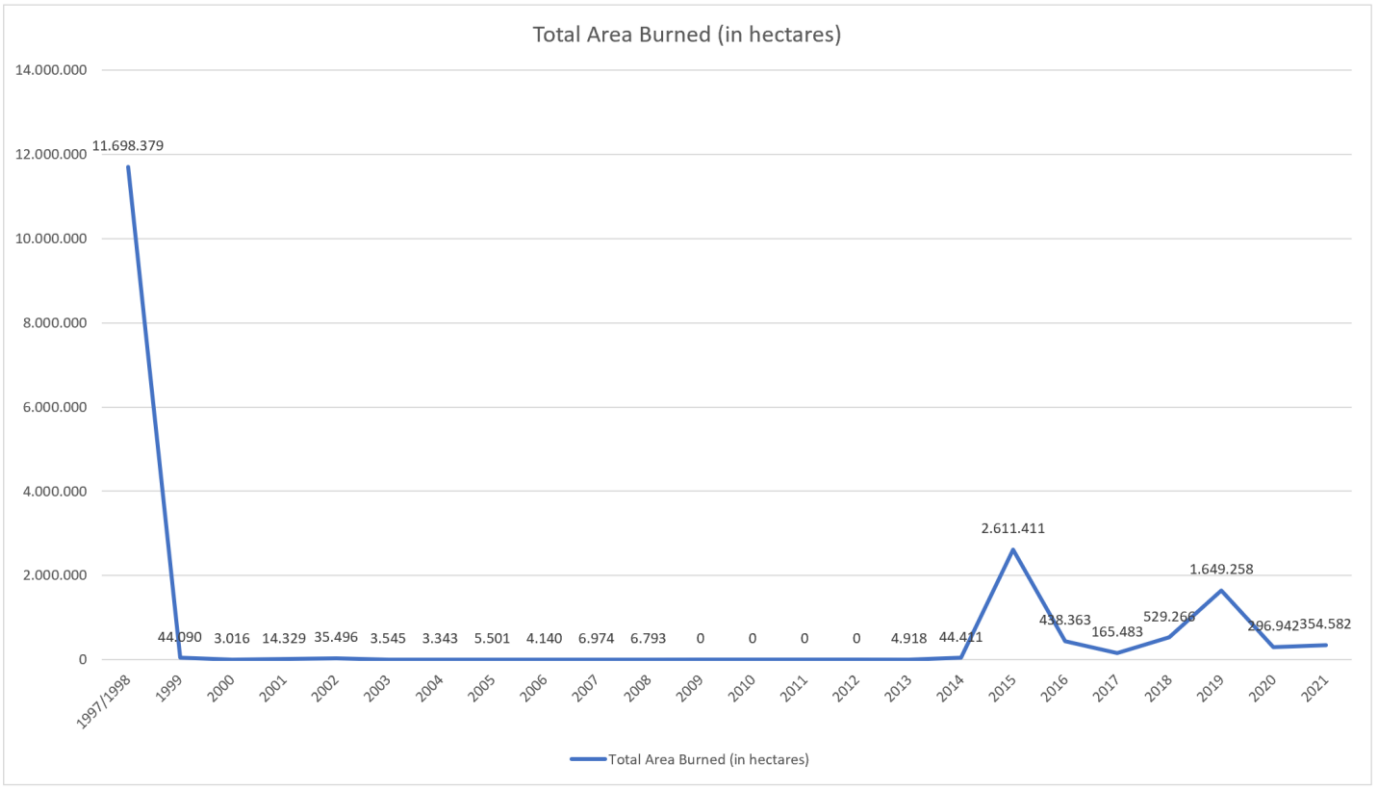

Figure 2. Total area burned in Indonesia 1997–2021.

(Source: Tacconi, 2003 and Compilation data from Ministry of Environment and Forestry and Ministry of Agriculture).

4.2. Sipongi System

The Indonesian government has implemented proactive measures to combat the persistent problem of forest and land fires. Among these efforts, one that stands out is the highly innovative Sipongi System, introduced by the Directorate General of Climate Change Control (Ditjen PPI) under the Ministry of Environment and Forestry. Sipongi has emerged as the cornerstone of information and resource management related to forest and land fires in Indonesia and has received recognition from various sources (Administrator, 2019; Al Fathon, 2015; Allawiyah, 2019; etc.).

The Sipongi System, readily available to the general public, can be conveniently accessed through the official website, www.sipongi.menlhk.go.id or by downloading the Sipongi Android application. Implementing this novel technology significantly mitigates forest and land fires by facilitating timely hotspot detection and disseminating crucial information. Sipongi acquires its data from a constellation comprising four satellites: Terra Aqua, NOBM, SNPP, and Landsat 8. In addition, Sipongi integrates essential meteorological information from the Meteorology, Climatology, and Geophysics Agency (BMKG). The accuracy of the data provided by this system is highly reliable, encompassing precise information regarding the location and condition of land at the village level. Regular updates are conducted every 30 minutes, guaranteeing that the fire data remains consistently current and nearly instantaneous (Administrator, 2019; Al Fathon, 2015; Allawiyah, 2019; etc.).

The exceptional nature of the Sipongi System stems from the remarkable level of collaboration that serves as the foundation for its achievements. The gathering above

convened multiple governmental entities, namely the Ministry of Environment and Forestry (KLHK), the Peat and Mangrove Restoration Agency (BRGM), the Meteorology, Climatology and Geophysics Agency (BMKG), the National Research and Innovation Agency (BRIN), and the National Disaster Management Agency (BNPB) (Gumilar et al., 2021). This collaborative effort across sectors demonstrates a comprehensive recognition that the issue of forest and land fires extends beyond the confines of a single department or ministry.

The Sipongi System embodies a cohesive and symbiotic relationship across many entities. The cooperative endeavours have demonstrated immense value in Indonesia's persistent endeavour to combat forest and land fires. The success story of this endeavour serves as evidence of the efficacy of collaborative action and innovative approaches in tackling intricate environmental issues.

5. Discussion

5.1. Features available in Sipongi System

The Sipongi System encompasses several significant features, among which a prominent attribute is incorporating meteorological data analysis. This sophisticated system harnesses various meteorological parameters such as temperature, humidity, and wind speed to assess fire risk comprehensively (Negara et al., 2020). By scrutinising prevailing weather patterns and conditions, Sipongi is not only capable of gauging the potential for fire outbreaks but can also issue timely warnings and alerts to pertinent authorities and local communities.

