BMKG

COUNTRY REPORT:
PROGRESS ON INDONESIAN WEATHER MODIFICATION

ENDARWIN
Director of Weather Modification Governance
Meteorological, Climatological, and Geophysical Agency (BMKG)
Indonesia

BRIEF HISTORY The Development of Indonesia Weather Modification

1976-1978

- **President Soeharto's** idea for supporting **agriculture sector** → best practice from **Thailand**
- **First rain making experiment → 1977** under the assistance of **Prof. Devakul from Royal Rainmaking Thailand**. Led by **Ir. Soebagio** and supervised by **Prof. Dr. Ing. B.J. Habibie**.
- As an organization → **Pertamina (National Oil and Gas company) - Advanced Technology Division** and still in the scale of **experimental project,** known as **Rain Making Project**.

1978-2021

- **1978**, Agency for the Assessment and Application of Technology (**BPPT**) was established and supervised The Rain Making Project
- As the Rain Making Project made good progress and results, in **1985 UPT Hujan Buatan** was formed as organization under BPPT which **responsible to implement weather modification technology (WMT) service and conducting research and development for WMT.**
- During BPPT's era, WMT **has experienced rapid development for its implementation and widely known in Indonesia as a reliable technology for various relevant purposes.**

Sept 2021-2024

- **BRIN** was formed as a merging institution to combine several national research and development institutions, including BPPT → transformation to **Laboratory for Weather Modification Technology** as organization.

2024

- **President Jokowi** formed **The Weather Modification Deputy under Meteorological, Climatological, and Geophysical Agency (BMKG)**
- The development for Indonesia Weather Modification as **global player for implementing its services and knowledge sharing**

