

FOREST AND LAND FIRES POLICIES IMPLICATIONS IN INDONESIA: TECHNOLOGICAL SUPPORT NEEDS

Implikasi Kebijakan Kebakaran Hutan dan Lahan di Indonesia: Kebutuhan Dukungan Teknologi

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ABSTRACT

The occurrence of forest and land fires in Indonesia has been a critical environmental issue in the South East Asia Region, closely related to the transboundary haze pollution. The government of Indonesia has shifted the fire management paradigm from fire suppression concern to fire prevention priority since 2016. The study aims to systematically review the development of forest and land fire-related policies in Indonesia and to evaluate the use of mobile and web-based applications of The Smart Patrol Information System (SIPP Karhutla) implemented in the Sumatera and Kalimantan regions. We conducted Systematic Literature Reviews to identify the roadmaps of forest and land fire-related policies in Indonesia. Field surveys, questionnaires, and interviews with fire brigades in 7 provinces in the Sumatera and Kalimantan regions to evaluate the use of the SIPP Karhutla. There has been a significant increase of fire-related policies since 2014, which enhance fire management development. The SIPP Karhutla has been widely used in Sumatera and Kalimantan regions. The applications have reduced time for patrol data recording and reporting significantly. Therefore, they supported the fire brigades' patrol activities effectively and efficiently.

Keywords: fire management, Smart Patrol Information System, transboundary haze pollution

ABSTRAK

Kebakaran hutan dan lahan (karhutla) merupakan isu lingkungan yang penting di kawasan Asia Tenggara, terkait dengan polusi kabut asap yang melintas batas. Pemerintah Indonesia telah mengubah paradigma dengan memprioritaskan kegiatan pencegahan kebakaran dari pemadaman sejak tahun 2016. Penelitian ini bertujuan untuk melakukan tinjauan sistematis perkembangan kebijakan terkait karhutla dan untuk mengevaluasi penggunaan aplikasi mobile dan web dari Sistem Informasi Patroli Pencegahan Karhutla (SIPP Karhutla) di wilayah Sumatera dan Kalimantan. Metode penelitian mencakup: kajian pustaka secara sistematis kebijakan karhutla di Indonesia., survei lapangan, kuesioner, dan wawancara dengan para pemadam kebakaran di tujuh provinsi di Sumatera dan Kalimantan. Kebijakan terkait karhutla mengalami peningkatan sejak tahun 2014, yang mendorong perbaikan pengendalian karhutla. Aplikasi SIPP Karhutla telah digunakan secara luas di wilayah Sumatera dan Kalimantan. Aplikasi tersebut terbukti menurunkan waktu pencatatan dan pembuatan laporan patroli secara signifikan. Aplikasi ini mendukung kegiatan patroli secara efektif dan efisien.

Kata kunci: manajemen kebakaran, Sistem Informasi Patroli Pencegahan Karhutla, polusi kabut asap lintas batas

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INTRODUCTION

Forest and land fires in Indonesia have been a regular phenomenon that causes vast environmental impacts, including Green House Gases emissions and smoke haze transboundary haze pollution (Betha *et al.* 2018; Heymann *et al.* 2017; Parker *et al.* 2016; Quah 2002). The fires come from burning activities in land clearing for various purposes, including land preparation for agriculture and forest plantation, settlement, and other development programs, burning due to land conflicts, unintentional spreading of fire, and natural resources extraction activities, particularly in Sumatera and Kalimantan (Applegate 2001; Agus *et al.* 2013; Carmenta *et al.* 2017; Harrison *et al.* 2009; Reimer and Eriksen 2018).