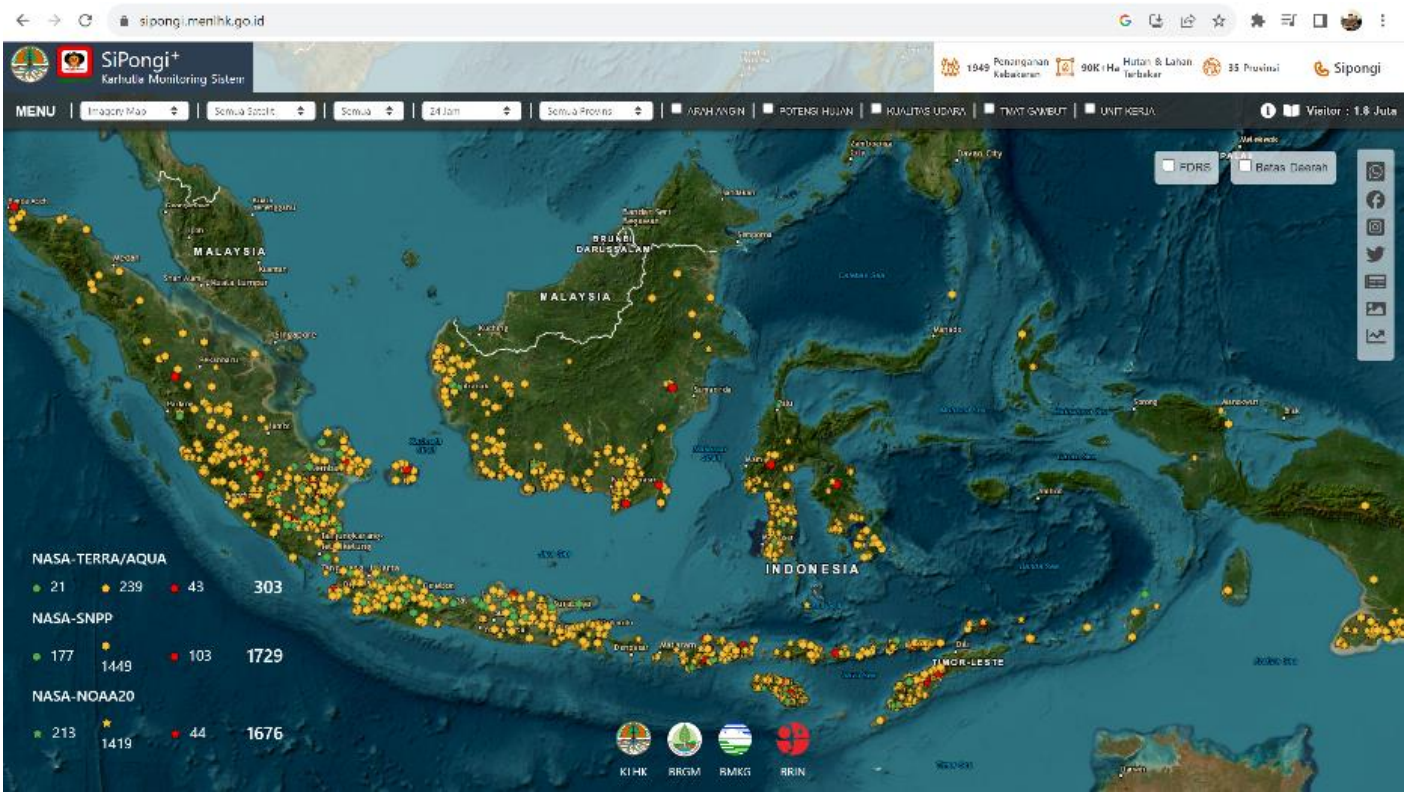

Figure 3. Front view of the Sipongi website, which can be accessed at www.sipongi.menlhk.go.id.