Vehicle and Seeding Material for WMT

Ground	Air
	
Ground-Based Generator (GBG) Flare	Aircraft Powder and Flare

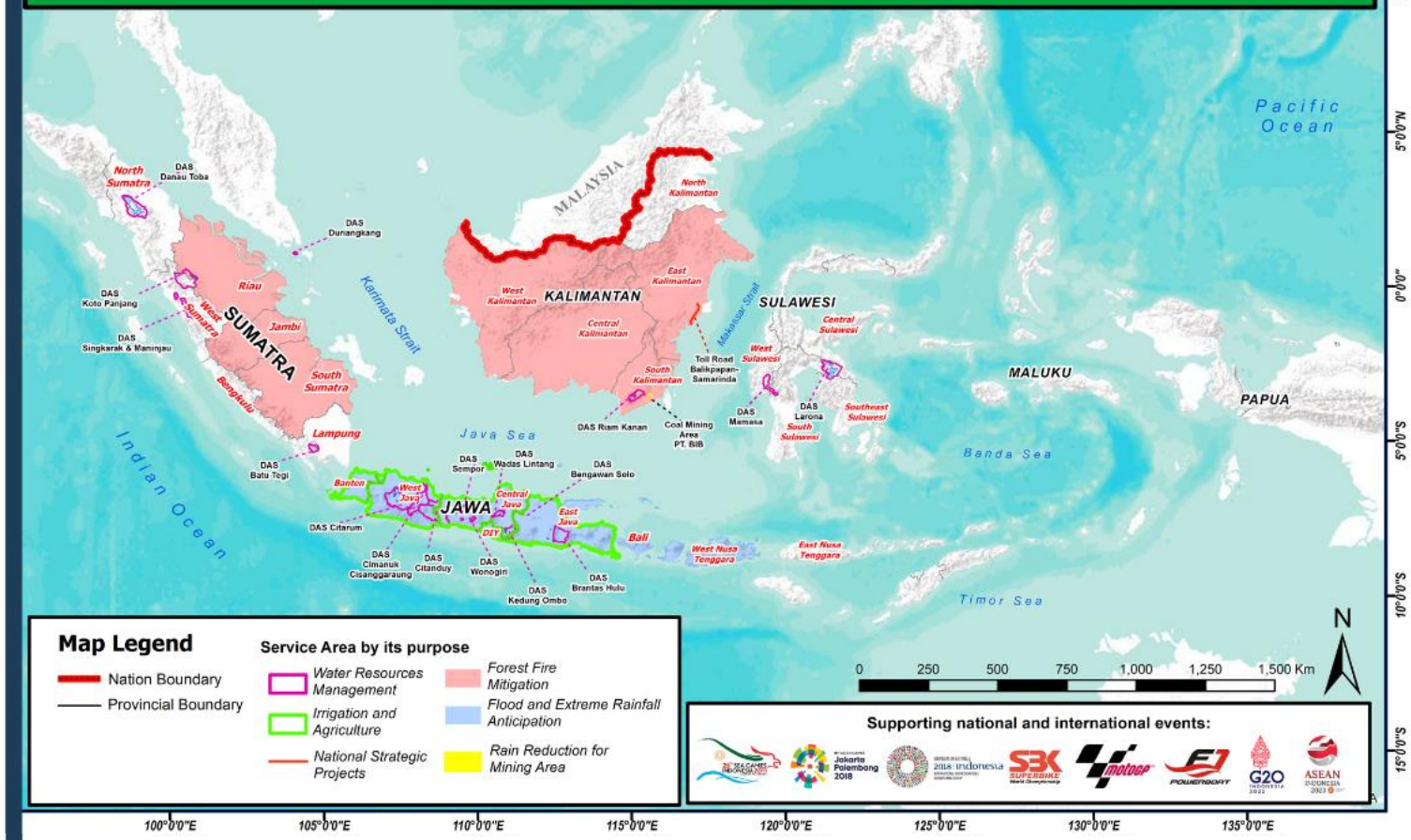
WMT Main Purposes

- Rain Enhancement
- Rain Reduction
- Fire Suppresion

WMT Utilization for Various Needs

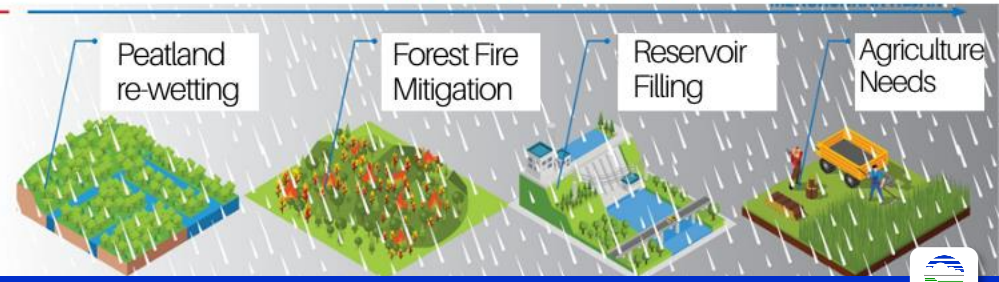
- Reservoir Filling
- Hydrometeorological Disaster Mitigation (forest fire, drought, floods, landslides),
- Mining (reduced slippery time)
- Securing State Events (G20, MotoGP, ASEAN Summit, Asian Games, SEA Games, etc.)
- Security for the National Infrastructure Development Project others