Fire-related policies are essential in effective forest and land fire management. In the global context, Indonesia has developed policies related to REDD+, where fire is one of the contributors to global warming (Nurhidayah *et al.* 2017). As the most extensive fire occurred in 1997/1998, the ASEAN member states came up with The Transboundary Haze Pollution Agreement, which was signed by the ASEAN environment ministers in Kuala Lumpur on 10 June 2002 and entered into force on 25 November 2003 (Heilmann 2015; Safitri 2021). Indonesia is the last country that ratified the Agreement in 2015. At the national level, fire-related policies have been issued in several regulations, including (Isna 2018): Act No. 41, 1999 on Forestry (Forestry Act), Act No. 32, 2009 on the Environmental Protection and Management (Environmental Act), and Act No. 39, 2014 on Plantation (Plantation Act). For site-level policy implementation, the local government policies play a crucial role in fire management. Some fire-prone provinces have conducted multistakeholder approaches to control fire by developing the provincial level policies, such as in Riau, South Sumatera, and Central Kalimantan (Sarmiasih and Pratama 2019; Rauf *et al.* 2020; Cenny *et al.* 2017). In technical aspects, Indonesia has developed technology in forest and land fire information systems, early warning systems, early detection and early suppression for fire control, and social innovation, including wood vinegar, charcoal briquette, and compost production. Good practices of social approaches such as MPA (Fire Care Community) and Integrated Patrols have been identified and need to be replicated and enhanced. Multistakeholder and techno-socio approaches need to be conducted integratively to minimize the fire problems in Indonesia (Syaufina and Sitanggang 2020).

However, the regulations seem not to be implemented effectively, as significant fire occurrences still occur. Natural factors like El Nino strongly correlated with significant fire occurrences. The fire management prioritized fire suppression, resulting in a significant funding allocation. In 2015, a large fire occurred again, which burned forest and land area of 2.61 million hectares as the most severe fire in 2013-2018 (MoEF 2018). Since then, Presidential Instruction No. 11, the year 2015, was released to strengthen forest and land fire control, particularly in strengthening coordination inter sectoral institutions at the national and

regional levels and in law enforcement for individuals or legal entities who burn the lands. In response to the Instruction, the Ministry of Environment and Forestry issued Ministerial Regulation No. 32 in the year 2016 on Forest and Land Fire Control, which includes fire patrol activity for the prevention and early suppression. By this regulation, fire patrol is conducted in specific forest and land areas by the fire brigades under the MoEF (called Manggala Agni), supported by police officers, the army, village officials, and volunteers from the community. It was followed by Ministerial Regulation No. P.8/MENLHK/SETJEN/KUM.1/3/2018 on ground checking of hotspot and information system.

In patrol activities, the fire brigades reported the area condition manually and sent the reports through WhatsApp Group, and an Open Camera was used to capture the patrol location. This kind of reporting cause ineffective and inefficient communication and management. The daily patrol reports from each team in the field need to be compiled by the administrator in the 34 operational areas in the 12 provinces in Sumatera, Kalimantan, and Sulawesi regions. This condition resulted in bulky hard copy reports in the Ministry and difficulties in analyses and decision-making. Therefore, we developed the mobile and web-based application for forest and land fire prevention patrol information system (called the Smart Patrol Information System or SIPP Karhutla) in 2020 under the collaboration between IPB University and the Ministry of Environment and Forestry. The Indonesia Endowment Fund for Education (LPDP) funded the system development. Sixty-nine parameters need to be measured and recorded in the system, including general information, vegetation condition, soil condition, and social condition. Our system was then accepted and developed into regulation by MoEF through the Regulation of the Directorate General for Climate Change No. P.10/PPI/SET/KUM.1/12/2020 on the Usage of the Smart Patrol Information System or SIPP Karhutla, which resulted in implementing the Smart Patrol Information System for the whole of Indonesia. This new policy reflects technology support for fire management policy in Indonesia as only a few studies appeared concerning this matter.

The study aims to systematically review the development of forest and land fire-related policies and evaluate the use of mobile and web-based applications of fire prevention patrol information systems (The Smart Patrol Information System) implemented in the Sumatera and Kalimantan regions.