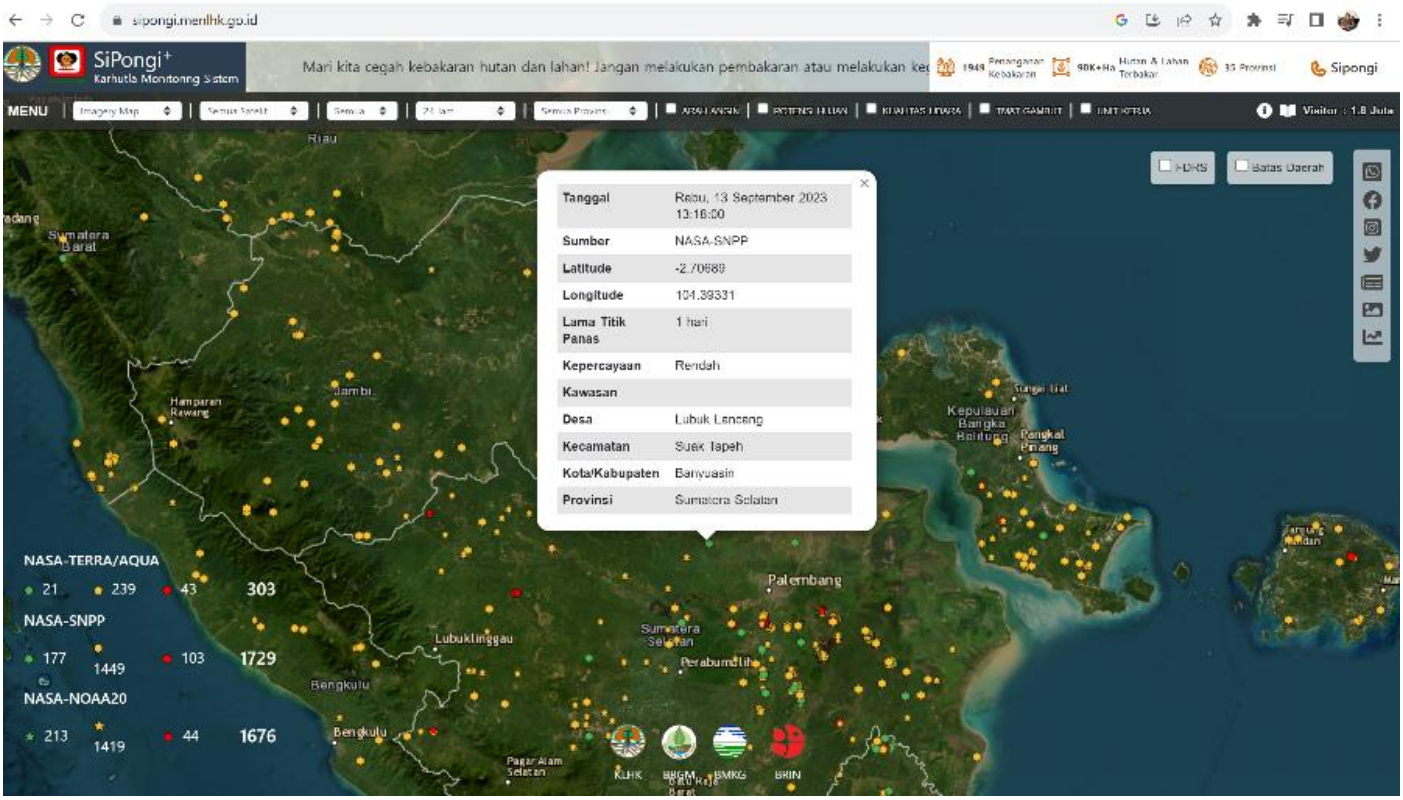

Figure 4. The green dot is a sign that there is a hotspot with a low level of confidence.

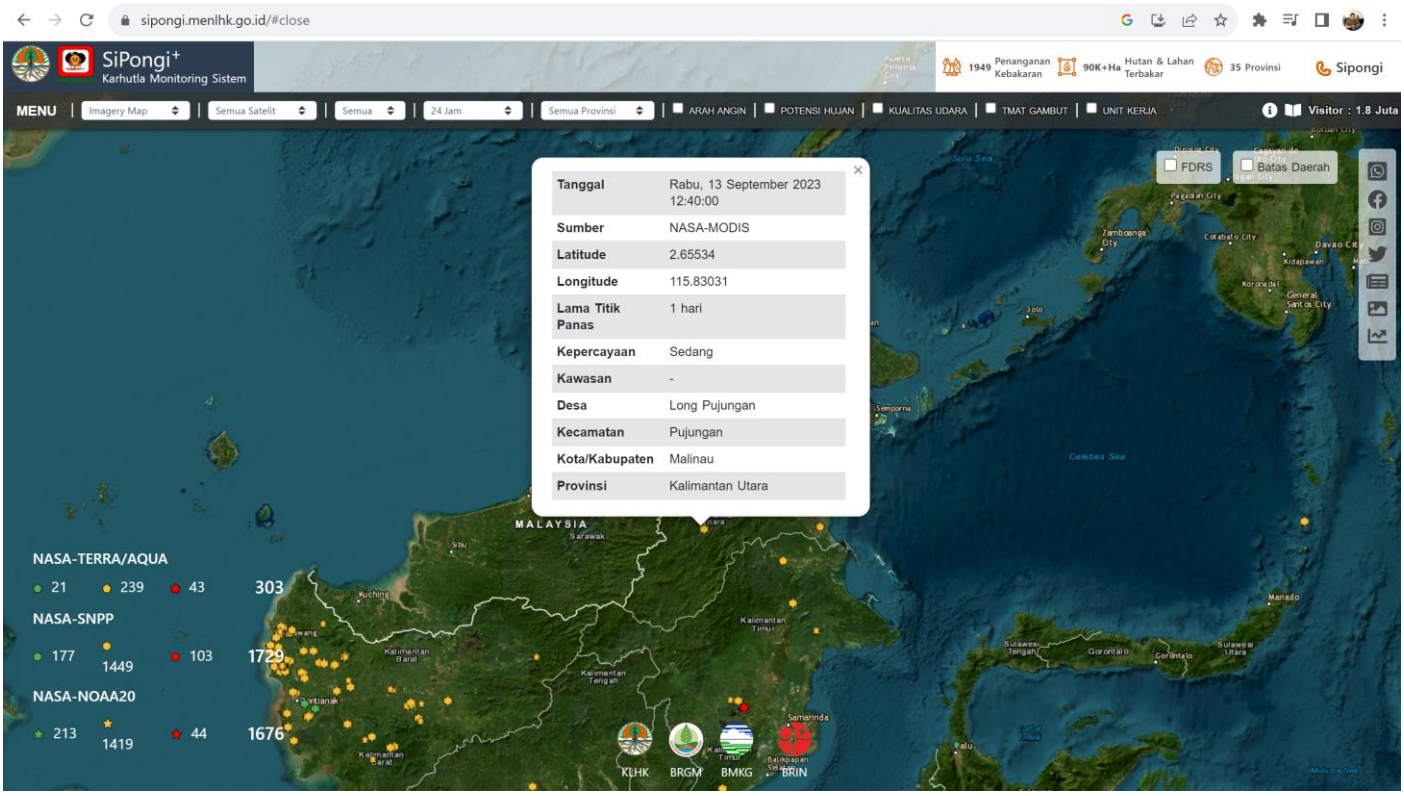

Figure 5. The yellow dots indicate hotspots with medium confidence.

