



Controlling fires in peatlands and peatland forests in Southeast Asia

A manual

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1 Introduction

Peatlands are vital ecosystems with roles in carbon storage, water regulation and biodiversity conservation (Joosten and Clarke 2002). Southeast Asia is estimated to contain approximately 24-30 million ha of known global tropical peatlands (Poulter et al. 2021; ASEAN 2023). Beyond their ecological significance, peatlands have a range of functions, including use as agricultural land, habitats for diverse species, and carbon sequestration. Figure 1 illustrates these multifaceted functions. However, the 1997 and 1998 wildfires¹ revealed significant challenges in managing peatland fires in the region (Page et al. 2002; Huijnen et al. 2016). These events, along with other large wildfire events that have since followed, have emitted billions of metric tons of CO₂, exacerbating climate change and creating transboundary haze, and severely impacted biodiversity, air quality, public health and regional economies (Tacconi 2003; Gaveau et al. 2014; Miettinen et al. 2017; Harrison et al. 2020). Thus, controlling fires in peatlands, and balancing peatland functions with sustainable management are critical to maintaining ecological integrity while supporting human development (Joosten and

Clarke 2002; Dargie et al. 2017; Finlayson and Milton 2016; Page and Rieley 2018).

The original manual, Adinugroho et al. (2005), was published to provide guidance on controlling fires in peatlands and peatland forests in Indonesia, specifically addressing the unique challenges posed by these ecosystems. It covered fire control strategies, factors that support fire occurrence, government policies, and practical techniques for preventing and suppressing fires in peatland areas. However, our understanding of peatlands has increased over the past two decades. Thus, this manual is an updated overview of the original manual, and incorporates modern approaches and insights from the two decades of experience in peatland fire management. It expands on the manual to present practical, region-specific strategies designed to address the unique challenges of managing fires in Southeast Asia's peatland ecosystems. This revision aims to make the manual more accessible and applicable for a broader audience, thereby supporting sustainable peatland conservation practices.

This updated manual provides a holistic framework to address the unique challenges of peatland fires in Southeast Asia. It emphasizes four main topics related to fire control measures that when implemented together can reduce greenhouse gas emissions, protect biodiversity, and

¹ Wildfires are a range of vegetation fire types and sizes, including large uncontrolled fires in forests, grasslands or brushlands caused by natural factors (e.g., lightning) or human activities (e.g., arson, accidental ignition, land clearing); land management fires for ecological or management goals; prescribed burns; peatland fires; landscape fires affecting large areas of land across multiple ecosystems and land uses; and agricultural burning. The terms wildfires and forest and land fires are used interchangeably.

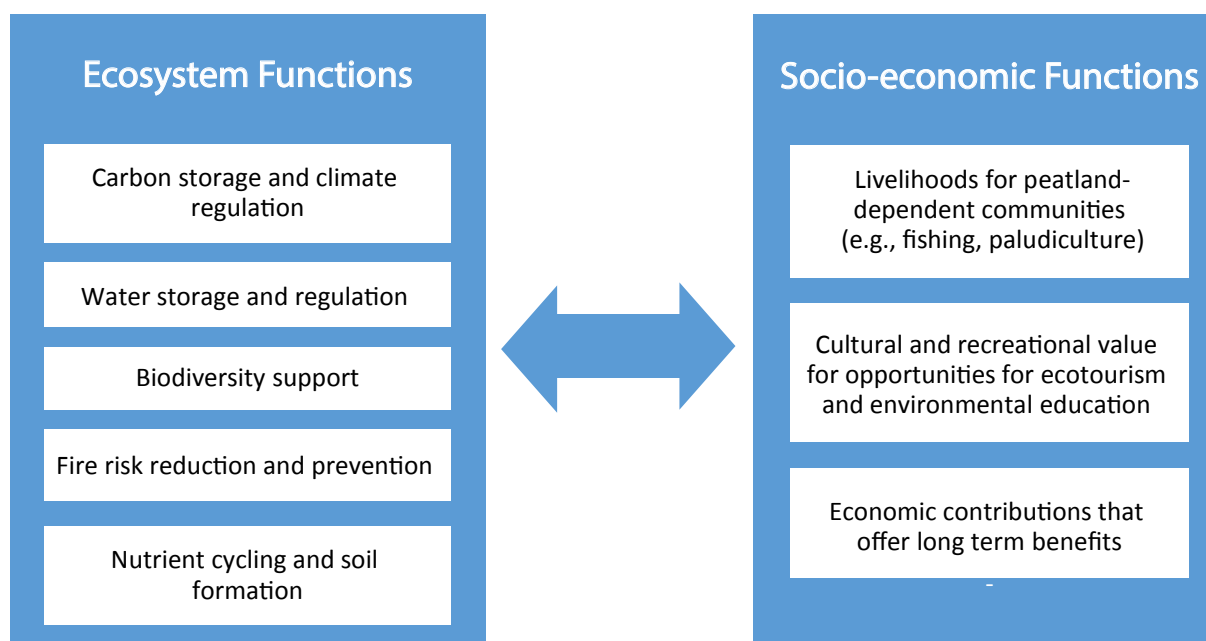


Figure 1. Ecological functions and services underpin socio-economic functions from peatlands, highlighting the interconnected relationship between ecosystem management and societal benefits for both environmental sustainability and human well-being.

Source: Created by the authors

mitigate socioeconomic impacts, offering a comprehensive solution for sustainable peatland fire management in the region:

1. Hydrological restoration, including canal blocking and water reservoir construction, to maintain groundwater levels and prevent fires.
2. Use of technologies, which can enhance regional coordination and response to transboundary haze while supporting sustainable peatland management are also included, such as advanced monitoring systems (e.g., SiPongi, Sipalaga, PRIMS) that offer real-time
3. Community engagement, including through initiatives such as forming firefighting brigades, promoting zero-burning policies, and offering alternative livelihoods to reduce fire risks.
4. Policy enforcement, including regulations like Indonesia's Government Regulation No. 4/2001, underpins these efforts. Post-fire rehabilitation through rewetting, revegetation and innovative tools like *beje* ponds further ensures long-term ecosystem recovery.

data for fire detection and groundwater monitoring and restoration tracking.

2 Forest fire control measures

Peatland fires in Southeast Asia are primarily caused by human activities, particularly land-clearing practices for agriculture and plantations. Fires for land clearing are widely used because they are low cost and efficient (Harrison et al. 2019). Further, draining peatlands for these activities significantly increases fire risks, as dried peat becomes highly flammable (Miettinen et al. 2017). Once ignited, peatland fires can burn on the surface and underground, making them difficult to detect and extinguish (Huijnen et al. 2016). These risks are exacerbated by El Niño-induced droughts, which create drier conditions that facilitate the spread of fires (Page et al. 2002).

The impacts of peatland fires are severe. The 1997 fires in Indonesia, for instance, released an estimated 0.81 to 2.57 gigatons of carbon into the atmosphere, contributing significantly to global climate change (Page et al. 2002). Fires also degrade the physical and chemical properties of peat soils, reducing their water retention capacity and negatively affecting biodiversity (Miettinen et al. 2017). Additionally, the dense haze generated by peatland fires contain fine particulate matter and toxic substances, causing widespread health problems such as respiratory and skin conditions (Huijnen et al. 2016). During the 1997/1998 fires, over 20 million people were affected across Indonesia and neighbouring countries, highlighting the socioeconomic and health burdens of these events (Harrison et al. 2020). Economically, peatland fires are devastating; the 2015 fires in Indonesia alone

caused losses estimated at USD 16.1 billion, impacting agriculture, forestry, tourism and public health systems (World Bank 2016).

Forest fire control measures integrate prevention, suppression and post-fire management strategies, aligning with the principles of Integrated Fire Management (IFM), as laid out in the ASEAN Peatland Management Strategy (APMS) 2023–2030 and the ASEAN Guidelines on Peatland Fire Management (2021). IFM involves multistakeholder engagement from sectors such as forestry, agriculture, local communities and the private sector to tackle fire risks through four principles: prevention (risk reduction); preparedness (readiness); suppression (response); and restoration (recovery; ASEAN 2021; FAO 2024). Fire control measures also incorporate technological tools for real-time fire monitoring and groundwater management, alongside the development of fire-free alternatives and wetland agriculture practices (e.g., paludiculture, water regulation) to minimize fire risks and enhance fire resilience across peatland areas. This approach ensures that fire management strategies are tailored to the unique environmental, social and economic contexts of each region, fostering resilience against recurring fire incidents.