WEATHER MODIFICATION TECHNOLOGY SERVICE AREA

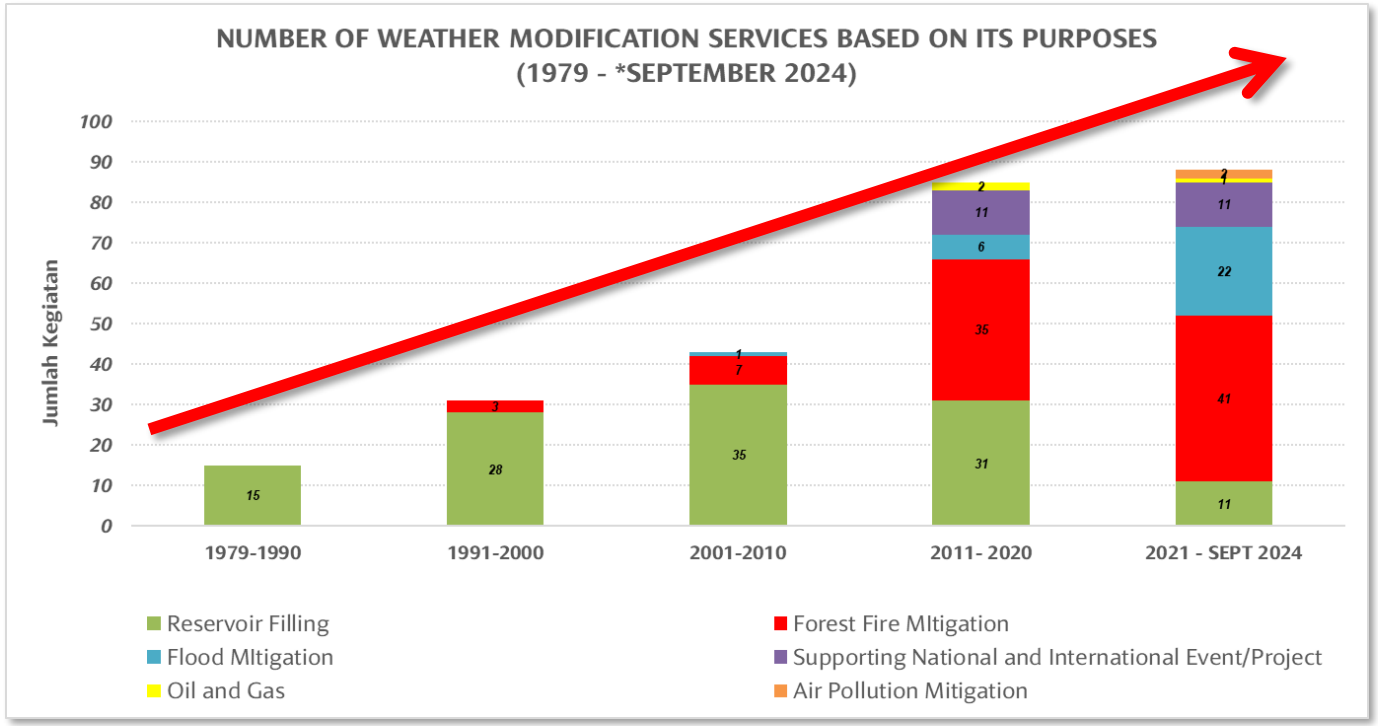


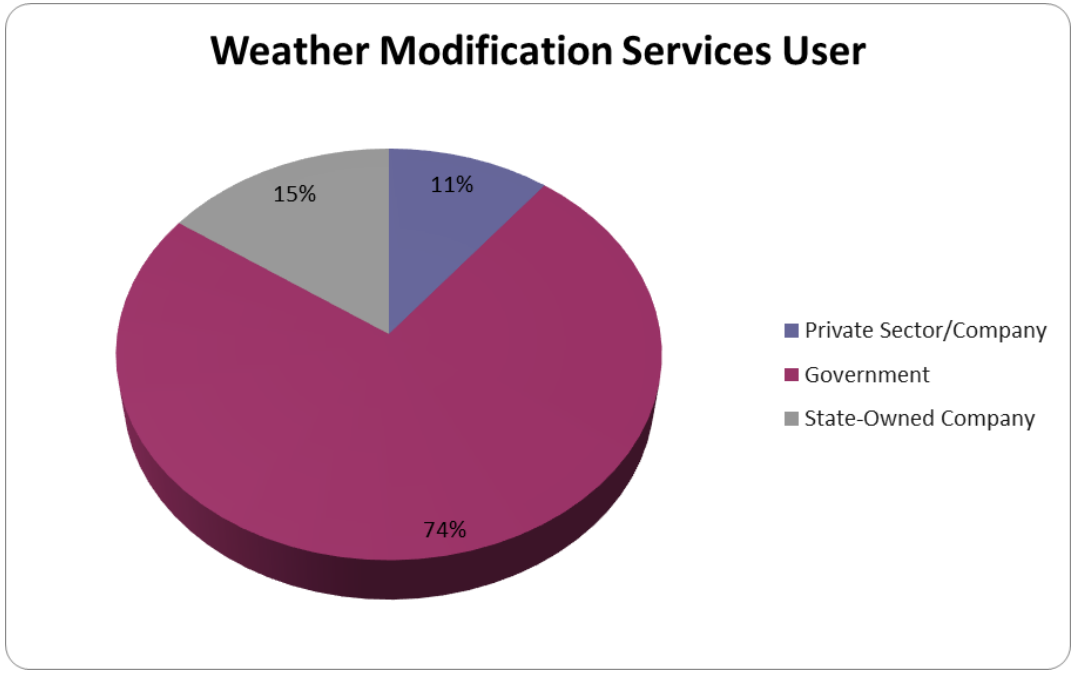
Rain Reduction

Rain Enhancement



TREND OF WEATHER MODIFICATION SERVICES IN INDONESIA





- The increasingly developed Weather Modification services for various interests → **WMT services are increasing**
- The number of activities in the period 2021 - September 2024 (<4 years) **has exceeded the cumulative number of services in the previous decade (2011-2020)**
- Utilization of WMT to **support State Events (national and international) and National Strategic/Priority Projects is growing very rapidly** → expansion of the weather modification ecosystem