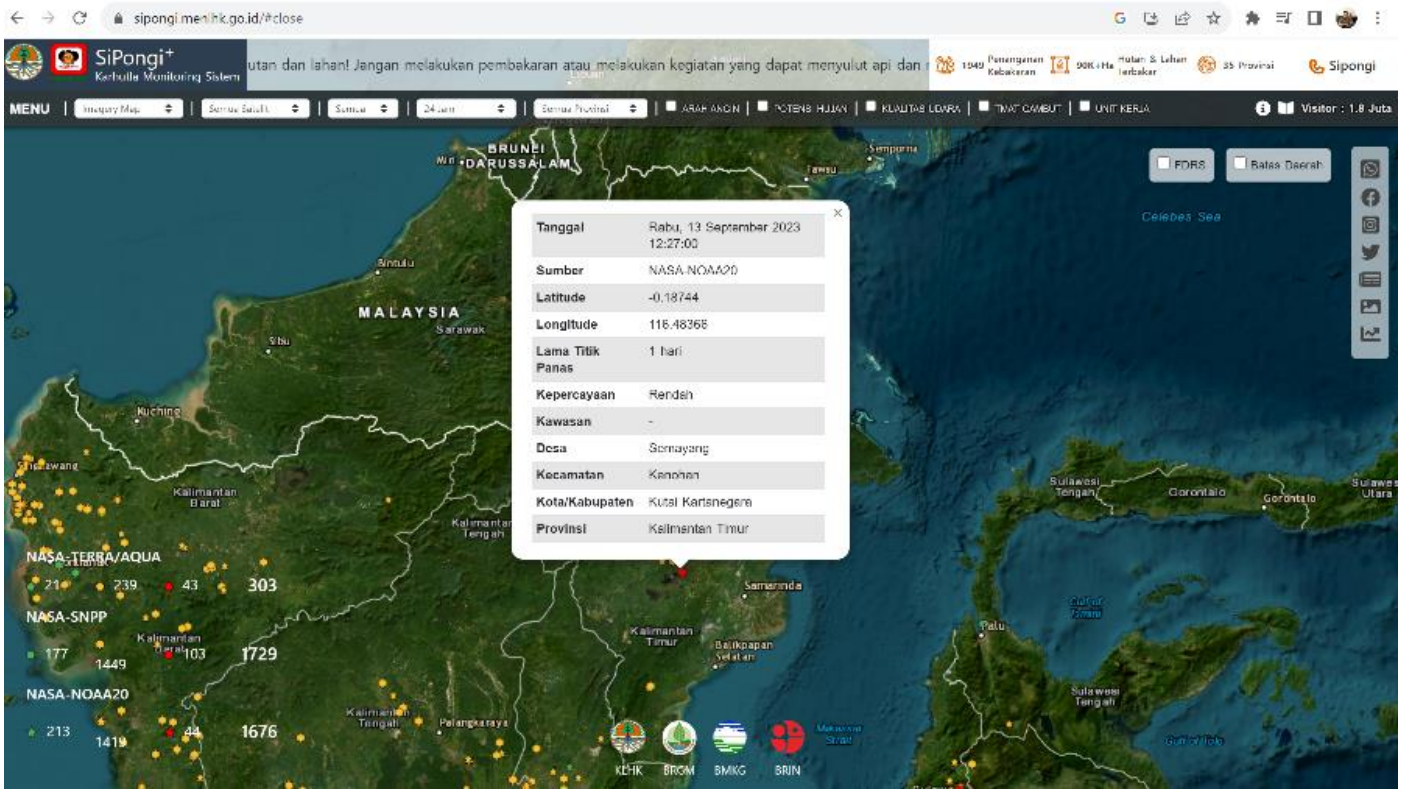

Figure 6. The red dot is a sign that there are hotspots with a high level of confidence.

Figure 3 provides a captivating glimpse into the Sipongi website's initial interface, which provides a gateway to a wealth of critical information for the scientific and governmental communities. This visually engaging dashboard presents a comprehensive and dynamic overview of the prevalent hotspot activity sprawled across the vast expanse of Indonesia. Beyond its aesthetic appeal, the intuitive design empowers users, including scientists, policymakers, and the general public, to rapidly and comprehensively discern the geographical extent and potential severity of fire incidents in the region. It thus emerges as an indispensable tool for wildfire monitoring, management, and scientific analysis.

A more granular exploration of specific hotspot incidents is facilitated through **Figures 4–6**, which become accessible upon hovering over individual hotspots. **Figure 4** reveals the existence of green hotspots, indicating a low confidence level regarding the hotspot's status. **Figure 5**, conversely, unveils yellow hotspots, signalling a moderate confidence level in their veracity. **Figure 6** serves as a poignant reminder, displaying red dots to emphasise the high confidence level associated with certain hotspots. These varying confidence levels offer invaluable cues for the scientific community to assess and prioritise their research and intervention efforts.

Further enhancing the utility of the Sipongi System is its interactive feature, which allows users to click on hotspots, thereby revealing a trove of additional scientific information. These details encompass the data source, precise latitude and longitude coordinates, hotspot duration, level of confidence in the hotspot's status, and the specific region, village, sub-district, city, and province where the hotspot is situated. This granularity of information transcends mere convenience, serving as an indispensable scientific resource. It facilitates meticulous data analysis, collaborative

coordination with relevant stakeholders, swift deployment of response measures, and targeted wildfire management and mitigation strategies.

In essence, the Sipongi System, with its interactive interface and comprehensive data accessibility, not only empowers government agencies and engages the scientific community and the broader public in the collective effort to combat the perennial challenge of forest and land fires in Indonesia. This robust tool epitomises the symbiosis of technology and data, demonstrating their potent role in safeguarding the environment and the communities inhabiting this ecologically significant region. Its contributions to scientific inquiry and actionable insights for policymakers underscore its pivotal role in addressing complex environmental issues.

The Sipongi website is a multi-purpose centre offering various environmental monitoring and management menus. These accessible menus, as depicted in **Figures 7–11**, significantly enhance the system's overall usability. A more detailed exploration of these menus follows:

1) The Wind Direction menu provides users with essential data concerning prevailing wind patterns and their potential impact on the spread of fires. This knowledge enables both authorities and communities to anticipate the paths that fires may take, allowing for the strategic deployment of resources and the implementation of efficient suppression measures.
2) The Weather Forecast feature in Sipongi offers up-to-date weather forecasts that are highly beneficial for immediate and future planning. This information equips stakeholders with the foresight to proactively anticipate and prepare for extreme weather conditions that can potentially intensify fire hazards.
3) Monitoring air quality is paramount in regions susceptible to forest and land fires. The Air Quality menu offers up-to-date information regarding atmospheric conditions, encompassing particulate matter measurements and pollutants. This data aids in evaluating the health hazards linked to inadequate air quality and informs public health interventions.
4) The Peat Water menu is relevant in regions with peatland ecosystems susceptible to fire incidents. The present research comprehensively analyses peat moisture levels, a critical determinant in fire protection. By engaging in ongoing surveillance of water levels in peatlands, the method facilitates the identification of regions characterised by heightened susceptibility to fires while also assisting in endeavours aimed at preserving optimal moisture levels.
5) The Work Unit menu is an effective organisational tool that facilitates coordinating efforts and allocating resources across agencies and units engaged in fire prevention and control activities. The enhanced communication and collaboration mechanism further enhances the system's overall effectiveness.