MATERIALS AND METHODS

Research Location and Time

The study area for evaluating the use of the Smart Patrol Information System is the command posts of fire brigades under the Ministry of Environment and Forestry in Sumatera and Kalimantan regions (Figure 1), including the command post in South Sumatera, Jambi, Riau, West Kalimantan, Central Kalimantan, South

Kalimantan, and East Kalimantan Provinces. Data were compiled in the year of 2021-2022 period.

Research Tools and Materials

Datasets used for the study were peer-reviewed research articles on forest and land fire-related policies published in indexed journals compiled from Google Scholar in 1997-2022 and questionnaires for mobile application users and 26 questionnaires for web application users of the Smart Patrol System.

Data Collection and Research Procedure

Systematic literature reviews on forest and land fire-related policies

Datasets used for the systematic literature reviews were free available peer-reviewed research articles on forest and land fire-related policies published in indexed journals compiled from Google Scholar in 1997-2022. *Publish or Perish* as a search engine used for systematic analyses to compile journal articles and *VOSviewer* to classify and cluster the articles based on the text mining approach. Combined keywords used in searching the literature include Indonesia, *forest fire policy*, *fire prevention*, *fire suppression*, *human resource*, *law enforcement*, and *fire organization*. Literature search with those combined keywords was applied using *Publish or Perish* software, which classifies the articles into cites, ranks, authors, title, journals, publisher, and year. The articles found were then selected as the most relevant articles to the research question.

Evaluation of the use of the Smart Fire Prevention Patrol System

We started to disseminate how to use the system and to measure or record the parameters after the issuance of the Regulation of Directorate General of Climate Change No. 20 the year 2020 in December 2020 to the fire brigades (*Manggala Agni*) of the command posts in fire-prone provinces in Sumatera and Kalimantan from mid of 2021 until June 2022. The dissemination materials cover the operational procedure of the mobile application and web application of the Smart Patrol Information System and the standard procedure for field parameter measurements. Distribution of the questionnaires and in-depth interviews with the fire brigades involved. One hundred four questionnaires for mobile application users and 26 questionnaires for web application users.



Figure 1. Study location for the Smart Patrol Information System

Data Analyses

Systematic literature reviews on forest and land fire-related policies

The articles were then analyzed with the following steps:

- Refining for the most relevant articles using advanced keywords: *transboundary haze*, *fire control*, *regulation*. All the irrelevant articles were deleted. The classification process resulted in 141 articles with those combined advanced keywords.
- The selected articles in *RIS* form file was imported to the software to be analyzed as text data. Maps were created based on a network constructed of peer-reviewed journals and terms. Items in these networks can be connected by co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation links. To construct a network, reference manager files (*RIS*) were used as input to *VOSviewer* (Van Eck and Waltman 2021). The object of interest of this study is terms related to forest and land fire-related policies in Indonesia.
- In-depth content analyses were conducted for 17 articles from the most cited journals to identify and summarize the scope and fire control aspects of fire-related policies in Indonesia.

Evaluation of the use of the Smart Patrol Information System

We received questionnaires from 104 mobile application users and 27 web application users. We analyzed the responses of the users for the following indicators:

- Time duration for recording parameters in one patrol activity before using the mobile application
- Time duration for recording parameters in one patrol activity after using the mobile application
- Time duration for reporting in one patrol activity before using the mobile application
- Time duration for reporting in one patrol activity after using the mobile application
- Time duration for compiling daily reports before using the web application
- Time duration for compiling daily reports after using the web application

The data was then analyzed using paired t-test of the *JASP 0.16* application to compare the time differences before and after using the application system.

RESULTS AND DISCUSSIONS

Systematic Reviews on Forest and Land Fire Policies in Indonesia

Forest and land fires in Indonesia have been a crucial environmental issue, which attracts academicians to study, particularly after the 1997/1998-fire episode as the largest fire that occurred in the past three decades in South East Asia. Fire articles published in scientific journals discuss various topics covering: the fire impacts on soil, biodiversity, water, air pollution, and health; fire behaviour; fire emission; fire detection; fire early warning system; fire use; and fire policy (Syaufina 2016).