WEATHER MODIFICATION AND ITS SUPPORT FOR ACHIEVING SUSTAINABLE DEVELOPMENT GOALS

The implementation of weather modification service has its potential in various sectors while also supporting the Sustainable Development Goals (SDGs)

Reducing The Impact of Hydrometeorological Hazards

An average of 3000 hydrometeorological disasters have been identified each year in 38 provinces in Indonesia

Reducing The Carbon Emission

Weather modification operations on peatlands can be directed to reduce carbon emissions and help the government's target of reducing carbon emissions by 26%.

Supporting Water Resource Management

Filling reservoirs → availability of clean water, energy and food self-sufficiency → FEW Nexus

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The Optimization of Mining Sector

By reducing rain in mining areas → lowering the number of *loss time* → increase production → efficiency in mining sector

Agricultural

Supporting water needs for agricultural sector and plantation

Supporting National Priority Projects

Help government achieving their target for many priority infrastructure projects from the impact of torrential rain or drought

ROLE OF BMKG AS REGULATOR AND OPERATOR FOR WEATHER MODIFICATION IMPLEMENTATION IN INDONESIA

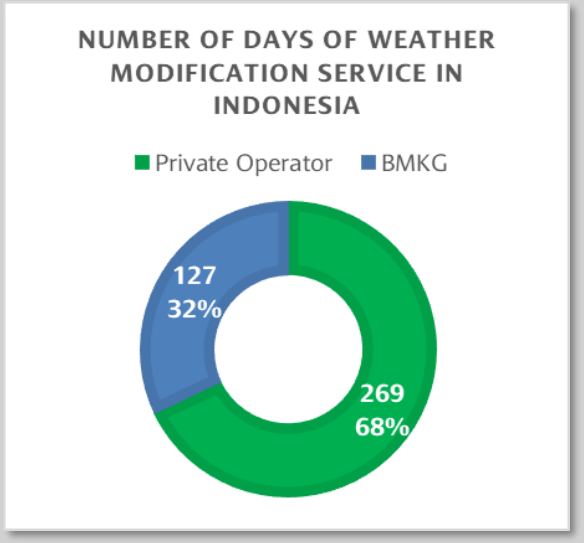
2024

BMKG

Effective this year, BMKG has expanded its mandate to include the comprehensive **regulation, management, and implementation of weather modification activities in Indonesia**.

REGULATOR

OPERATOR



(Jan 1 – Oct 13, 2024) : There have been 369 days of weather modification for various purposes, with **269 days (68%)** of these being carried out by private operators.

As a **regulator**, it plays a vital role in forming a weather modification service ecosystem in Indonesia, **controlling** and **providing assistance** in the implementation of weather modification carried out by private operators so that it is in accordance with scientific principles and provides optimal results for users.

As an **operator**, BMKG is tasked with providing modification services that have **national interests**, such as hydrometeorological disaster management, as well as in supporting national strategic projects (development and securing international events).

NOTABLE PROGRESS ON WEATHER MODIFICATION SECTOR IN INDONESIA

GROUND-BASED GENERATOR

- For high altitude (mountainous) area which is too risky for aviation
- Using flare as seeding material
- Tele-burning by remote (automatization)
- Effective for triggering orographic clouds into rain for upstream watershed → reservoir filling

2-5 MICRON SEEDING MATERIAL

- Production of 2 - 5 micron hygroscopic seeding material
- For better efficiency of the use for cloud seeding material

DRONE FOR CLOUD SEEDING

- Using fixed-wing drone
- Carrying flare seeding material
- Applicable for cloud seeding (cloud base)
- Lower operational cost

NIGHT CLOUD SEEDING

- Applicable for rain reduction → Areas with diurnal characteristics of rain that occurs more at night
- First project in July-September 2024 for supporting the development project of new Indonesian capital city in Kalimantan (IKN)