- **Fire prevention** focuses on proactive actions such as education, awareness campaigns, community engagement and policy enforcement. It incorporates technological tools like SiPongi and

Sipalaga for real-time fire monitoring and groundwater management.

- **Fire suppression** is a critical suppression strategy that includes firefighting, developing firebreaks and communal reservoirs, and mobilizing resources for effective fire response. It also includes equipping local firefighting brigades with tools, safety equipment and logistical support.
- **Post-fire control management** emphasizes rehabilitation of damaged peatlands through rewetting (e.g., canal blocking) and revegetation. Conducting ecological, economic and health impact assessments to guide recovery efforts is crucial for this measure to be successful.

Key approaches to each of these measures are summarized in Table 1.

2.1 Responsibility for fire control

In Southeast Asia, forest fire control measures are implemented through collaborative efforts among governments, businesses and communities. Governments play a central role by developing early detection systems, enforcing regulations, and coordinating suppression activities. Businesses are increasingly held accountable for sustainable land-use practices to prevent fires, while communities

Table 1. Approaches to forest fire control measures

Measure	Approach	Details
Fire prevention	Education and awareness	Public campaigns utilizing media, visual aids and workshops to raise awareness about fire risks and promote zero-burning practices
	Community engagement	Formation of local fire brigades, community trainings, incentives for sustainable land-use practices, developing alternative sources of income for communities living near peatlands
	Implementation with technological integration	Use of early warning systems to ensure real-time updates; mapping of forests prone to fires for monitoring and developing fire risk maps; managing possible fuel sources for fires; developing information and communication technology, namely the peat water level monitoring system using groundwater level (GWL) monitoring, e.g., SiPongi for hotspot detection and Sipalaga for groundwater monitoring
	Policy and enforcement	Strengthening regulatory frameworks to ensure compliance and mitigation followed by strong monitoring and enforcement
Fire suppression	Infrastructure development	Construction of firebreaks, communal reservoirs and elongated ponds to prevent fire spread; fire watchtowers or guard posts complete with binoculars and communication equipment with the complementary early fire warning alarms so firefighters can act quickly to extinguish fires before they spread; water reservoirs at fire-prone points; using natural and/or artificial firebreaks for wildfire control, e.g., canal blocking
	Resource mobilization	Equipping fire brigades with appropriate tools, safety gear and logistical support through command posts for quick and effective responses
Post-fire management	Rehabilitation efforts	Restoration of damaged peatlands through rewetting techniques (e.g., canal blocking), replanting native species, and improving soil quality
	Impact assessment	Burned area mapping and estimation; evaluation of fire damage based on ecological, economic and health parameters to inform policy adjustments

contribute through local fire brigades and traditional knowledge. Institutional frameworks further strengthen these efforts by integrating advanced technologies like satellite monitoring and GIS-based systems with localized water management and

rehabilitation initiatives. These measures collectively aim to mitigate the devastating impacts of forest fires on ecosystems, human health and regional economies. Table 2 provides examples from selected Southeast Asian countries.

Table 2. Stakeholder responsibilities and institutional measures in selected Southeast Asian countries

Country	Stakeholder responsibilities	Institutional measures	Sources
Indonesia	Government develops vulnerability maps, conducts public awareness campaigns, and coordinates fire suppression efforts to mitigate risks as well as monitoring using advanced technologies Business entities are obligated to install early warning systems, establish fire control teams, and adhere to sustainable land management practices Communities are encouraged to form local fire brigades or <i>Masyarakat Peduli Api</i> (MPA), promoting collective responsibility for fire prevention and suppression	Integrated fire control teams address fire prevention, suppression and rehabilitation, while penalties are enforced against offenders to ensure compliance	Ministry of Environment and Forestry (MoEF), 2018, 2022; World Bank 2021
Malaysia	Government monitors fire-prone areas using advanced technologies such as the Fire Danger Rating System (FDRS), and maps hotspots using MODIS and VIIRS satellite systems Businesses and communities collaborate on fire prevention, focusing on maintaining water reservoirs and implementing canal blocking to retain peatland moisture	State-level regulations in Sarawak and Sabah mandate water management and restoration practices to protect peatlands and prevent fires	Jabatan Meteorologi Malaysia 2025.; Chew et al. 2022
Philippines	Communities act as first responders to fire incidents, utilizing traditional knowledge to prevent fire spread Local governments implement capacity-building programmes and provide firefighting equipment to enhance community efforts	Collaborative efforts focus on building communal water reservoirs and integrating GIS-based hotspot monitoring for rapid fire response	Republic of the Philippines 2021; RECOFTC 2024
Thailand	Communities actively participate in fire prevention through participatory mapping and collaborative fire management plans Government and NGOs provide technical training, monitoring systems and post-fire rehabilitation support	Fire control units utilize real-time satellite monitoring, such as NASA's FIRMS, to enhance fire response efforts	Makarabhirom 1998; Ganz et al. 2001; Chien 2011
Vietnam	Government agencies lead fire prevention through national forest protection programs, such as the Five Million Hectare Reforestation Program (Program 661), which includes fire risk reduction and forest monitoring Local communities participate in forest patrols and early warning systems, often supported by decentralized forest management policies Businesses are required to comply with land-use regulations and fire prevention protocols under national forest law	Vietnam has a well-established fire management framework under the Forest Protection Department, supported by legal enforcement and satellite-based monitoring systems integrated into national forest policy	Meyfroidt & Lambin 2008; Dinh & Wesseler 2024

3 Strategies for controlling fires in peatlands and peat forest

To support forest and peatland management objectives in Southeast Asian countries, fire control measures involve three key components: **prevention, suppression** and **post-fire rehabilitation**. For each of these measures, there are strategies and approaches that aim to protect forests and peatlands from fire, minimize its usage, and maintain ecosystem sustainability.

The **key strategy** for preventing and suppressing wildfires involves continuous efforts to disrupt the 'fire triangle' (heat, fuel and oxygen; Figure 2), which are essential for combustion (Clar and Chatten 1954). Removing or reducing any of these elements can effectively prevent fire outbreaks.

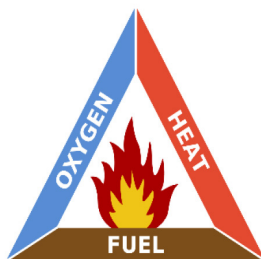


Figure 2. Fire Triangle

3.1 Fire prevention

There are three main approaches to fire prevention: developing fire information systems, engaging and empowering communities and addressing socioeconomic factors, and enhancing land and forest management practices.

3.1.1 The fire information system approach

A key success factor for fire prevention is having a system that provides accurate information on the likelihood of fire occurrence, and an early warning. This information must be effectively distributed to all relevant stakeholders, including local communities, as they play a vital role in forest and land fire prevention. With the help of modern technology, it is possible to develop a fire information system based on factors that influence fire incidence, such as fuel conditions, climate conditions and fire behaviour.

Foundational to this is the availability of information and database systems that track and provide critical data on various environmental factors, including occurrence of El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) events, groundwater level, water level, and management and restoration activities. Daily weather represents one of the most immediate and significant factors influencing fire incidence. Thus, a reliable fire information system that integrates short-term weather data is a key component in effective fire prevention strategies.

Some examples of information and database systems are:

- Information System for Peatland Ecosystem Protection and Management (SiPPEG, <https://sippeg.menlhk.go.id/apps/>) integrates and provides data related to peatland protection and management.

Key features include public accessibility, the Peatland Ecosystem Quality Index (IKEG), groundwater level monitoring, environmental performance evaluation, hotspot monitoring and early warning systems that enables real-time decision-making and transparency. (MoEF 2021; Redaksi 2022).

- Peat Water Level Monitoring System (Sipalaga, <https://sipalaga.brg.go.id/>): Offers real-time monitoring of peatland water levels, critical for fire prevention
- Peat Ecosystem Restoration Information Platform (PRIMS): Displays digital data on restoration activities across priority provinces (BRGM 2019).