In the last two decades, satellite-based fire articles have been in tremendous increase, covering: fire emission and pollution (46%), fire risk and detection (42%), and fire impacts assessment (12%) (Syaufina *et al.* 2016).

Text mining with VOSviewer on fire policies research articles produces a network representation of fire policy aspects (Figure 2). The main aspects that appeared in the network are smoke, remote sensing, law enforcement, air pollution, and disaster management. Generally, the closer two terms are placed, the closer they are connected. The distance between two items determines their strength. A closer relationship suggests a shorter gap. Lines connect the most significant sentences that connect the various components of fire policy (Munn *et al.* 2018) and forms clusters.

Clustering as a process of grouping entities from an ensemble into classes of entities that are similar in some sense has been applied in bibliographical studies. The clustering algorithms have been used in grouping text documents to extract interesting patterns from the documents (Farid and Sitanggang 2020; Jalal and Ali 2021). The study revealed that there are six clusters of terms related to fire policy aspects, namely:

Cluster 1: smoke, forest fire prevention, ASEAN Agreement, transboundary haze pollution, peatland management, implementation, strategy, program, Riau province

Cluster 2: remote sensing, deforestation, tropical forest, agriculture, forestry, forest area, policy maker, environment

Cluster 3: air pollution, biomass, combustion, emission, exposure, health, Indonesia forest fire, wildfire smoke

Cluster 4: law enforcement, climate change, community, forest fire management, forest

policy, mitigation, regulation Central Kalimantan

Cluster 5: peatland fire, peat fire, land management, information, wildfire, wildland fire

Cluster 6: Disaster management, Indonesia government, peat, public policy, role

These clusters reflect the relatedness of fire policy aspects, which indicate essential issues. Cluster 1 shows that the smoke produced by Indonesian fire has contributed to transboundary haze pollution. Forest fire prevention is one of the ASEAN Agreement on Transboundary Haze Pollution programs, highlighting sustainable peatland management as the implementation strategy. Cluster 2 emphasizes deforestation of tropical forest area for agriculture, which change the environment. Policymakers and remote sensing are essential to assess deforestation. Indonesia's forest fire has contributed to the emission and air pollution due to biomass combustion, which produces wildfire smoke. It is a threat to health exposure, as explained by cluster 3. Forest policy in terms of regulation in Cluster 4 needs to strengthen forest fire management, including law enforcement, to support climate change mitigation. Cluster 5 focuses on peatland fire, or peat fire, as well as wildland fire or wildfires that need to be concerned in land management. Cluster 6 describes the vital role of disaster management conducted by the Indonesian government as public policy.

Published articles on fire policies from 1997-2022 (Figure 3) indicate a robust, increasing trend ($R^2=0.80$). The publication was started in 1999 with a mean yearly publication of 6 articles and the highest number of articles found in 2021, of 27 articles.

