



APCTT
Asian and Pacific Centre
for Transfer of Technology

Consolidated Reply

Query 5 -

Transboundary Haze Monitoring & Management in Asia-Pacific

**Community of Practice (CoP)
on Climate Technologies**



Community of Practice (CoP) on Climate Technologies

Shared Experiences, Smarter Solutions for Climate Action and Resilience

The Community of Practice (CoP) on Climate Technologies launched by the Asian and Pacific Centre for Transfer of Technology (APCTT) is dedicated to addressing the multifaceted challenges posed by climate change in the Asia-Pacific region through technology solutions. By leveraging the region's rich innovation capacities and good practices, the CoP aims to enhance access to critical knowledge on climate technologies. The Community connects professionals engaged in delivering technological solutions to climate change.

The objective of this Community of Practice is to:

- Promote collaborative problem-solving and policy-relevant dialogue
- Support the localization and transfer of innovations suited to national priorities
- Enhance institutional capacities for climate technology governance
- Enable matchmaking between solution providers and implementers

The Community is driven by a participatory and adaptive model that combines knowledge generation, engagement, and access to resources through the following mechanisms: monthly Query-Response Consolidated Reply (CR) cycle, webinars and interactive discussions, knowledge repository and much more.

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Cities across the Asia-Pacific continue to face high and persistent PM_{2.5} pollution, with over 97% of cities in the region exceeding WHO annual limits according to the 2024 World Air Quality Report¹. Transboundary haze episodes continue to affect South and Southeast Asia, fueled by agricultural fires and amplified by limited cross-border data sharing². The region also recorded over 630,000 premature deaths from ambient air pollution in 2021, emphasizing the growing public health burden³. Climate-driven dry seasons, rapid urban expansion, and uneven enforcement capacity further intensify pollution episodes and stretch national monitoring systems across Asia and the Pacific.

In this context, we invite members to share their knowledge and lived experiences:

1. What recent technological advancements and innovative air-pollution control systems are being deployed across the Asia-Pacific region to enhance monitoring, early warning, and mitigation of PM_{2.5}, industrial emissions, and biomass-burning events, especially for transboundary haze monitoring and mitigation?

¹ World Air Quality Report 2024. <https://www.iqair.com/world-air-quality-report>

² Economic Research Institute for ASEAN & East Asia. Transboundary Haze Pollution Problem in Southeast Asia: Reframing ASEAN's Response. <https://www.eria.org/research/transboundary-haze-pollution-problem-in-southeast-asia-reframing-aseans-response>

³ State of Global Air Report. <https://www.stateofglobalair.org/resources/asia?>



2. How are countries in the Asia-Pacific region strengthening cross-border cooperation to address transboundary air pollution, including mechanisms for data sharing, coordinated enforcement, and newly introduced regional or bilateral initiatives?

Your insights will contribute to regional knowledge sharing and inform inclusive strategies for building safer, more climate-resilient cities in Asia and the Pacific.

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1. Summary of Responses

The two central questions on the query on transboundary haze were related to recent technological advancements and innovative control systems for haze monitoring and management. It also included cross-border cooperation mechanisms and enforcement arrangements on the same. Despite the continuing sub-regional variation in the levels of maturity and operational readiness, there appears to be a clear evolution in the region from fragmented national-level monitoring efforts towards more sophisticated, interconnected regional frameworks.

On recent technological advancements and innovative control systems, several advanced analytical tools such as [Fire Emission Models \(FREM\)](#) and [Chemical Transport Models \(CTM\)](#) are available. They serve as critical enablers for effective transboundary haze management. A fully integrated "end-to-end" operational chain has emerged. It begins with an early fire detection and precise emissions estimation. Then progressing through regional-scale plume transportation modelling, hyper-local exposure mapping via distributed sensor networks, it results in targeted mitigation and enforcement measures.