To provide warnings and alerts regarding possibility of fire, several types of systems have been developed:

1. Early Warning System – Drought Index

An early warning system is crucial for predicting fire risks by providing early alerts using predictions based on climate and other parameters to assess fire-prone periods and potential drought conditions.

Examples include:

- Keetch-Byram Drought Index (KBDI, <https://www.drought.gov/data-maps-tools/keetch-byram-drought-index>). A widely used tool for estimating fire risk by evaluating the balance between precipitation and soil moisture, which influences fire potential (Taufik et al. 2019)
- Peatland Ecosystem Quality Index (IKEG). IKEG employs the KBDI to calculate drought risks, factoring in rainfall, temperature and soil moisture conditions to assess fire danger (Suhartono et al. 2022)
- Southeast Asia Drought Watch (SEADW, <https://seadw-servir.adpc.net>). An integrated web-based system providing current and forecast drought indices to support decision making among local policymakers and agricultural stakeholders using various data sources, including meteorological observations, remote sensing data and drought indices.

A recent reference on the drought index is Taufik et al. (2022) on an improved drought-fire assessment for managing fire risks in tropical peatlands.

2. Fire danger rating systems

Fire danger rating systems (FDRS) play a fundamental role in wildfire management by providing timely and reliable information on fire risk and behaviour, supporting proactive fire management efforts. FDRS can generate detailed maps highlighting fire-prone areas, the difficulty of fire control, and prevailing drought conditions. These outputs derived from key indicators such as fuel moisture levels, drought indices and weather data, make FDRS a reliable predictor of fire risks. See Box 1 for more information on fire danger rating and indicator classification and interpretation. With localized fire danger ratings, FDRS facilitates targeted interventions and resource allocation, thereby enhancing the efficiency of fire prevention and suppression efforts.

Recent advancements have integrated satellite imagery and real-time monitoring systems, further improving the accuracy and usability of the FDRS for stakeholders at national and local levels (Taufik et al. 2022; Taylor et al. 2022). In Southeast Asia, these systems are largely based on the Canadian Fire Weather Index (FWI), developed by the Canadian Forest Service, which has proven to be an effective framework for assessing fire risks in diverse forest ecosystems.

It is important to note that some FDRS are developed for operational daily use by government agencies, while others are designed primarily for research purposes and are not used in real-time decision-making.

Examples of FDRS in Southeast Asia include:

- Fire Danger Rating System ASEAN (FDRS ASEAN, <https://myclimate.met.gov.my/fdrsWmsObsAseanMetPortal>). Developed based on Canadian Forest FDRS, it uses meteorological variables (temperature, relative humidity, rainfall and wind speed) measured at meteorological stations throughout the region, FDRS ASEAN is

Box 1. FDRS classification and interpretation

Fire danger rating classifies the potential for fire initiation and spread based on environmental and weather conditions. It provides guidance for fire management decisions, helping prioritize areas for monitoring and resource allocation by informing fire suppression teams and policymakers of the potential severity of fire risks in different areas, ensuring preparedness and response measures are efficiently directed. Below are the interpretations of the fire danger levels:

FDRS level	Definition
Low	Fires are unlikely to ignite, and environmental conditions do not support wildfire spread. Minimal fire management efforts are needed.
Moderate	Fires are plausible and pose some level of risk. Although spread rates are moderate, they can generally be controlled with basic firefighting efforts.
High	Fires can easily ignite from multiple sources. Without immediate intervention, these fires may escalate quickly and become challenging to control.
Very high	Fires are very likely under current conditions. Environmental factors make suppression difficult, and fires can spread rapidly, requiring significant resources for containment.
Extreme	Fires can ignite and spread extremely quickly. Erratic and uncontrollable conditions prevail, making suppression efforts highly challenging and resource intensive.

Fine Fuel Moisture Code (FFMC) quantifies moisture content of fine organic fuels, such as dry leaves, grass and small twigs, which are highly flammable and serve as ignition sources in wildfires. This code is crucial in evaluating how easily fires can start and spread, particularly under varying weather conditions such as temperature, humidity and wind. Fine fuels, being the first to ignite, often catalyse larger fires, making FFMC a valuable tool for real-time fire risk assessment and decision making. Its sensitivity to weather fluctuations enables more precise monitoring and prediction of fire behaviour, thus improving early warning systems and fire management efforts (Krasovskii et al. 2018; Manalu et al. 2021). FFMC classification and interpretation:

FFMC level	Fire characteristics	Fire suppression difficulty
Low	Low probability of fire starts	No problem in controlling fire
Moderate	Fire spreads on the surface	Fire control by a direct attack using hand tools and water
High	Fire spreads rapidly or is of moderate to high intensity	Fire control requires water pumps or mechanical equipment for fire-break construction
Extreme	Fire spreads rapidly or burns with high intensity, depending on the fuel accumulation index	Fire is challenging to control; indirect suppression using control lines may be necessary

Drought Code (DC) is a numerical index representing the moisture content of the deep organic soil layer, which includes thick organic materials and large pieces of wood. This code serves as a critical indicator of the impact of prolonged drought conditions on forest fuel availability and the persistence of live embers in the soil. A high DC value suggests dry and highly flammable conditions, where fires can smoulder underground for extended periods, even after surface fires are extinguished. This metric is particularly important for managing fire risks in peatland and forest ecosystems, where deep organic layers are a significant fuel source during droughts. The DC is widely used in conjunction with other fire danger indices to enhance the accuracy of fire risk assessments and inform fire management decisions (Shawki et al. 2017; Pan et al. 2018). It also highlights the increasing challenges in fire suppression as drought conditions intensify, emphasizing the critical need for preventive measures in peatland fire management. DC classification and interpretation:

FFMC level	Fire characteristics	Fire suppression difficulty
Low	Low probability of fire starts	No problem in controlling fire
Moderate	Fire spreads on the surface	Fire control by a direct attack using hand tools and water
High	Fire spreads rapidly or is of moderate to high intensity	Fire control requires water pumps or mechanical equipment for fire-break construction
Extreme	Fire spreads rapidly or burns with high intensity, depending on the fuel accumulation index	Fire is challenging to control; indirect suppression using control lines may be necessary

managed and updated on a daily basis by the Malaysian Meteorological Department.

- Forest Fire Warning System (Spartan, <https://spartan.bmkg.go.id/>). Developed by the Meteorology, Climatology, and Geophysical Agency (BMKG) based on the Canadian Forest FDRS, this system provides public access to fire hazard warnings (BMKG 2017). It is an early warning system that estimates the level of fire danger, and the spread of fire when one occurs.
- Fire Danger Rating System (FDRS) for Upper Southeast Asian Region (<http://www2.dnp.go.th/gis/FDRS/FDRS.php>). A high-resolution forecast based on the Canadian Forest FDRS that has been calibrated for the region using MODIS fire hotspot data and recent regional climatic data. It is operated by the Forest Fire Control Division and the Geo-Informatics Division (Department of National Parks, Wildlife and Plant Conservation, Ministry of Natural Resources and Environment).

The adaptation of the FWI system to Southeast Asian conditions, particularly for Indonesia and Malaysia, was initially developed by de Groot et al. (2007) and remains a primary reference for regional fire danger rating systems. Building upon this foundation, recent studies have further refined the systems for specific regional contexts. For instance, Field et al. (2021a) explored the use of satellite precipitation data for fire risk assessment, while Graham et al. (2021) developed a Peat Fire Danger Rating System tailored to Indonesian peatlands. Additionally, Trang et al. (2022) applied the Modified Nesterov Index to assess fire danger conditions in northern Vietnam.

3. Fire occurrence monitoring systems

Fire occurrence monitoring systems play a crucial role in identifying areas with active fires or high fire probability, enabling early detection and timely intervention. These systems are especially critical during dry seasons when fires can spread rapidly. Hotspot data collected from satellite imagery and ground observations are analysed to

prioritize areas requiring surveillance and suppression efforts. Ground truthing ensures that the detected hotspots correlate with actual fire events, minimizing false alarms and enhancing response accuracy.