Including these menus not only enhances the capabilities of the Sipongi System in monitoring and controlling forest and land fires but also broadens its purview to encompass broader environmental factors. The multidimensional approach highlights the system's dedication to ensuring complete environmental protection and safeguarding public safety. Consequently, this system has become an essential and

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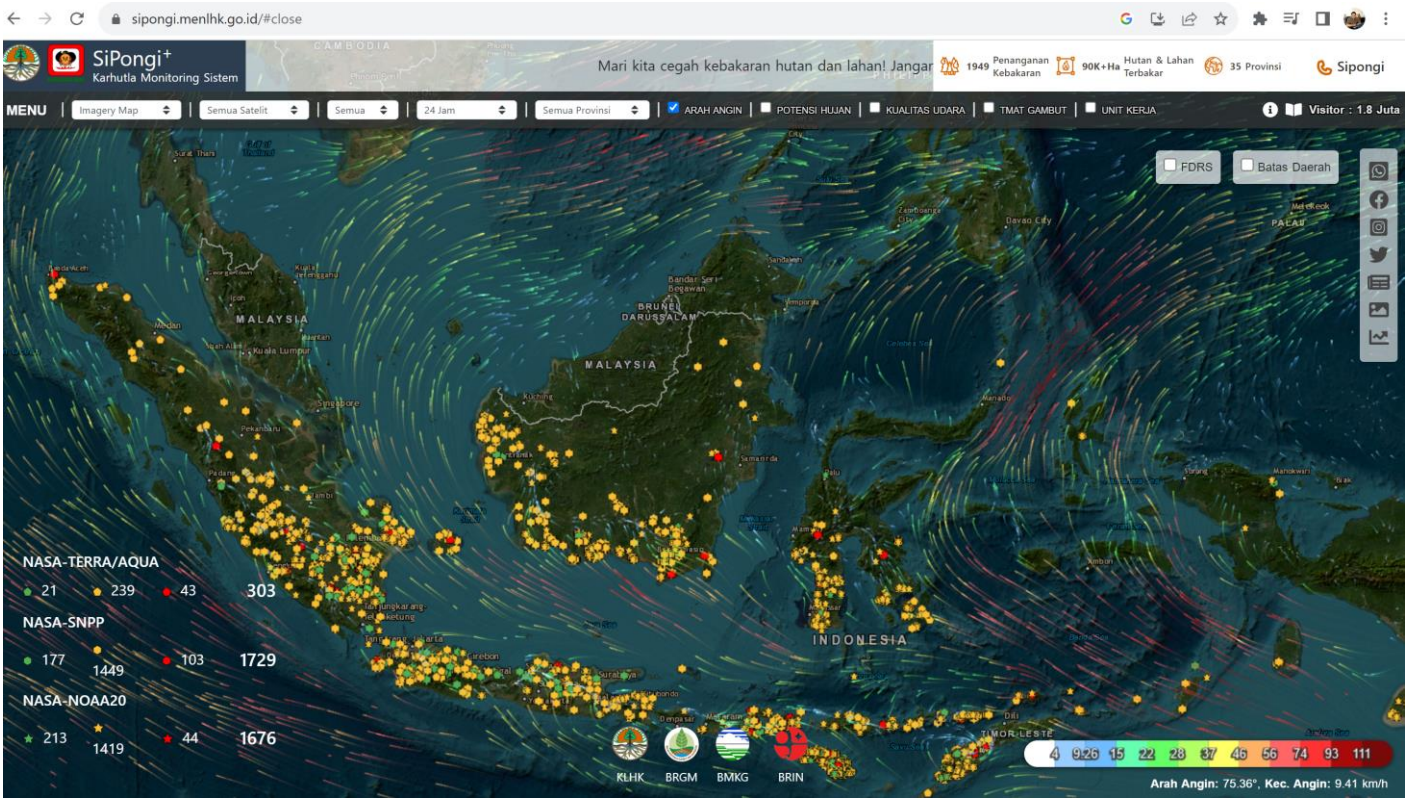

Figure 7. Wind direction on the Sipongi website.