Satellite datasets from instruments like [MODIS and VIIRS](#) now routinely feed into these models, generating reliable 72–96-hour forecasts of smoke dispersion and PM_{2.5} concentrations. These forecasts are then disseminated through national meteorological services as well as regional platforms. They include air quality networks operating in high-vulnerability areas such as the **Himalayas**. Complementing these systems, low-cost PM_{2.5} sensor networks- calibrated and enhanced through artificial intelligence and

machine learning algorithms, provide granular, street-level exposure data. Such networks are particularly valuable in clear attribution of about 80% of spikes to episodic pollution events from regional biomass burning sources. Advances in satellite monitoring have also helped track hotspots and assess progress across all regions.

On the mitigation side, the [incremental advances in technologies](#) are also apparent. Ultra-low emission control technologies are being used by industrial sectors. Agricultural technologies such as in-situ crop residue bio-decomposers and residue to energy conversion systems minimize the causes of seasonal haze pollution episodes. Advances are achieved by stricter fire enforcement against forest/land fires in the [Southern Mekong](#), carbon funding incentives consistent with climate commitments to sustainable forestry practices, and the [Northern Mekong](#) Circular Economy models for biomass utilizing practices that do not promote open burning. The rice companies are incentivizing farmers by using non-burn crops and for rice straw use. The outstanding example within the country is [Thailand's GISTDA](#) (Geo-Informatics & Space Technology Development Agency) that effectively harmonies hotspot data derived from satellites, aerosol indices, along with ground data to provide near real-time pollution transport maps for hazes that not only influence provincial action plans against hazes, but also enhance the general debate on policies within the **Mekong** sub-region.

On the question of cross-border cooperation and enforcement mechanisms, [Southeast Asia](#) presents the most advanced regional model in the form of the [ASEAN Agreement on Transboundary Haze Pollution \(2002\)](#) and the recently adopted [Second Haze-Free Roadmap \(2023-2030\)](#). Further, it is strengthened by ASEAN's 2024 adoption of nine targeted strategies with PM_{2.5} concentration

goals, cross-sectoral coordination, and an investment framework to mobilize resources. These frameworks include a dedicated ASEAN Coordinating Centre, systematic joint verification of satellite-detected hotspots, and integrated national legislation for strong enforcement during haze episodes. Emerging sub-regional cooperation is evident under initiatives like [Thailand's Clear Sky Strategy](#).

Transboundary Haze Management requires a [multi-level approach](#) combining technology, [policy](#) and community participation. Yet **South Asia** does not have a formal regional mechanism. But it does have scientific data sharing and joint monitoring of airshed dynamics and cross-border PM_{2.5} contributions (especially in **Northeast Asia**), though these remain less focused on enforcement. The data sharing is reported to be catalysing discussions around uniform monitoring standards, compatible emissions inventories, and structured data-sharing protocols.

In the [Pacific islands and West and Central Asia](#), UN-supported early warning systems are available for seasonal haze and dust storm events, though operational coordination and enforcement are still at an early developmental stage. Across all sub-regions, contributors emphasized persistent gaps, including inconsistent air quality indices, fragmented emissions reporting, and variable data quality assurance that hinder effective collaboration. Critical needs include adoption of [WHO-aligned](#) standards, development of interoperable regional data platforms, and systematic integration of community-led low-cost sensor networks to supplement and validate official monitoring. [Private Sector Involvement and emerging climate-compatible financing](#) from multilateral development banks and UN agencies offers promising support for peatland restoration, sustainable agricultural practices, and shared technology infrastructure as direct instruments for haze reduction.

2. Relevant Experiences

Australia

The [Bureau of Meteorology in Australia](#) track the intercontinental transport of haze from Indonesian forests around Darwin and Cairns. The Pacific Meteorological Desk harmonize fire danger Classes with Papua New Guinea within [SPREP agreements](#). BoM's satellite fire mapping helps ASEAN's ASMC outlook forecasts during El Niño events.