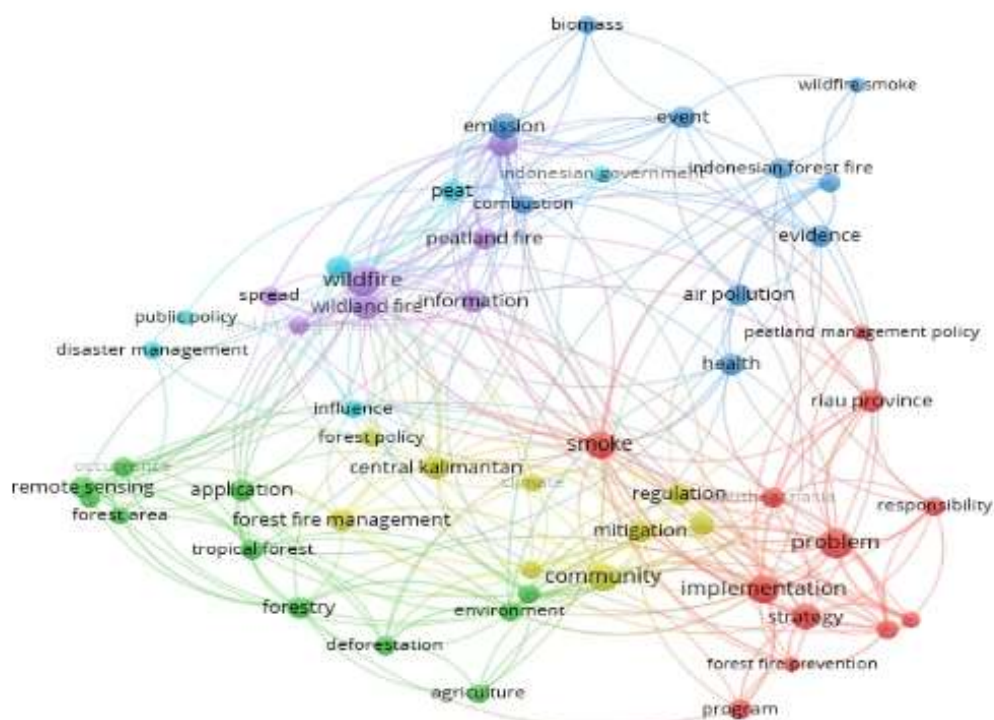


Figure 2. Network visualization of fire policy aspects

It seems that the interest of researchers in fire policy significantly increased after 2010. It is in line with the study on peatland fire status, which concluded that research on peatland fire has been on the increasing trend since the 1997/1998-fire episode, particularly within the 2013-2014 period when the research articles have significantly increased. It is seemingly due to significant transboundary haze pollution impacts from peatland fire in Sumatera and Kalimantan and the critical issue of carbon emission and global climate change (Syaufina 2016).

The increased study on fire policies seems to enhance the development of fire management approaches. Techno-Socio approaches in fire control have been in tremendous progress since 2015 (Syaufina and Sitanggang 2020). Having experienced a significant fire occurrence in 2015 with 2.61 million ha of burned area, Indonesia has shifted the forest and land fire management paradigm to focus more on fire prevention than fire suppression. This shifting paradigm has decreased the burned area trend from 2015 to 2021 (Figure 4). Though there was a high burned area in 2019 (1.65 million ha), it is strongly influenced by the El Nino phenomenon. The polynomial model can explain the burned area distribution, with $R^2 = 0.77$ as a good model. Our study found that only a few fire-related policies in Indonesia regulate technology support in fire management.

Evaluation of the Use of the Smart Patrol Information System

The legal basis for controlling land and forest fires is based on Law No. 41/1999 on Forestry (Forestry Act), Law No 32/2009 on the Environment Protection and Management, Law No. 39/2014 on Plantation, and

Regulation No 4/2001 concerning Environmental Damage Control. Fire management divided forest and land fire control programs into five categories, namely: Fire prevention, fire suppression, human resources development, and post-fire activities. Fire prevention includes: Integrated prevention patrol, Routine patrol, Early warning, and early detection, Campaign and education, Land preparation without burning/zero burning, Peatland Management, Fire Care Community, and Coordination meeting; Fire suppression covers: Ground suppression and aerial suppression; Human Resources Development consist of Forest and Land Fire Brigades (Manggala Agni), Forest Fire Brigades in Forest Management Unit, Capacity building: training, Coaching clinic, and Equipment, and post-fire activities covering: Burn area calculation and Law enforcement (Syaufina and Sitanggang 2020).

One technological approach to fire prevention is The Smart Patrol Information System, which consists of 1) a database of fire patrol management, 2) a mobile application for patrol data recording, and 3) a web application for patrol data analyses and management. The Smart Patrol Information System users are the fire brigade (Manggala Agni), staff, and officers of the Directorate of Forest and Land Fire Management, Directorate General Climate Change, Ministry of Environment and Forestry. The Smart Patrol Information System refers to the Regulation of the Director General of Climate Change No. P.10/PPI/SET/KUM.1/12/2020 on the Smart Patrol Information System procedure, which supports the patrol team and the involved members to record and report patrol data faster and easier. It seems that this regulation is the only fire policy that involves technology support for fire management.