SEVERAL LATEST SCIENTIFIC REPORTS AND PROOF FOR CLOUD SEEDING IN INDONESIA

atmosphere

MDPI

Article

Hygroscopic Ground-Based Generator Cloud Seeding Design; A Case Study from the 2020 Weather Modification in Larona Basin Indonesia

Findy Renggono, Mahally Kudsy, Krisna Adhitya, Purwadi Purwadi, Halda Aditya Belgaman *, Saraswati Dewi *, Rahmawati Syahdiza, Erwin Mulyana, Edvin Aldrian and Jon Arifian

National Research and Innovation Agency (Indonesia), B.J. Habibie Building 15th–24th Floor, Jl. M.H. Thamrin No. 8, Jakarta Pusat 10340, Indonesia; find001@brin.go.id (F.R.); maha001@brin.go.id (M.K.); kris0134@brin.go.id (K.A.); purw016@brin.go.id (P.P.); rahm0408@brin.go.id (R.S.); erwi0058@brin.go.id (E.M.); edvin.aldrian@brin.go.id (E.A.); jona002@brin.go.id (J.A.)
* Correspondence: hald001@brin.go.id (H.A.B.); saraswati.dewi@brin.go.id (S.D.)

Abstract: Cloud seeding activities have been carried out in the form of experiments and operation activities as part of water resource management in some parts of the world. Recently, a new method of cloud seeding using a ground-based generator (GBG) was introduced in Indonesia. This method is used to seed orographic clouds with the aid of a 50 m GBG tower located in a mountainous area. By taking advantage of the topography and local circulation, the GBG tower will introduce hygroscopic seeding materials into orographic clouds to accelerate the collision and coalescence process within the clouds, increasing the cloud's rainfall amount. The hygroscopic ground-based cloud seeding was conducted over the Larona Basin in Sulawesi, Indonesia, from December 2019 to April 2020. There were five towers installed around Larona Basin, located over 500 m above sea level. The results show that there was an increase in monthly rainfall amount from the GBG operation period in January, February, and March compared to its long-term average of as much as 79%, 17%, and 46%, respectively. Meanwhile, despite an increase of 0.4% in Lake Towuti water level, it is still not concluded that the GBG cloud seeding operation was involved in the lake water level raise. Therefore, more studies need to be performed in the future to answer whether the cloud seeding affected the lake water level.

Keywords: cloud seeding; ground-based generator; hygroscopic flares; weather modification; Larona Basin Indonesia; orographic clouds

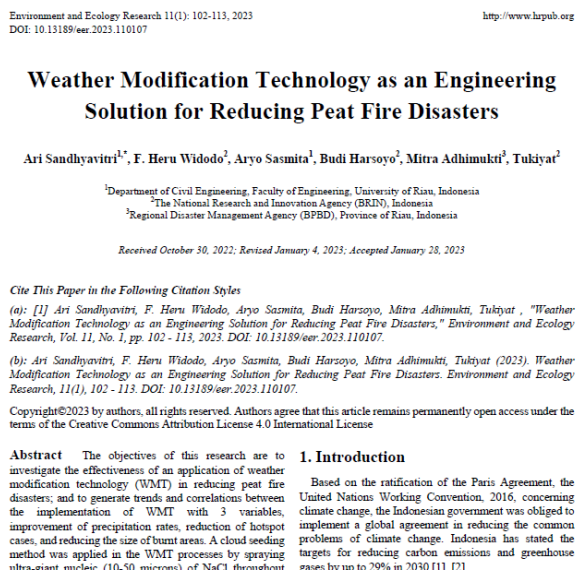
check for updates

Citation: Renggono, F.; Kudsy, M.; Adhitya, K.; Purwadi, P.; Belgaman, H.A.; Dewi, S.; Syahdiza, R.; Mulyana, E.; Aldrian, E.; Arifian, J. Hygroscopic Ground-Based Generator Cloud Seeding Design; A Case Study from the 2020 Weather Modification in Larona Basin Indonesia. *Atmosphere* **2022**, *13*, 968. https://doi.org/10.3390/atmos13060968

Academic Editors: Ali M. Abshaev, Thara Prabhakaran and Roelof Burger

"The implementation of weather modification using ground-based generator (GBG) in shows that there was an increase in monthly rainfall amount from the GBG operation period in January, February, and March compared to its long-term average of as much as 79%, 17%, and 46%, respectively."