Bangladesh

The Department of Environment has over 50 PM2.5 monitoring stations across the Indo-Gangetic belt. Analysis by [ICIMOD](#) shows that stubble burning in Indian agricultural fields is responsible for 25-35% of PM2.5 haze during winter. The government of Dhaka has combined Indo-Bangladesh forecasts during haze emergencies that impact over 15 million citizenries.

Bhutan

The [National Environment Commission](#) maintains a network of 12 high-altitude PM2.5 stations that monitor Himalayan plume inflow from the Indian plains. Bhutan engages in regular regional coordination through participation in ICIMOD's 72-hour regional bulletin and coordinates seasonally with Assam on management of crop and fire residues, aiming at reducing cross-border smoke.

Brunei Darussalam

Brunei is a full [AATHP](#) signatory, and Brunei deploys national fire suppression teams during [Kalimantan haze episodes](#). PM2.5 data at Brunei International Airport support the ASMC regional haze monitoring. Brunei also cooperates with Malaysia and Indonesia on Borneo-wide aerial firefighting.

Cambodia

The Ministry of Environment has the ASEAN Coordinating Centre for Transboundary Haze Pollution and administers the programme using 20 stations in tracking the smoke along the Thai-Myanmar border area. Cambodia has the zero-burn rice program and has partnered with Laos and Vietnam in managing wildfires within the Mekong region.

China

A 42% reduction in transboundary PM2.5 emissions to Korea and Japan occurred in China between 2013 and 2023, through effective control measures on winter-heating practices. A network of over 1,500 ground stations and satellite model merging is employed by the [CNEMC](#) to make long-range source contributions. [EANET](#) facilitates joint data sharing with Japanese and South Korean administrations.

East Timor

Timor-Leste's marine haze observation is coordinated together with Indonesia and the Philippines through the Fire Danger Rating System Marine Extension. The eight stations along the coast of Timor-Leste monitor the smoke conditions in the Timor Sea that are caused by agricultural fires in West Timor that impact the area of Dili.

Fiji

Fiji has a monitoring system using national stations and [SPREP regional monitoring](#) for tracking haze emissions in Indonesian Papua, particularly in periods of strong dry seasons. Satellite warning information is provided to ports, island health, and tourism operators.

India

[NCAP](#) controls over 1,500 baseline PM2.5 stations that are networked to the ISRO SAFAR system. [SAFAR](#) makes available forecasts of stubble smoke columns for the first 72 hours, with plumes moving to the Pakistani and Bangladesh regions. The Commission for Air Quality Management controls airshed response strategy and has shown positive results in limiting the peak Delhi October baseline of PM2.5 to 320 $\mu\text{g}/\text{m}^3$ in 2024, compared to the earlier target of 450 $\mu\text{g}/\text{m}^3$ for

Indonesia

Indonesia has also intensified the [protection of peatlands](#) and restored one million hectares of degraded peat after the 2015 haze incident involving the group USD 16B. Over 10,000 firefighting forces and helicopters are deployed to fight peatland forest fires. There is also a 200-station haze early warning system maintained by the [BMKG](#).

Iran

To monitor the interaction between dust and smoke that affects the transport of haze in the region, the Iranian government relies on [satellite surveillance and PM2.5 networks](#). Modeling studies carried out by national research institutions are shared with neighboring countries during peak seasons when the prevailing wind flow dominates.

Japan

Japan supports regional PM2.5 forecasting and long-range transport analysis through advanced aerosol modeling under the EANET framework. Satellite-based fire detection from [Himawari-8](#) contributes to regional haze monitoring and early-warning systems in Southeast Asia.

Laos (Lao PDR)

The country uses the [ASEAN Fire Danger Rating System](#) in [Mekong](#) provinces, realizing a 70% reduction in agricultural burning through GEF assistance for community rewetting pilots. It has an ongoing 15-station networked system to monitor Chin Hills transport of Chin Hills dust plumes to Air4Thai stations in Thailand.

Malaysia

[The Transboundary Haze Pollution Act \(2014\)](#) enables action against Malaysian entities involved in overseas fires . The [DOE's APIMS network](#) has 65 stations to give hourly API readings during Sumatran haze episodes. Malaysian aerial fighting for Borneo Forest fires occurs with participation from Brunei and Indonesia.