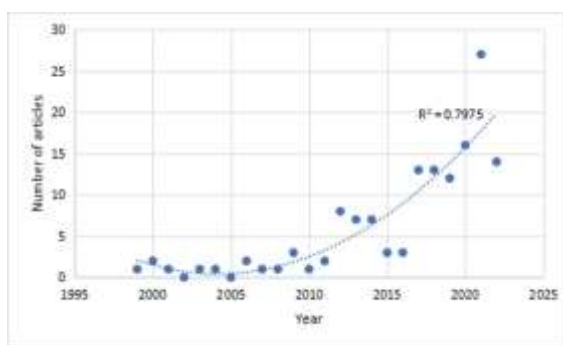


Figure 3 Yearly distribution of forest and land fire-related policies

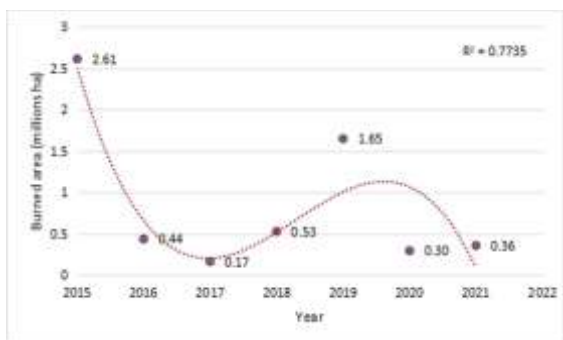


Figure 4 Yearly burned area in Indonesia in the period of 2015-2016

Table 1 Descriptive analyses of patrol data recording and reporting before and after using the mobile application of the Smart Patrol Information System

	N	Mean	SD	SE
Data recording before application (minutes)	104	30.447	24.523	2.405
Data recording after application (minutes)	104	19.163	16.995	1.667
Reporting before application (minutes)	104	45.183	38.197	3.746
Reporting after application (minutes)	104	26.433	26.786	2.627

Table 2 Paired Sample T-Test for patrol data recording and reporting before and after using the mobile application of the Smart Patrol Information System

Measure 1	Measure 2	t	df	p	Cohen's d	95% CI for Cohen's d	
						Lower	Upper
Data recording before	Data recording after	8.156	103	< .001	0.800	0.577	1.019
Reporting before	Reporting after	8.352	103	< .001	0.819	0.595	1.040

Note. Student's t-test.

After one year of implementation, the study indicates that the patrol teams are pleased to use the applications on their mobile phones without any significant obstacles. They key in the patrol parameters after observing or measuring them in the field through their mobile phone, which is automatically sent to the database managed by the administration staff. Data analyses (Table 1.) show that the mean recording patrol data after using the mobile application (19.1 minutes) is faster than that before using the mobile application (30.4 minutes). Similarly, the mean daily patrol reporting after using the mobile application (26.4 minutes) is faster than before (45.1 minutes). It means there is a time efficiency of 37.06% for patrol data recording and 41.5% for patrol data reporting.

Statistical analyses indicate significant differences between patrol data recording and patrol data reporting before and after using the Smart Patrol Information System mobile application (Table 2 and Figure 5).

For the web application, data analyses show that daily reporting after (13.69 minutes) using the Smart Patrol Information System web application is faster than

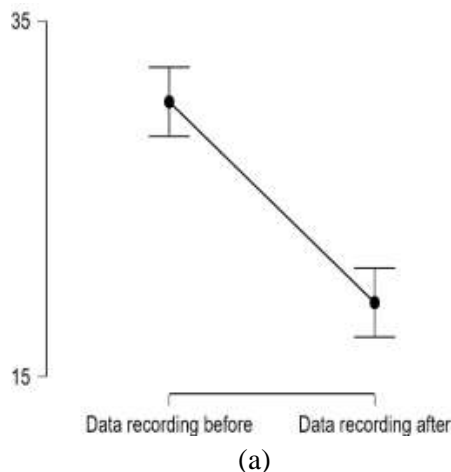
Table 3 Descriptive analyses of patrol data reporting before and after using the web application of the Smart Patrol Information System