However, the use of thermal imagery for hotspot detection has limitations. Not all thermal anomalies indicate active fires. According to Sofan et al. (2022), approximately 13% of VIIRS-detected hotspots in Indonesia were false positives caused by non-fire sources such as active volcanoes, industrial areas, water bodies, and other static land features.

These false positives can be distinguished by differences in fire radiative power (FRP), confidence levels, and spatial characteristics. To address this, the study proposed a zone map to identify areas prone to false-positive detections, improving the efficiency of ground validation efforts. Thus, this highlights the need to combine satellite data with ground observations and other information to improve the accuracy and reliability of fire detection.

Examples of hotspot monitoring systems:

- The ASEAN Specialised Meteorological Centre (ASMC) Hotspot (<https://asmc.asean.org/asmc-hotspot>). Land and forest fires are monitored and assessed using satellite sensors to detect hotspots at the regional level.
- SiPongi (<https://sipongi.menlhk.go.id>). Managed by Indonesia's Ministry of Forestry, SiPongi provides hotspot detection, fire danger analysis, wind and smoke trajectory modelling, and a platform for public complaints. This system integrates various data sources to strengthen fire management efforts.
- BMKG Satellite-Based Monitoring (<https://satelit.bmkg.go.id/BMKG>). BMKG offers satellite-based fire monitoring services, including the detection of hotspots, and fire behaviour analysis.
- Moderate Resolution Imaging Spectroradiometer (MODIS) Fire Detection System (<https://modis.gsfc.nasa.gov/about/>). This system, operated by NASA, uses satellite imagery to detect hotspots globally. The data collected helps in the

early identification of potential fire-prone areas, with near-real-time monitoring to guide firefighting strategies.

- Global Forest Watch (GFW; <https://www.globalforestwatch.org/>). GFW provides real-time monitoring of global forest cover, fires and deforestation. Through satellite imagery, GFW helps identify areas of forest loss and fires worldwide, enabling better forest management and conservation practices.
- Visible Infrared Imaging Radiometer Suite (VIIRS) Hotspot Detection (<https://landsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/>). VIIRS, aboard the Suomi NPP satellite, offers high-resolution fire detection and monitoring capabilities, especially useful for detecting smaller fires. It provides data on fire intensity, location and smoke, which helps improve wildfire management and forecasting.
- ASEAN Fire Alert Tool (<https://aseanfirealert.org/>). This mobile application designed for public, particularly ASEAN Member States and land managers, facilitates hotspot notifications for users' area of interest, enabling effective monitoring and management of potential fire risks using FDRS ASEAN and ASMC hotspot data.

3.1.2 Socioeconomic and community approach

Community involvement plays a critical role in the prevention and control of forest and land fires. This necessity is underpinned by three key assumptions:

1. The limited ratio of forest rangers to the vast forest areas necessitates active participation from local communities to ensure the protection of forests and peatlands (Miettinen et al. 2017).
2. Local communities are more likely to engage in safeguarding forest resources when they understand the ecological and socioeconomic benefits of forests, provided there are no external pressures or coercive factors (Chew et al. 2022).
3. Many fire risks are generated within neighbourhoods, emphasizing the importance of empowering communities to address and mitigate these risks at their source (Ganz et al. 2001).

Increasing local community participation in the prevention of forest and land fires depends on several factors, such as motivation and stimulus, incentive, opportunity, capability and guidance (Figure 3). Box 2 provides an example on developing community-based business models for peatland restoration in Indonesia.

Box 2. Developing community-based business models for peatland restoration in Indonesia

Community-based fire prevention and peatland restoration in Indonesia are essential components of the national effort to address the recurrent forest and land fires. Utilizing Participatory Action Research (PAR), CIFOR-ICRAF has been facilitating the involvement of local communities in fire prevention, promoting sustainable peatland management, and enhancing local livelihoods. The efforts and research have focused on regions like Riau Province, which is particularly prone to fires, involving local stakeholders in decision making and allowing them to test various sustainable practices, including fire-free land preparation and restoration of degraded peatlands. By incorporating the Institutional Analysis and Development (IAD) framework, the study identified key elements for successful restoration: community demand, political support, active participation, and business models that support sustainable livelihoods. These interventions were seen as vital for mitigating the destructive impacts of fire and fostering long-term environmental and economic resilience (Purnomo et al. 2024).

Similarly, in Riau's Bengkalis Regency, the approach to peatland restoration integrated community-based interventions with fire prevention measures. By combining biophysical restoration efforts, such as canal blocking and rewetting, with sustainable livelihood transformations, communities were encouraged to shift away from fire-dependent practices. The Sustainable Business Model for Communities (SBMC) developed in this project helped guide these transitions, enabling communities to create viable, fire-free agroforestry and ecotourism ventures that also supported the ecological restoration of peatlands. This process involved the active participation of local farmers, fire care groups, and other stakeholders, and was facilitated by intensive capacity-building efforts. The results showed that, through collective action and continuous engagement, local communities were able to significantly reduce fire risks, restore ecosystem functions, and improve their livelihoods (Puspitaloka et al. 2024).



Figure 3. Several factors need to be addressed or strengthened to increase local community participation in the prevention of forest and land fires, this includes motivation, stimulus, incentives, opportunities, guidance, and capability.

3.1.3 Land and forest management approach

Effective fire control begins with the implementation of appropriate land and forest management techniques. Activities such as land preparation, planting, cultivation and harvesting must be carefully managed to reduce fire risks. Land preparation often involves the use of fire to clear vegetation because of its low cost and the belief that it enhances soil fertility. However, this practice frequently leads to uncontrolled fires, causing significant environmental and economic damage.

Transitioning to sustainable land management practices, such as mechanical clearing and agroforestry, along with stricter enforcement of land-use regulations, is essential to minimizing fire incidents and safeguarding peatland ecosystems (Chew et al. 2022).

3.2 Fire suppression

Fire suppression should be initiated promptly to contain and extinguish wildfires. Key strategies include:

- Human resources support. Training and deploying firefighting teams with adequate knowledge and skills
- Water source mapping. Identifying and mapping reliable water sources for firefighting operations
- Funding and infrastructure. Ensuring sufficient financial support and the availability of necessary equipment and infrastructure, such as firebreaks and access roads
- Smoke-free zones. Establishing areas free from smoke to protect vulnerable populations
- Organization of firefighting teams. Forming and maintaining dedicated teams to respond to fires in peatland areas
- Developing and implementing guidelines or standard operating procedures for systematic and coordinated fire suppression efforts. The ASEAN Standard Operating Procedures (SOP) for Monitoring, Assessment, and Joint Emergency Response (SOP MAJER) provides a framework for managing and mitigating the impacts of land and forest fires, including those resulting from controlled or uncontrolled burning practices.

3.3 Post-fire measures

Post-fire measures are critical to addressing the aftermath of fire incidents, and thus should include the following:

- Impact assessment. Conducting evaluations to determine the economic, ecological, health and social impacts of the fire
- Judicial actions. Identifying the causes, responsible actors and processes behind the fire incidents to support legal proceedings and enforce accountability
- Rehabilitation. Accelerating the recovery of burned areas through human interventions such as rewetting, replanting native vegetation, and restoring land cover to facilitate ecological succession.

These strategies and measures collectively contribute to effective fire management, reducing the frequency and severity of fires while supporting the long-term sustainability of forest and peatland ecosystems.

4 Case studies

Countries in Southeast Asia have been implementing and institutionalizing many of these strategies. Below is information from four different countries on their key policies and regulatory frameworks, technology and monitoring, community-based approaches and challenges as they relate to controlling fires.