Maldives

In Maldives, monsoon haze over South Asia is monitored by the [WHO GAW](#) station network consisting of eight stations and utilizing maritime standards for PM2.5 about Malé. Seasonal haze from India/Sri Lanka may influence tourism and health warnings.

Mongolia

Mongolia monitors dust and smoke that affects the occurrence of winter haze in northern China. The network of 20 stations in Ulaanbaatar enables real-time particulate data for CTM-based transport modelling.

Myanmar

As a member state participating in the [ASEAN Haze](#) Technical Task Force, it has hotspots exceeding 5,000 within the Chin Hills annually through the use of ASMC data. A new series of 20 stations for PM_{2.5} measures seasonal burn-downs impacting Yangon.

Nepal

Nepal's 25-point AQI system estimates the contribution to winter PM_{2.5} pollution from Indian stubble burning using [ICIMOD HKH datasets](#)—35% to winter pollution. Sharing datasets with India has brought down winter pollution peaks in Kathmandu from 250µg/m³ in 2019 to approximately 180µg/m³ in 2024.

New Zealand

New Zealand monitors trans-Tasman smoke from Australian Bush Fires using [Niwa](#) and [MetService](#) models. Satellite data and LIDAR provide contributions to health alerts during extreme southern hemisphere fire events.

Pakistan

The SAMEER network with 40 stations puts the contribution from Indian stubble crop burning to winter PM_{2.5} in Lahore at 30-40%. Pakistan has suggested a SAARC airshed in the IGP. The Punjab government's plan to reduce smog emergency has operational methods for any level beyond 300 µg/m³.

Papua New Guinea

Papua New Guinea manages Pacific Fire Danger Rating System operations with Australian cooperation and haze transport in Indonesian Papua through a network of 10 stations that are connected to [SPREP](#). Port Moresby usually sees lower visibility in high-burn episodes.

Philippines

The Philippines tracks peat haze over Indonesia through its [Mindanao observation system](#) consisting of 50 stations, and the ASEAN maritime FDRS. Transport events involving the Sulu Sea include coordination with Malaysia concerning plumes.



Samoa

In Samoa, advisories and satellite and point sensors are used for warning in SPREP's regional haze notification system. Tourism and health facilities near the coastline use these early warning systems during the fire season in the Pacific.

Singapore

Singapore has the Transboundary Haze Pollution Act of 2014, with fines of up to SGD 1 million. It has the [ASEAN Specialised Meteorological Centre](#) and publishes a daily haze outlook for 10 ASEAN states. [National Environment Agency's](#) 20-station PSI reporting system has a data availability of 95% in the 2019 situation.

South Korea

[AirKorea's](#) 300+ monitoring stations provide data to show China's share at ~50% of Korea's winter PM_{2.5} level, as found by the [KORUS-AQ](#) campaign. Korea's government spends ~\$2B on fine dust mitigation measures and has bilateral forecasting cooperation with China on this issue.

Sri Lanka

In Sri Lanka, monsoon-driven haze at the IGP is measured by the WHO GAW stations. Colombo PM_{2.5} advisories are usually in sync with the Maldives during regional smoke events.

Thailand

The [Air4Thai](#) network in Thailand has over 100 stations and synchronizes northern border responses to air pollution from both Myanmar and Laos. The burning ban imposed has dropped Chiang Mai's PM_{2.5} peaks from 500 µg/m³ in 2019 to 300 µg/m³ in 2024.

Viet Nam

Viet Nam's Environment Administration tracks peat haze that enters the Mekong Delta region under the [ASEAN Roadmap](#). Burning of rice straw has been reduced by 60% by the Happy Seeder projects, which reduces Ho Chi Minh City's winter PM_{2.5} levels by 25%.