(Renggono *et al.*, 2022)



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http://www.hrpub.org

Weather Modification Technology as an Engineering Solution for Reducing Peat Fire Disasters

Ari Sandhyavitri[1,*], F. Heru Widodo[2], Aryo Sasmita[1], Budi Harsoyo[2], Mitra Adhimukti[3], Tukiyat[2]

[1]Department of Civil Engineering, Faculty of Engineering, University of Riau, Indonesia
[2]The National Research and Innovation Agency (BRIN), Indonesia
[3]Regional Disaster Management Agency (BPBD), Province of Riau, Indonesia

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(a): [1] Ari Sandhyavitri, F. Heru Widodo, Aryo Sasmita, Budi Harsoyo, Mitra Adhimukti, Tukiyat , "Weather Modification Technology as an Engineering Solution for Reducing Peat Fire Disasters," Environment and Ecology Research, Vol. 11, No. 1, pp. 102 - 113, 2023. DOI: 10.13189/eer.2023.110107.

(b): Ari Sandhyavitri, F. Heru Widodo, Aryo Sasmita, Budi Harsoyo, Mitra Adhimukti, Tukiyat (2023). Weather Modification Technology as an Engineering Solution for Reducing Peat Fire Disasters. Environment and Ecology Research, 11(1), 102 - 113. DOI: 10.13189/eer.2023.110107.

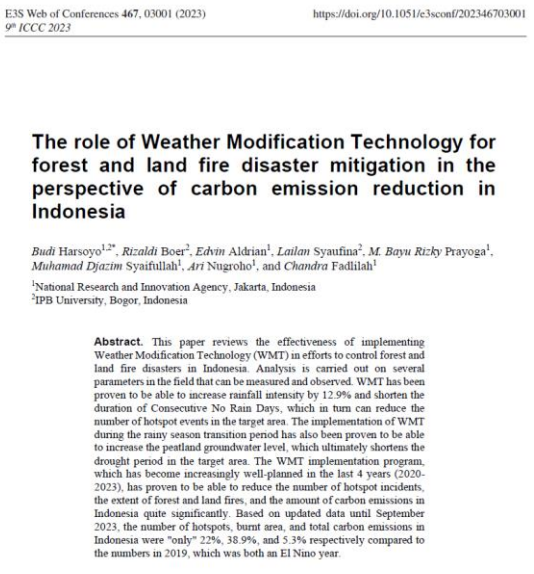
Abstract The objectives of this research are to investigate the effectiveness of an application of weather modification technology (WMT) in reducing peat fire disasters; and to generate trends and correlations between the implementation of WMT with 3 variables, improvement of precipitation rates, reduction of hotspot cases, and reducing the size of burnt areas. A cloud seeding method was applied in the WMT processes by spraying ultra-giant nucleic (10-50 microns) of NaCl throughout

1. Introduction

Based on the ratification of the Paris Agreement, the United Nations Working Convention, 2016, concerning climate change, the Indonesian government was obliged to implement a global agreement in reducing the common problems of climate change. Indonesia has stated the targets for reducing carbon emissions and greenhouse gases by up to 29% in 2030 [1, 2]

"During 4 years of the observation period, the implementation of WMT in this research location was considered effective in improving the precipitation rates as PCH = 1.33 >1. There was also a trend that the higher the precipitation rates were, the lower the size of burnt areas would be (R2 > 80%)."

(Sandhyavitri *et al.*, 2023)



E3S Web of Conferences **467**, 03001 (2023) https://doi.org/10.1051/e3sconf/202346703001
9th ICCC 2023

The role of Weather Modification Technology for forest and land fire disaster mitigation in the perspective of carbon emission reduction in Indonesia