4.1 Indonesia

1. Key policies and regulatory frameworks

Indonesia has implemented a variety of policies and regulations aimed at controlling forest and land fires, focusing on prevention, enforcement and sustainable land management practices. These laws and frameworks play a critical role in managing forest ecosystems, protecting the environment, and addressing the challenges of land clearing by fire. Below are some of the key policies and regulatory frameworks in place:

- Law No. 41/1999 on forestry prohibits the burning of forests and holds permit holders accountable for fires within their areas. It mandates community involvement in forest protection and prescribes criminal sanctions for violations.
- Government Regulation No. 4/2001 addresses environmental damage caused by fires, emphasizing prevention and mitigation. While Government Regulation No. 45/2004 on Forest Protection, amended by Government Regulation No. 60/2009, detail measures for forest protection, including fire prevention and suppression strategies.
- Law No. 32/2009 on Environmental Protection and Management strengthens the legal framework to address fire issues by prohibiting land clearing by burning, and outlines responsibilities for preventing and controlling environmental damage related to forest and land fires. It also grants local authorities the power to form organizations dedicated to fire control.
- Law No. 39/2014 on Plantations requires plantation businesses to have resources and systems in place to prevent and control fires. It imposes strict sanctions on those who fail to manage fires on their plantations.
- Presidential Instruction No. 11/2015 strengthens cross-sector collaboration for integrated fire management while Ministry of Environment and Forestry Regulation No. 32/2016 explains the responsibilities of forest and land fire control organizations at the national, provincial and municipality/regency levels.
- Presidential Instruction No. 5/2019 in Indonesia made permanent the moratorium on issuing new permits on primary forest and peatlands.
- Presidential Instruction No. 3/2020 outlines the mandate for local governments concerning forest and land fire handling, urging them to remain vigilant. It also strengthens prevention efforts and law enforcement against forest and land fires. It assigns specific responsibilities to various government agencies, including the Ministry of Environment and Forestry, the National

Disaster Management Agency (BNPB), the Attorney General's Office, the Indonesian National Armed Forces (TNI), and the National Police, to collaboratively combat forest and land fires (Secretariat of the Cabinet of the Republic of Indonesia 2020).

- For additional information on other regulations and policies related to forest fire management see [Gunadi et al. 2019](#) and [Prayoga and Koestoer 2021](#).
2. Technology and monitoring
 - Indonesia has two main systems to support the control of fires. SiPongi is a monitoring system used to track hotspots, fire-prone areas and wind trajectories, which enhances response coordination and provides real-time information for fire management.
 - Sipalaga is a system designed to monitor groundwater levels in peatland areas, ensuring that the peat remains hydrated and below fire-prone thresholds. This helps in preventing fires by maintaining adequate moisture levels in peatlands (<https://dw.sipalaga.brg.go.id/>).
 3. Community-based approaches
 - Community fire brigades or fire care communities (*Masyarakat Peduli Api* - MPA): Local communities or fire brigades trained and equipped to conduct fire prevention and suppression efforts independently ([Nurjanah et al. 2021](#)).
 - Education campaigns: Outreach programmes to raise awareness of zero-burning practices and promote sustainable land-use methods ([Syahza et al. 2024](#)).
 - Post-fire rehabilitation: Restoration of degraded peatlands through rewetting techniques like canal blocking and replanting native vegetation ([Warren et al. 2017](#); [Yuwati et al. 2021](#); [Suwito et al. 2022](#)).
 4. Challenges and future directions
 - Indonesia had a 59.4% reduction in hotspots in 2024 compared to 2023 ([Channel News Asia 2024](#)). But in 2023, 1.16 million hectares were burned despite improvements in management due to the drier El Nino

conditions, a significant increase from 2022 ([Jong 2024](#)).

- Using data from Sipalaga, the Indonesian government has been able to coordinate efforts to prevent fires in peatlands where groundwater level is below 40 cm, indicating a vulnerable status or a fire risk. For example, in 2024, the BMKG conducted cloud seeding ahead of the peak fire season in West Kalimantan to maintain the wetness of peatlands in fire prone areas to reduce fire risks ([BMKG 2024](#)).

4.2 Malaysia

1. Key policies and regulatory frameworks
 - Environmental Quality Act 1974 (Act 127) serves as the primary legal framework to prevent, control and eliminate air pollutants in Malaysia. Act 127 aims to preserve the environment, control air pollution, and support other environmental initiatives. Several important regulations have been established under Act 127 to address air pollution effectively:
 - Environmental Quality (Clean Air) Regulation 1978 (effective 1 October 1978), which established the first comprehensive legal measures to control air pollution
 - Environmental Quality (Clean Air) Regulation 2014 (effective 4 June 2014), which updated air quality standards and introduced new measures to address emerging environmental challenges.
 - Control of open burning, a significant contributor to haze, is regulated under three orders:
 - Environmental Quality Act (Declared Activity) (Open Burning) Order 2003 aims to mitigate the harmful effects of open burning on air quality (effective 1 January 2004)
 - Environmental Quality Act (Compounding of Offences) (Open Burning) Rules 2000 (effective 21 August 2000) allows for the imposition of fines on offenders involved in open burning activities
 - Environmental Quality Act (Delegation of Powers) (Investigation of Open Burning) Order 2000 (effective 21 August 2000)

delegates powers to specific authorities to investigate and take enforcement actions against open burning violations.

- Malaysia has implemented the National Action Plan for Peatlands (NAPP) as the central framework for managing peatland ecosystems that emphasizes three core pillars: fire prevention, ecosystem restoration and biodiversity conservation (Ministry of Natural Resources and Environment, Malaysia 2011; Chew et al. 2022).
- The Zero-Burning Policy, a groundbreaking regulation, prohibits open burning in the plantation sector and contributes to mitigating transboundary haze. Furthermore, state governments in Sarawak and Sabah have enacted additional measures, including restrictions on intensive drainage in pristine peatland areas, to ensure the effective protection of these ecosystems (Chew et al. 2022).
- Beyond the regulatory framework, Malaysia has implemented several strategic policies to address air pollution:
 - National Haze Action Plan 1997: Focuses on preventing and mitigating haze resulting from transboundary pollution and open burning, particularly during dry seasons
 - Open Burning Prevention Plan 2015: A more recent initiative to reduce open burning and mitigate the resulting air quality impacts on local and regional levels
 - Clean Air Action Plan 2011: A comprehensive policy aimed at improving air quality by reducing emissions from vehicles, industries and other major sources of pollution.

2. Technology and monitoring

Advanced fire prediction and monitoring technologies play a crucial role in Malaysia's approach. The Fire Danger Rating System (FDRS) integrates satellite data, such as MODIS and VIIRS, with indices for fuel moisture and drought, providing real-time hotspot detection and analysis. The incorporation of drone technology has further improved canal mapping and the identification of high-risk areas. Notably, canal-blocking initiatives in Selangor and Sarawak have successfully

reduced fire incidents by approximately 50 percent (Chew et al. 2022).

3. Community-based approaches

The Community-Based Fire Management (CBFM) programme actively involves local communities in fire prevention and sustainable land-use practices. Through training programmes and economic incentives, such as pineapple cultivation on peatlands, the programme encourages community participation in conservation efforts. Education campaigns targeting schools, media and local organizations aim to increase awareness about sustainable peatland management and reinforce the importance of collective action (Chew et al. 2022).

4. Challenges and future directions

While Malaysia has made significant progress, challenges persist. The high costs of zero-burning practices and maintaining extensive fire prevention infrastructure remain key obstacles. Integrating traditional community knowledge with modern technologies is essential for overcoming these barriers. Strengthened regional cooperation through initiatives like the ASEAN Haze-Free Partnership offers a promising pathway for enhancing fire management efforts and ensuring long-term sustainability (Chew et al. 2022).

4.3 Thailand

1. Key policies and regulatory frameworks

Thailand has a regulatory approach to combat open burning, which is a major contributor to air pollution, particularly during the harvest season. While no specific forest fire control act exists, there are four acts that contain legislation on forest fire control, including a penalty for setting forest fire: Forest Act 1941, section 54; Wildlife Conservation and Protection Act 1960, section 24; National Park Act 1961, section 16(1); and National Reserved Forest Act 1964, section 14 (Forest Fire Control Division 2003).

In 2016, The National Reserved Forest Act was amended to impose severe penalties and sanctions for violations of the ban on burning in forest areas (Uttajug 2024). Sanctions for forest fire violations include offenders facing fines of up to THB 50,000 and/or imprisonment of up to five years, depending on the specific law violated.