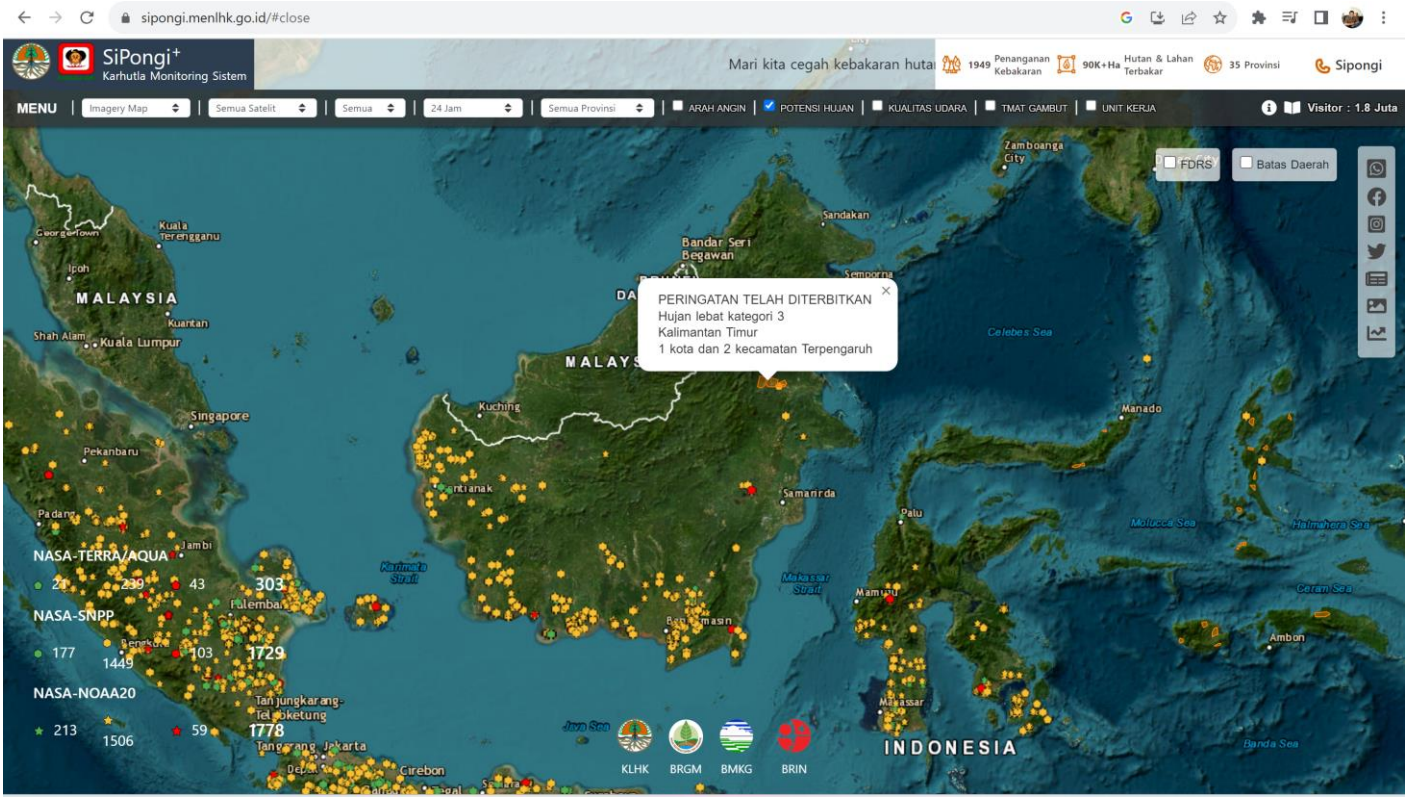

Figure 8. Weather forecast on the Sipongi website.

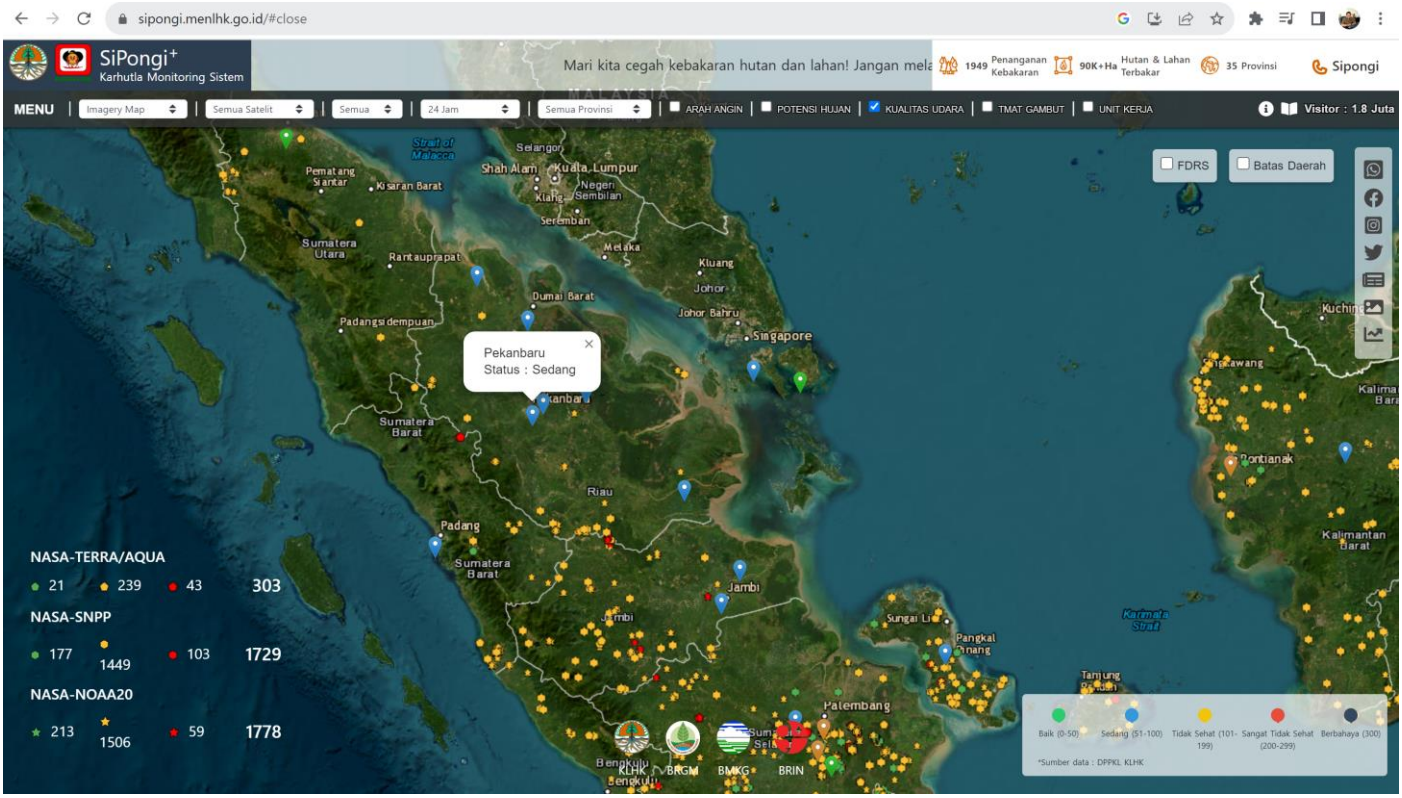

Figure 9. Air quality on the Sipongi website.