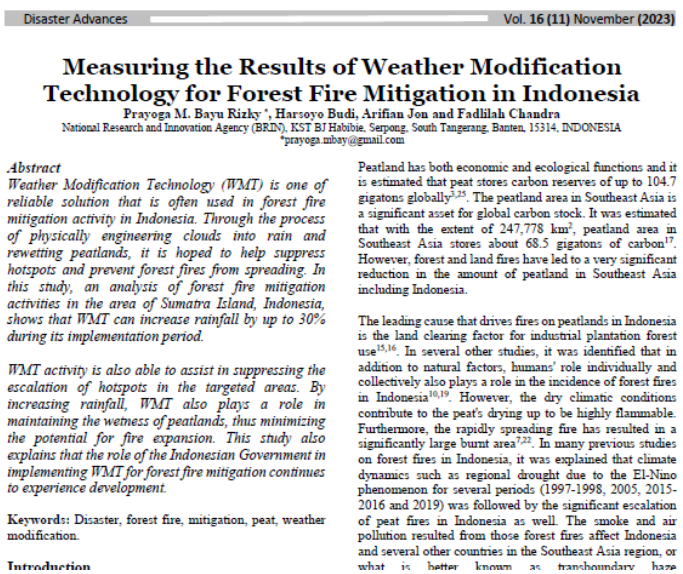
Budi Harsoyo[1,2*], *Rizaldi* Boer[2], *Edvin* Aldrian[1], *Lailan* Syaufina[2], *M. Bayu Rizky* Prayoga[1], *Muhamad Djazim* Syaifullah[1], *Ari* Nugroho[1], and *Chandra* Fadlilah[1]

[1]National Research and Innovation Agency, Jakarta, Indonesia
[2]IPB University, Bogor, Indonesia

Abstract. This paper reviews the effectiveness of implementing Weather Modification Technology (WMT) in efforts to control forest and land fire disasters in Indonesia. Analysis is carried out on several parameters in the field that can be measured and observed. WMT has been proven to be able to increase rainfall intensity by 12.9% and shorten the duration of Consecutive No Rain Days, which in turn can reduce the number of hotspot events in the target area. The implementation of WMT during the rainy season transition period has also been proven to be able to increase the peatland groundwater level, which ultimately shortens the drought period in the target area. The WMT implementation program, which has become increasingly well-planned in the last 4 years (2020-2023), has proven to be able to reduce the number of hotspot incidents, the extent of forest and land fires, and the amount of carbon emissions in Indonesia quite significantly. Based on updated data until September 2023, the number of hotspots, burnt area, and total carbon emissions in Indonesia were "only" 22%, 38.9%, and 5.3% respectively compared to the numbers in 2019, which was both an El Nino year.

"The number of hotspots, burnt area, and total carbon emissions in Indonesia were "only" 22%, 38.9%, and 5.3% respectively compared to the numbers in 2019, which was both an El Nino year, due to weather modification implementation"

(Harsoyo *et al.*, 2023)



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Measuring the Results of Weather Modification Technology for Forest Fire Mitigation in Indonesia

Prayoga M. Bayu Rizky *, Harsoyo Budi, Arifian Jon and Fadlilah Chandra
National Research and Innovation Agency (BRIN), KST BJ Habibie, Serpong, South Tangerang, Banten, 15314, INDONESIA
*prayoga.mbay@gmail.com

Abstract
Weather Modification Technology (WMT) is one of reliable solution that is often used in forest fire mitigation activity in Indonesia. Through the process of physically engineering clouds into rain and rewetting peatlands, it is hoped to help suppress hotspots and prevent forest fires from spreading. In this study, an analysis of forest fire mitigation activities in the area of Sumatra Island, Indonesia, shows that WMT can increase rainfall by up to 30% during its implementation period.

WMT activity is also able to assist in suppressing the escalation of hotspots in the targeted areas. By increasing rainfall, WMT also plays a role in maintaining the wetness of peatlands, thus minimizing the potential for fire expansion. This study also explains that the role of the Indonesian Government in implementing WMT for forest fire mitigation continues to experience development.

Keywords: Disaster, forest fire, mitigation, peat, weather modification.

Introduction

Peatland has both economic and ecological functions and it is estimated that peat stores carbon reserves of up to 104.7 gigatons globally[3,25]. The peatland area in Southeast Asia is a significant asset for global carbon stock. It was estimated that with the extent of 247,778 km^2, peatland area in Southeast Asia stores about 68.5 gigatons of carbon[17]. However, forest and land fires have led to a very significant reduction in the amount of peatland in Southeast Asia including Indonesia.