	N	Mean	SD	SE
daily reporting before (minutes)	26	31.462	25.713	5.043
daily reporting after (minutes)	26	13.692	7.656	1.502

Table 4 Paired Sample T-Test for daily patrol data reporting before and after using the web application of the Smart Patrol Information System

Measure 1	Measure 2	t	df	p
daily reporting before	daily reporting after	3.967	25	< .001

Note. Student's t-test.



before (31.46 minutes). It resulted in a time efficiency of 56.48%.

The statistical analyses indicate a significant difference in daily patrol data reporting before and after using the Smart Patrol Information System web application (Table 4. and Figure 6).

In-depth interviews with the fire brigade respondents show that the use of the mobile application of the Smart Patrol Information System is as follows: 1) easier for field patrolling, 2) more accessible for patrol data reporting, and 3) easier for patrol target evaluation. Similarly, the Evaluation of the web application of the Smart Patrol Information System is as follows: 1) make it easy in patrol data reporting, 2) make it easy to control/monitor patrol activities, and 3) make it easy in final reporting.

This Smart Patrol Information System has policy implications, including (Syaufina and Sitanggang 2022):

- 1) Setting up the hard wares and soft wares to support the system
- 2) Training needs for the use of mobile and web applications of the Smart Patrol Information System
- 3) Training needs for standard measurement of parameters of the Smart Patrol Information System
- 4) Needs for human resources development and funding support for the Smart Patrol Information System

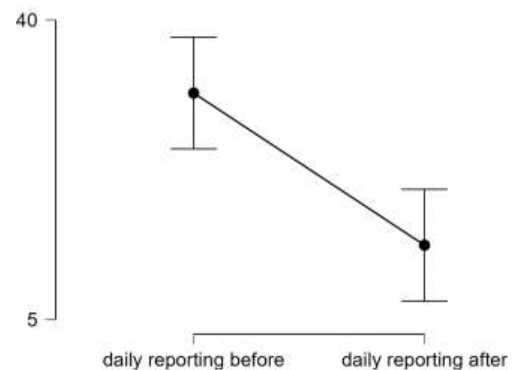


Figure 6. Differences between daily patrol data reporting before and after using the web application of the Smart Patrol Information System

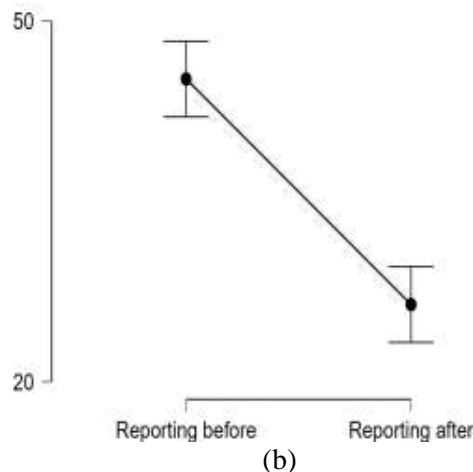


Figure 5 Differences between patrol data recording (a) and patrol data reporting (b) before and after using the mobile application of the Smart Patrol Information System

CONCLUSIONS

The studies on forest and land fire-related policies have increased tremendously since 2014 and enhanced the development of fire management in Indonesia. Only a few studies were found concerning fire policy and technology support in fire management. It seems that the Regulation of Director General of Climate Change No. P.10/PPI/SET/KUM.1/12/2020 on the Smart Patrol Information System procedure is the first fire policy that involves technology support for fire management in Indonesia. After one year of implementation of the Smart Patrol Information System, daily patrol data recording and reporting using the mobile application have significant differences before and after the use of the mobile application. Similarly, daily patrol reporting is significantly different before and after using the web application.

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