- National Forest Policy: This policy supports forest restoration and fire risk mitigation, addressing conflicts over traditional land use practices (RECOFTC 2024)
- The National Forest Policy (1985): Mandates a comprehensive plan to address deforestation, including forest fires, with a focus on law enforcement, prevention and suppression measures
- The Cabinet Resolution (1981): Requires mandatory fire reporting by commercial and state flights, procurement of firefighting aircraft, implementation of a fire suppression plan, and international collaboration to enhance firefighting effectiveness
- Long-Term Fire Prevention Strategy: Develops a nationwide volunteer firefighting training programme, proposes a Forest Fire Control Act, mandates fire response training for government employees in fire-prone areas, and strengthens fire control institutions
- Community Forest Act (2019): This act provides a legal basis for communities to manage forests, promoting sustainable use and potentially reducing uncontrolled burning. It allows communities to participate in forest management, provided they form a Community Forest Management Committee and adhere to an approved management plan.

Additionally, local administrative agencies have issued regulations to control open burning. These include setting zero-burning zones in high-risk areas, implementing burning plans, and requiring farmers to report their burning activities to local authorities and obtain permission (Wangwongwatana 2020; Noipa and Pakdeelun 2021; Uttajug 2024). Zoning regulations identify fire-prone regions and integrate traditional knowledge with modern policies. A key component of these

efforts is the establishment of community-based fire monitoring networks, which help track and manage fire risks across regions (Ganz et al. 2001).

2. Technology and monitoring

While traditional practices such as digging trenches and controlled burns remain important components of fire management strategies, Thailand has increasingly adopted Geographic Information Systems (GIS) and remote sensing tools (e.g., MODIS and other satellite-based data) to map high-risk zones, plan prevention efforts, and monitor hotspots across large forested and agricultural areas (Chaiyana et al. 2024). More recently, aerial drones with thermal sensors have been tested to monitor fire spread and intensity particularly in mountainous regions and early warning systems that combine weather forecasts and machine learning are being piloted to better predict periods of high fire risk (Tang et al. 2024). Community reporting via mobile and sensor-integrated platforms, such as those utilizing IoT, blockchain, and digital messaging, have increased local participation in real-time fire detection and alerts (Shankar et al. 2022). Community-based monitoring programs continue to be central, particularly in Chiang Mai and Mae Hong Son, fostering local engagement and accountability in fire prevention.

To manage agricultural burning and ensure compliance with environmental standards, Thailand has established several monitoring and enforcement mechanisms:

- Pollution control and enforcement: The government has implemented stricter regulations and monitoring systems to control burning in high-risk areas. This includes designated 'zero burning' zones, particularly in areas near communities, schools and hospitals. In cases where burning is necessary, farmers must submit a plan and report the results to local authorities.
- Collaborative efforts for local regulations: Local administrative organizations play a crucial role in implementing regulations specific

to their regions. These efforts include providing incentives for farmers to adopt non-burning practices, such as financial support for machinery purchases or providing access to biomass processing facilities.

3. Community-based approaches

Post-fire rehabilitation efforts focus on collaborative activities between communities and local authorities. For example, the Mae Tha community in Chiang Mai integrates forest fire management into broader forest management plans, emphasizing sustainable resource use and collective responsibility (Ganz et al. 2001). Emerging programmes like Payment for Ecosystem Services (PES) offer incentives to align community livelihoods with conservation goals, promoting long-term restoration in fire-prone and degraded landscapes (Nabangchang 2014).

4. Challenges and future directions

To enhance the effectiveness of community-based fire management in Thailand (see Box 3 for more details), several community engagement recommendations have been proposed: (1) empower communities through technical knowledge and training for forest fire management; (2) establish collaborative networks for fire management, linking communities, government officials and NGOs; and (3) develop policies that incorporate traditional knowledge and community

needs into national forest fire strategies (Ganz et al. 2001; Salam 2006; RECOFTC 2024).

4.4 Vietnam

1. Key policies and regulatory frameworks

Vietnam has adopted a series of policies to protect forests and reduce the risk of forest fires. Below are the key policies:

- Forest Protection and Development Act (1991) divides Vietnam's forests into three categories – special-use, protection and production forests – with specific regulations for their management and protection. It prohibits burning on forested land and assigns responsibility to state agencies for formulating and implementing forest fire prevention plans.
- Decree No. 17-HDBT (1992) regulates the implementation of the Forest Protection and Development Act, focusing on forest fire prevention and legal mechanisms for its management. It enhances coordination among government agencies in managing forest fires.
- Decree No. 22/CP (1995) provides guidelines for forest fire prevention and fighting through technical measures and operational standards. It offers guidance to government bodies and local communities in tackling forest fires.
- Direction No. 19/TTg (1999) outlines emergency measures to prevent and fight forest fires, particularly during peak fire

Box 3. Community-Based Fire Management (CBFiM) Project

The Community-Based Fire Management (CBFiM) project (October 2022 – March 2025), addresses the root causes of forest fires in the Asia-Pacific region. This initiative tackles pressing national and regional concerns about the environmental and public health impacts of forest fires. It builds the capacity of communities and governments to manage fires effectively while adapting to climate change across landscapes in Cambodia, Lao PDR, Thailand and Vietnam. The project is supported through a five-year regional cooperative agreement between the U.S. Department of Agriculture Forest Service and RECOFTC.

CBFiM emphasizes community involvement in decision making, leveraging local knowledge to prevent, control and utilize fires sustainably. Communities are empowered to define objectives and implement practices that align with broader fire management frameworks. The project aims to ensure that local populations who depend on forest landscapes for their livelihoods are positioned as key stakeholders. This participatory approach enhances the capacity of forest-dependent communities to protect forests, manage fires and sustain biodiversity.

seasons. It enhances preparedness and rapid response to forest fires during the high-risk season.

- Forest Protection and Development Law (2004) shifts the responsibility for forest fire management to all forest owners, including local communities. It involves local communities in forest fire prevention, and introduces the Payment for Forest Environmental Services (PFES) system, supporting forest protection. Further role delineation and coordination between the government and local communities in preventing fires is strengthened under Decree No. 06/2006/NĐ-CP.
- Law on Forestry (2017) and Decree No. 156/2018/NĐ-CP regulate and implement the use of fire in and around forest areas and the prevention and fighting of forest fires, including compensation for fire-related damages. They establish more detailed planning and allocate funds for forest fire mitigation.
- Circular No. 25/2019/TT-BNNPTNT provides detailed guidelines for training in forest fire prevention and firefighting. It improves the skills of technical staff and local communities in preventing and fighting forest fires.

2. Technology and monitoring

Vietnam has adopted several technologies and monitoring systems to enhance forest fire management:

- The Vietnam Forest Protection Department has developed an online monitoring system for forest fires, providing SMS notifications for early fire detection.
- Remote sensing and GIS technologies are used by a small percentage of organizations (about 25 percent) to detect and monitor forest fires. However, their use is still limited due to resource constraints and staff training needs.

3. Community-based approaches

Local communities play a key role in managing forest fires in Vietnam. Based on the Forest Protection and Development Law 2004, the responsibility for forest fire prevention has been transferred to all forest owners, including local communities. Additionally, Nguyen et al. (2022) state that local media such as community meetings, loudspeakers, and social media are effective in spreading information about forest fire prevention. Trainings are also important and needed to improve the capacity of local staff and communities in preventing and fighting forest fires.

4. Challenges and future directions

Based on Nguyen et al. (2022), some challenges and future steps that Vietnam must address regarding forest fires have been identified:

- Climate change and the increase in plantation areas present additional challenges where plantations are becoming more vulnerable to forest fires.
- While technologies like remote sensing and GIS can help in monitoring forest fires, many organizations have not fully utilized them. Additional training and capacity building are needed to expand the use of these technologies.
- The limited number of staff and inadequate resources hinder forest fire prevention and firefighting efforts. Therefore, more investments in human resources and equipment are needed.
- Programmes like REDD+ and sustainable forest certification can be effective tools for reducing forest fires and incentivizing sustainable forest management, but attention needs to be given to the expansion of plantation areas.

5 Techniques for peatland fire control

Peatland fire control requires a comprehensive approach combining awareness campaigns, community involvement, sustainable land management practices and innovative techniques. These include public awareness raising, creating alternative income sources, setting up community fire brigades, applying environmentally friendly (zero-burning) cultivation methods, and utilizing traditional structures like blocked canals and 'beje' ponds as communal firebreaks.