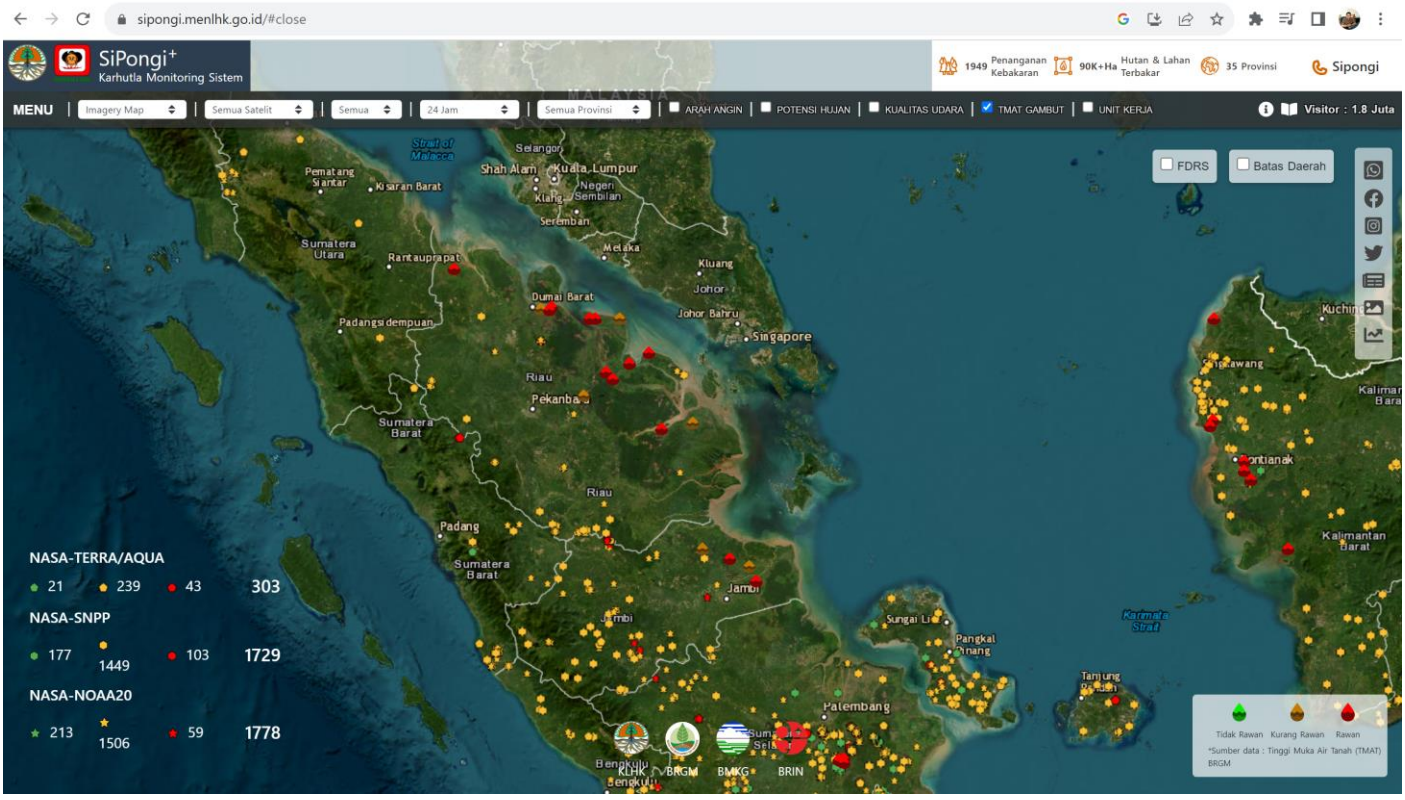

Figure 10. The condition of the peatland water level on the Sipongi website.

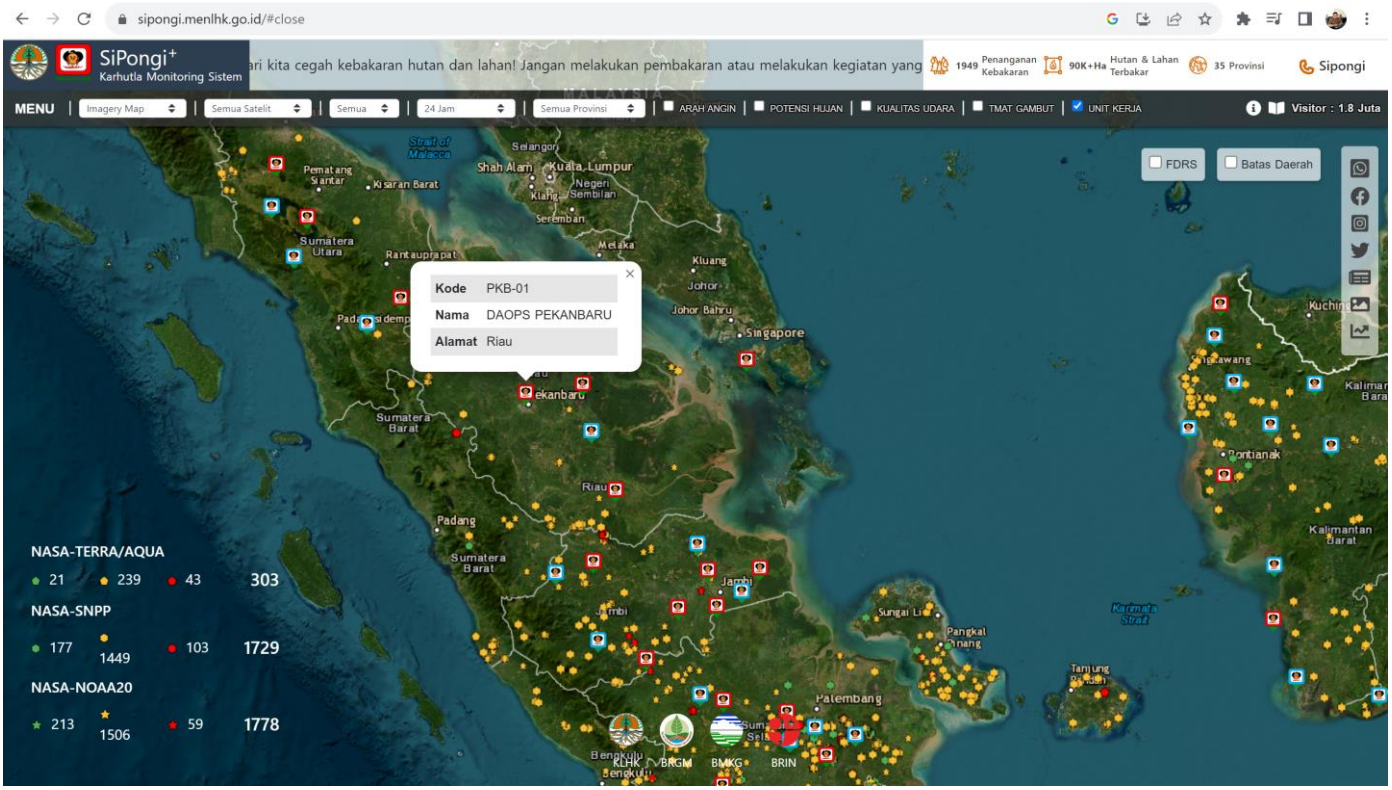

Figure 11. Work units (related stakeholders in forest areas) on the Sipongi website.