The leading cause that drives fires on peatlands in Indonesia is the land clearing factor for industrial plantation forest use[15,16]. In several other studies, it was identified that in addition to natural factors, humans' role individually and collectively also plays a role in the incidence of forest fires in Indonesia[10,19]. However, the dry climatic conditions contribute to the peat's drying up to be highly flammable. Furthermore, the rapidly spreading fire has resulted in a significantly large burnt area[7,22]. In many previous studies on forest fires in Indonesia, it was explained that climate dynamics such as regional drought due to the El-Nino phenomenon for several periods (1997-1998, 2005, 2015-2016 and 2019) was followed by the significant escalation of peat fires in Indonesia as well. The smoke and air pollution resulted from those forest fires affect Indonesia and several other countries in the Southeast Asia region, or what is better known as transboundary haze

"An analysis of forest fire mitigation activities in the area of Sumatra Island, Indonesia, shows that weather modification can increase rainfall by up to 30% during its implementation period."

(Prayoga *et al.*, 2023)

CHALLENGE AHEAD: IMPLEMENTING ARTIFICIAL INTELLIGENCE FOR WEATHER MODIFICATION OPERATION

On recent years, the artificial intelligent have been used in several sectors, mainly for increasing the accuracy of weather forecasting.

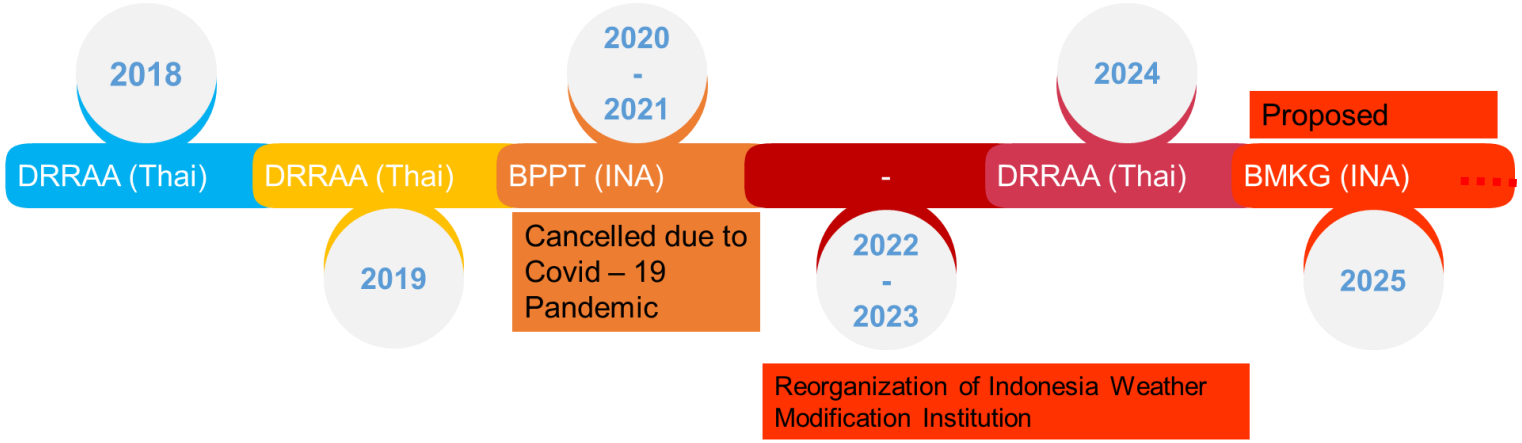
The question arise: How this "AI" can help to make our WMT more efficient and effectively?

The prospect of AI for supporting weather modification operation:

- Better **weather forecasting**
- **Enhance decision-making** on cloud seeding time and precision
- **Determination of target area**
- **Automatization** for weather modification

FOOTAGES ON INDONESIA WEATHER MODIFICATION OPERATION

ASEAN Weather Modification Workshop Series



The 2025 ASEAN Workshop on Weather Modification:
" Weather Modification for Hydrometeorological Disaster Mitigations and Water Resources Management"
will serve as a platform for experts, researchers, and practitioners in the field of weather modification technology to share their experiences, best practices, and the latest advancements, with a particular emphasis on the integration of AI.

TERIMA KASIH
khàawp Khun
Thank You

DEPUTY FOR WEATHER MODIFICATION
METEOROLOGICAL, CLIMATOLOGICAL, AND GEOPHYSICAL AGENCY (BMKG)
INDONESIA

tu5@bmkg.go.id dmc_bmkg