5.1 Techniques for public awareness raising

In principle, peatlands should not be burned, as doing so is highly unsustainable and causes significant environmental, economic, and health-related damage. In many countries, the burning of peatlands is illegal, and laws are in place with enforcement mechanisms and sanctions to deter such practices. Strengthening public understanding of these legal and environmental principles is vital. Although indigenous communities have a deep understanding of the significance of peatlands and forests in their lives that is rooted in generations of traditional ecological knowledge (Dove 2006), broader societal awareness is essential to promote sustainable practices and prevent fires. Public awareness campaigns can be implemented through:

- **Warning signs:** Posting clear and visible warnings in high-risk areas to alert the public to fire hazards (Figure 4)

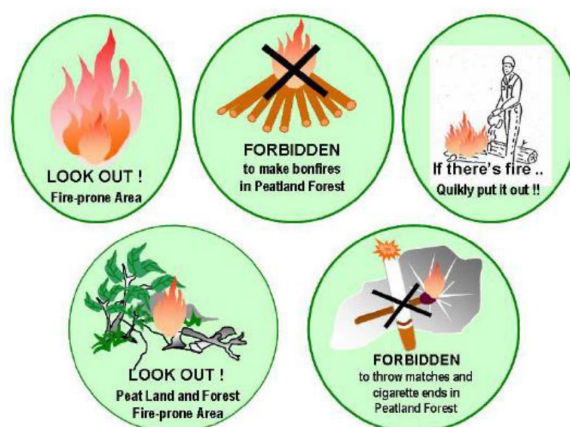


Figure 4. Examples of warning signs featuring visually compelling and informative designs to enhance public attention and understanding of fire prevention measures

Source: Adinugroho et al. 2005

- **Educational materials:** Creating and distributing leaflets, magazines, posters and fire calendars with information about fire prevention and the environmental impacts of fires
- **Media outreach:** Producing video content and leveraging traditional and digital media to convey messages effectively to diverse audiences
- **Community engagement:** Conducting direct communication campaigns, such as workshops, public meetings and interactive sessions, to engage local communities in discussions about sustainable peatland management.

These initiatives not only educate communities, but also foster a sense of responsibility and collaboration, which are critical for reducing the incidence of fires in peatlands.

5.2 Techniques for involving communities in fire control

Effective community involvement in peatland and forest fire control goes beyond awareness campaigns. It requires creating sustainable and environmentally friendly activities that provide alternative livelihoods. These initiatives help discourage harmful practices, such as illegal logging, and encourage sustainable roles as farmers, craftspeople or fishers utilizing eco-friendly techniques.

Key strategies include:

1. **Awareness campaigns and education programmes:** Conduct workshops, training sessions and public meetings, and distribute educational materials to inform communities about the risks and impacts of forest and land fires; these programmes enhance understanding and foster a sense of responsibility toward sustainable land management.
2. **Training and capacity building:** Equip community members with skills in fire prevention, early detection and firefighting techniques; this includes training in fire safety, first aid, firefighting equipment use and communication protocols, ensuring readiness to respond to fire incidents effectively.
3. **Participatory fire management planning:** Involve communities in developing fire management plans through participatory mapping exercises, consultations and community meetings. Leveraging traditional knowledge and local insights ensures that management plans are practical and culturally relevant.
4. **Community-based early warning systems:** Establish systems that enable communities to monitor and report fire risks; these may include mobile applications, community networks or traditional communication methods to alert authorities quickly to

potential hazards. Where possible, these early warning systems should link to national and subnational early warning systems to enhance coordination, response time and data integration across governance levels.

5. **Collaboration on fire prevention measures:** Work with communities to implement practical fire prevention strategies such as constructing firebreaks, using controlled burning techniques responsibly, and managing vegetation. Activities like clearing dry vegetation, creating fire-resistant zones, and maintaining access roads reduce fire risks while fostering community involvement.

These strategies empower local communities to play a central role in fire prevention and management, building resilience against peatland and forest fires while promoting sustainable livelihoods.

5.3 Techniques for setting up community fire brigades

Establishing community fire brigades (CFBs) is a vital strategy to address delays in fire suppression due to slow reporting or difficulties in accessing fire locations. By empowering local communities, CFBs enhance the efficiency and responsiveness of fire control efforts. Their core functions are to prevent and suppress fires, and manage post-fire activities in their local areas.

- **Prevention and monitoring:** CFBs play a proactive role in preventing forest and land fires by conducting regular surveillance and monitoring within their village and surrounding areas.
- **Rapid suppression:** These brigades are trained to respond quickly to fire outbreaks, minimizing the likelihood of fires spreading out of control before external firefighting teams can arrive.
- **Post-fire support:** CFBs assist in rehabilitating burned areas by supporting restoration activities such as soil improvement, vegetation recovery and community health initiatives after fire incidents.

Coordination with relevant institutions

CFBs act as liaisons between local communities and official forest fire control agencies, facilitating the alignment of prevention, suppression and post-fire measures with national and regional fire management frameworks. Through effective organization, training and support, community fire brigades can become a critical asset in managing and mitigating the risks of peatland and forest fires.

In practice, the role and effectiveness of community fire brigades (Masyarakat Peduli Api or MPA) have been the focus of various studies. A stakeholder analysis using SWOT-AHP in peatland frontiers of Indonesia revealed that while MPAs are mandated by government regulation, their function is voluntary and depends heavily on local concern and commitment. MPAs often face operational challenges such as inadequate facilities, limited funding, and weak institutional support. Despite this, stakeholders—especially community groups, local governments, and NGOs—highlighted the importance of strengthening MPAs through enhanced partnerships and capacity building (Lembasi 2011).

Furthermore, participatory research in Riau demonstrated that MPAs can be integrated into broader fire prevention and restoration strategies. In Dompas Village, for example, MPAs were involved in coordinated fire patrols, fire-free land preparation, and restoration through canal blocking and agroforestry. These actions, supported by the community and external institutions, helped reduce fire incidence and supported livelihood development (Purnomo et al., 2024).

5.4 Use of ‘*beje*’ ponds and canals as communal firebreaks

Long traditional fishing ponds or canals created by local communities, often termed *beje*, are widely used in Indonesian peatlands and serve as effective tools for community-based fire management (BOSF 2024). These elongated ponds, measuring approximately 300m² in area, 10–60 meters long, and 1.5–2 meters deep (Jagau et al. 2008), are strategically constructed near settlements or rivers to retain water during the dry season. By maintaining moist conditions in surrounding peatlands, *beje* ponds function as natural firebreaks, reducing the risk of fire ignition and spread.



Figure 5. Villagers from Perigi Village in South Sumatra province in Indonesia install 3–5 pairs of fish traps made of bamboo (locally known as *bubu*) in *beje*. Photo by Rifky/CIFOR

Additionally, *beje* ponds contribute to local livelihoods by trapping fish during floods and allowing for the use of fish traps, providing a sustainable source of food and income for communities where households managing multiple ponds can harvest 500–1,200 kg of fish per season (Jagau et al. 2008). This system is a form of paludiculture (wetland-based cultivation) that supports peatland conservation and food security (Yuwati & Pratiwi 2022). However, regular maintenance, including desilting and debris removal, is essential to preserving their effectiveness (Jagau et al. 2008; Yuwati & Pratiwi 2022). And equitable community involvement must be ensured through continuous capacity development, trainings, and collaborations.

The integration of *beje* ponds into local fire control strategies underscores their dual functionality: protecting peatland ecosystems from fire hazards, and enhancing community resilience. This practical and sustainable approach aligns environmental conservation with socioeconomic benefits, offering a replicable model for other fire-prone regions and peatlands across ASEAN. It can build on existing practices, such as fish traps already utilized by local communities in peatlands of Lao PDR, on sourcing fish for local consumption and commercial trade from peat swamps in Vietnam that have been declining, and the recognized value of peatlands as fishing grounds for villagers in Thailand (ASEAN 2023b, Paphaphanh et al. 2024, Tran 2018).

5.5 Zero-burning on peatlands

Zero-burning is an environmentally sustainable policy put in place by ASEAN Member States to mitigate transboundary haze pollution resulting from peat fires. Guidelines on the implementation of zero burning (ASEAN 2003; Silviana et al. 2025) provides more details on its effective implementation.