5.2. What to do after a hotspot is detected in the Sipongi System?

Detecting hotspots in the Sipongi System marks the start of a coordinated response effort, as controlling forest and land fires in Indonesia requires collective action from multiple stakeholders at various organisational levels. This collaborative effort starts at the grassroots level and involves a network of entities with responsibilities and roles. These stakeholders include fire awareness communities, village officials, sector police, Military Rayon Commands, Forest Management Units, Regional Disaster Management Agencies, Meteorology, Climatology and Geophysics Agencies, and forestry-related companies.

To facilitate smooth communication and coordination among the stakeholders involved in controlling forest and land fires in Indonesia, each province prone to forest and land fires has established a WhatsApp group of representatives from each participating entity. These WhatsApp groups serve as important channels for information dissemination, real-time information updates, and coordination of rapid response in the event of forest and ground fires. Effectively managing forest and land fires in Indonesia relies on a holistic approach prioritising prevention, early detection, and rapid response. Integrating the Sipongi system with WhatsApp groups presents a robust framework for attaining these objectives. Upon detecting a fire, stakeholders can promptly initiate a communication and coordination network, enabling them to address a forest fire promptly.

Forest and land fires pose a significant hazard to the environment, human health, and the economy. Forest and land fires have the potential to inflict substantial ecological harm, encompassing detrimental effects on ecosystems and biodiversity, soil erosion, desertification, and diminished water quality. Furthermore, the emission

of smoke and haze from forest fires can harm human well-being, leading to respiratory complications and ocular discomfort.

In order to effectively avoid and minimise the adverse consequences of forest and land fires, stakeholders must employ a comprehensive array of methods. The techniques mentioned above encompass meticulous land use planning, comprehensive fire prevention education, and the construction of efficient early warning systems. Furthermore, stakeholders must embrace sustainable forest management practices that enhance biodiversity and mitigate the potential for forest fires.

In summary, utilising the Sipongi System, which incorporates a WhatsApp group, is proficient in communication and coordination among stakeholders in managing forest and land fires in Indonesia. The technology enables stakeholders to effectively mitigate the adverse effects of forest and land fires on the environment and society through coordinated efforts. In order to prioritise long-term sustainability, it is imperative to implement proactive methods for fire avoidance and sustainable forest management practices to safeguard Indonesia's invaluable ecosystems and its populace.

5.3. Benefits of the system in multi-stakeholder collaboration on forest and land fire management in Indonesia

The Sipongi System in Indonesia has numerous advantages in enabling multi-stakeholder collaboration for managing forest and land fires. The advantages above are essential in assuring the efficacy of fire control and prevention while promoting sustainable practises in land utilisation. The Sipongi System is a central platform for aggregating and examining hotspot data from many geographies and databases (Lohberger et al., 2017). Lohberger et al. (2017) argue that this technology enhances the accessibility and dissemination of current information about the probability and severity of fire incidents across diverse stakeholders, including governmental entities, local populations, and fire response teams. Accurate and current data facilitates stakeholders in making well-informed decisions and enhancing the effectiveness of their collaborative endeavours.

Furthermore, the Sipongi System has an early warning mechanism that employs meteorological data to assess the likelihood of a fire event (Negara et al., 2020). According to the study conducted by Negara et al. (2020), this system effectively disseminates notifications and warnings to pertinent authorities and the general public. As a result, this enables individuals or organisations to proactively implement preventive measures and effectively respond to possible fire incidents. Early warning systems significantly mitigate fire propagation and its consequences, as they afford valuable time for preparedness measures and potential evacuation procedures.

Furthermore, the Sipongi System employs remote sensing techniques and satellite data to effectively monitor and detect areas that have been subjected to burning as well as identify regions with high temperatures (Lohberger et al., 2017). Lohberger et al. (2017) suggest that identifying fire-affected areas and assessing fire damage can be accomplished by evaluating vegetation indices and satellite data alterations. Providing this information is of utmost importance to successfully steer post-fire recovery endeavours and allocate resources for rehabilitation and restoration.

In addition, the Sipongi System facilitates collaboration among many stakeholders by sharing information and coordination among various parties engaged in fire control (Fithriyyah et al., 2020). The entities encompassed in this category consist of governmental bodies, local communities, fire task groups, and other pertinent organisations (Fithriyyah et al., 2020). Through collaborative efforts and exchanging knowledge, resources, and information, stakeholders can augment their combined ability to prevent, manage, and alleviate forest and land fires.

The Sipongi System also facilitates the enforcement of policies and regulations about fire management. This platform facilitates the monitoring and evaluation of policy effectiveness, enabling the implementation of real-time data and feedback to make necessary adjustments and enhancements. The aforementioned iterative approach facilitates the enhancement of fire management techniques, ensuring their congruence with the dynamic requirements and obstacles encountered in practice.

In summary, the Sipongi System implemented in Indonesia presents numerous advantages in facilitating multi-stakeholder collaboration to mitigate forest and land fires. The system promotes fire management's efficacy by facilitating data collection and analysis through a centralised platform, integrating early warning systems, leveraging remote sensing and satellite data, and fostering collaboration among relevant parties. The advantages mentioned above provide enhanced efficacy in fire prevention, prompt response, and adoption of sustainable land use practices, reducing the adverse effects caused by forest and land fires in Indonesia.

6. Conclusion

The Sipongi System serves as evidence of innovative approaches in the surveillance and administration of forest fires. This institution is renowned for providing timely and precise information about probable forest and land fires. The development of this novel approach may be attributed to the joint endeavours of many government agencies, highlighting the significance of engaging multiple stakeholders in the successful management of forest fires. The deployment of this system has dramatically enhanced Indonesia's ability to actively monitor and promptly respond to possible dangers of forest fires.

The Sipongi System exhibits robust and intricate communication and follow-up systems, which effectively enable swift coordination among diverse stakeholders in Indonesia engaged in the prediction and management of forest and land fires across many regions. The integration of WhatsApp as a communication platform enhances the facilitation of information exchange and coordination among various stakeholder groups, hence augmenting the overall efficacy of endeavours aimed at extinguishing forest and land fires.

The Sipongi System represents a remarkable technological innovation that has significantly transformed the realm of forest fire management in Indonesia. The overwhelming success of this endeavour highlights the significant role that cross-institutional collaboration plays in addressing environmental concerns. By endorsing and executing these pioneering techniques and methodologies, we can proficiently alleviate the adverse consequences of forest and land fires on ecosystems, biodiversity, and human health. This exemplifies the capacity of technology and collaborative

efforts to safeguard the natural environment and society against the adverse consequences of forest and land fires.

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