5.5.1 Benefits of zero-burning

- **Environmental protection:** Eliminates open burning, significantly reducing air pollution

and greenhouse gas (GHG) emissions, including CO₂ and black carbon, thereby contributing to climate change mitigation and improved air quality (ASEAN 2003; Yabueng et al. 2020; Talang et al. 2024).

- **Improved soil fertility:** Promotes natural decomposition of organic matter, enhances nutrient cycling, and maintains soil organic content, supporting long-term soil productivity and boosts crop yields (Adinugroho et al. 2005).
- **Uninterrupted plantation operations:** Enables replanting activities to proceed without delays typically caused by land-clearing fires, supporting a continuous plantation cycle and minimizing economic disruption (Simorangkir et al. 2002; Adinugroho et al. 2005).
- **Hydrological benefits:** Helps retain higher water tables, reduces the risk of peat subsidence, and supports peatland resilience through reduced surface disturbance and controlled runoff (Raharjo 2023; Simorangkir et al. 2002).
- **Prevention of peat loss:** Protects the peat layer's integrity by maintaining its depth and quality, preserving key ecosystem functions and long-term carbon storage capacity (Murniati and Suharti 2018; Simorangkir et al. 2002).
- **Health protection:** Reduces exposure to fine particulate matter (PM_{2.5} and PM₁₀), which is linked to respiratory illnesses in surrounding communities (Yabueng et al. 2020).
- **Climate adaptability:** Can be applied year-round and is not dependent on dry weather conditions, offering greater flexibility across various climatic zones (Adinugroho et al. 2005).

5.5.2 Challenges of zero-burning

- Piles of organic matter increase vulnerability to pests such as termites and rodents, necessitating proactive pest control measures (ASEAN 2003). These biomass piles also pose fire hazards during prolonged droughts, requiring careful management to mitigate the associated threats.
- A key challenge in enforcing the no-burning policy is reduced effectiveness due

to physical obstacles, resource constraints and governance issues, which hinder compliance and fire prevention efforts (Resosudarmo et al. 2023).

- Traditional farming communities, such as the Dayak in Kalimantan, have long relied on burning as a land-clearing method. This practice is deeply ingrained in their cultural and agricultural traditions, with rituals and local wisdom surrounding its use (Ekawati et al. 2024). The shift to no-burn methods disrupts these cultural practices, causing resistance and reluctance to adopt new techniques.
- The zero-burning policy increases farming costs (Adinugroho et al. 2005), as traditional low-cost methods are replaced by mechanized systems that require expensive equipment, fertilizers and pesticides. Government support for agricultural machinery has been insufficient and poorly timed, leading to crop failures and financial strain for farmers (Ekawati et al. 2024).

Farmers in some areas have been forced to abandon rice farming due to the prohibition on fires, leading to a loss of food security and a shift to other livelihood activities, such as working in palm oil plantations or migrating for other jobs (Ekawati et al. 2024). This shift disrupts family structures and traditional community support systems like *handep* (mutual assistance) and *gotong royong* (cooperative work).

- While the policy has contributed to the improvement of peatland ecosystems, and reduced fire risks, it has also led to unintended ecological consequences. For example, drainage of peatlands to accommodate non-burn farming practices makes these areas more vulnerable to fires, and certain crops like palm oil are detrimental to the peatland environment (Ekawati et al. 2024).

5.5.3 Application in ASEAN countries

The application of zero burning in ASEAN, as outlined in the ASEAN Guidelines on Peatland

Fire Management and the APMS (Focal Area 5), focuses on preventing peatland fires and haze pollution through sustainable land management and fire prevention techniques. This includes promoting non-burning land clearing techniques, strengthening policies and compliance, building capacity, and integrating sustainable agricultural and peatland management practices across the region. There are also policies and approaches to zero-burning in peatlands across ASEAN countries including Indonesia, Malaysia, Philippines and Thailand.

Indonesia: Indonesia has implemented a zero-burning policy in peatland areas, particularly in response to recurrent forest and land fires. However, its effectiveness has been mixed, with challenges in local implementation due to reliance on traditional land-clearing methods, lack of adequate alternatives, and insufficient community engagement. The government continues to refine policies, offering support through food estate programmes and promoting alternative land preparation techniques (Ekawati et al. 2024). Zero-burning remains a cornerstone policy for promoting sustainable peatland and forest management, reducing environmental degradation, and fostering resilience to climate change.

Malaysia: Malaysia has successfully adopted a zero-burning policy in oil palm plantations, significantly reducing haze and promoting sustainable land management practices (Adinugroho et al. 2005; Murugiah 2022).

Philippines: The Philippines implements zero-burning within its Integrated Forest Fire Management framework, blending it with reforestation and community-led peatland restoration efforts (Adinugroho et al. 2005).

Thailand: Thailand has combined zero-burning with community-based fire prevention initiatives, employing zoning and sustainable land-use management to mitigate risks (ASEAN Secretariat 2003).

6 Conclusion

Peatland and forest fires remain a serious threat to environmental integrity, public health, and regional stability in Southeast Asia, largely due to unsustainable land-use practices, weak enforcement mechanisms, and growing climate variability. In response, this manual presents an updated, regionally relevant framework for integrated fire management, building on the foundational 2005 edition by Adinugroho et al.

While the original manual focused on Indonesia and introduced core principles of peatland fire prevention and suppression, this revised edition reflects two decades of accumulated field experience, expanded geographical scope, and enhanced tools. It addresses current challenges with evidence-based approaches, combining hydrological restoration, advanced remote sensing and monitoring systems, community engagement, and strengthened policy enforcement.

The manual synthesizes lessons learned from implementation across Indonesia, Malaysia, Thailand, and Vietnam—each offering distinct but complementary strategies. These include Indonesia's SiPongi and Sipalaga systems, Malaysia's zero-burning enforcement, Thailand's community-based fire networks, and Vietnam's legal and institutional frameworks. The case studies demonstrate

that successful fire control depends on multi-level governance, cross-sectoral collaboration, and local ownership.

Technological innovations such as fire danger rating systems, real-time hotspot detection, and groundwater monitoring are central to the revised guidance. However, their effectiveness hinges on robust institutional frameworks, adequate funding, and consistent enforcement. The manual also expands its focus to post-fire recovery—highlighting rewetting, revegetation, and traditional water management systems like beje ponds as part of a shift from reactive suppression toward proactive risk reduction and ecosystem restoration.

Ultimately, this revised manual provides a comprehensive and adaptable reference for policymakers, practitioners, and communities. By integrating foundational principles with contemporary scientific knowledge and practical insights, it offers a forward-looking blueprint for sustainable peatland and forest fire management. Its success will depend on sustained political commitment, inter-agency coordination, and empowered community participation to secure long-term ecological resilience and reduced fire risks across Southeast Asia.

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Peatland fires in Southeast Asia pose a serious threat to the environment, public health, and the economy. Their impacts include transboundary haze, ecosystem degradation, and massive carbon emissions that exacerbate climate change. These fires are often triggered by human activities, particularly due to its use for land clearing, and are further intensified by drought conditions caused by the El Niño phenomenon. Therefore, more effective and science-based strategies are needed to address this issue.

This manual updates the original manual by Adinugroho et al. (2005), integrating advancements in science, technology, and two decades of experience in peatland fire management and introducing various innovative approaches, including early warning systems, satellite-based hotspot monitoring, hydrological restoration, and community capacity development for fire management.

It further explains the crucial role that technology plays in fire prevention and mitigation. Systems such as SiPongi, Sipalaga, and PRIMS provide real-time data for detecting fire hotspots, monitoring peatland water levels, and coordinating fire suppression efforts, while the Fire Danger Rating System (FDRS) enables early identification of areas at high risk of fire.

The manual also highlights community involvement as a key component to successful fire management. Programs like Masyarakat Peduli Api (MPA) and incentive schemes encouraging farmers to adopt zero-burning methods have proven effective in reducing peatland fires. Lastly, the manual also presents case studies from various Southeast Asian countries, including Indonesia, Malaysia, Thailand, and Vietnam, to highlight policies and best practices in peatland fire management.

Designed for policymakers, researchers, practitioners, and the broader public, the manual aims to serve as a resource for achieving sustainable conservation and management of peatlands in Southeast Asia.

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