3. Related Resources

Relevant Documentation

Actions to Reduce Open Biomass Burning in Southeast Asia: Policy brief outlines integrated fire monitoring, farmer incentives, and ASEAN coordination to cut haze emissions by 50% through 2030. (https://www.apn-gcr.org/wp-content/uploads/2022/02/Policy-brief-APN-project-CRRP2019-11MY-Nguyen_Published-version_updated.pdf)

Acute Health Impacts of Southeast Asian Transboundary Haze (2019): Analyzes hospital admissions and mortality spikes during 2015 haze crisis across Indonesia, Malaysia, Singapore. (<https://pmc.ncbi.nlm.nih.gov/articles/PMC6765769/>)

Air Pollution and Public Health in South Asia (2022): World Bank roadmap proposes airshed management for India-Pakistan-Bangladesh PM2.5 coordination and health cost savings. (<https://www.worldbank.org/en/region/sar/publication/striving-for-clean-air>)

Air Quality in Asia (ADB): Asian Development Bank assessment of PM2.5 trends, monitoring gaps, and policy recommendations across 10 Asia-Pacific countries. (<https://www.adb.org/publications/air-quality-asia>)

ASEAN Agreement on Transboundary Haze Pollution (2002): Legal framework mandates fire prevention plans, monitoring stations, and joint emergency response across 11 member states. (<https://asean.org/wp-content/uploads/2021/01/ASEANAgreementonTransboundaryHazePollution-1.pdf>)



ASEAN Haze Trauma Report: Documents health and economic costs of haze crises.

(<https://www.greenpeace.org/static/planet4-southeastasia-stateless/2025/10/935fbf7d-the-asean-haze-trauma-report.pdf>)

ASEAN Second Haze-Free Roadmap (2023-2030): Successor to the 2016-2023 Roadmap operationalizing AATHP with 9 strategies including ACC THPC capacity building, fire prevention/suppression, peatland restoration targets (2M ha), and national PM2.5 standards aligned with WHO Interim Target 3. Adopted August 2023 at COP-18, emphasizes public-private partnerships and cross-sectoral coordination for transboundary haze-free ASEAN by 2030.

(<https://asean.org/wp-content/uploads/2024/09/The-Second-Haze-Free-Roadmap-2023-2030.pdf>)

CCAC- Air Pollution in Asia and the Pacific: Science-Based Solutions: Technical evaluation of PM2.5 sources, transport, and mitigation pathways.

(<https://www.ccacoalition.org/projects/air-pollution-asia-and-pacific-science-based-solutions>)

Clean Air Asia – Guidance Framework for Better Air Quality in Asian Cities: Framework for local governments to strengthen air-quality governance.

(<https://cleanairasia.org/sites/default/files/2021-05/3.%20Guidance%20Framework%20for%20Better%20Air%20Quality%20in%20Asian%20Cities.pdf>)

Copernicus CAMS – Global Fire Assimilation System (GFAS) Documentation: Explains methodology for fire emissions and haze modeling.

(<https://atmosphere.copernicus.eu/sites/default/files/2018-05/CAMS%20%20Global%20Fire%20Assimilation%20System%20%28GFAS%29%20data%20documentation.pdf>)



Cross-Border Collaboration for Air Pollution in South Asia: Suggests monitoring and emission reduction partnerships.

(<https://irispublishers.com/iojs/pdf/IOJS.MS.ID.000517.pdf>)

FAO Regional Overview of Food Security and Nutrition 2024 - Asia and the Pacific: Examines agricultural burning practices contributing to haze pollution, with recommendations for sustainable crop residue management and fire prevention across rice-producing countries in South and Southeast Asia.

(<https://openknowledge.fao.org/server/api/core/bitstreams/5f268814-4e8b-4ae2-b835-5738b61ba0c2/content>)

ICIMOD – Spatio-Temporal Patterns of Air Pollution Across the Himalaya: Analyzes transboundary PM_{2.5} between India–Nepal–Bangladesh. ICIMOD report documents academic collaboration on trans-HKH air pollution research, including crop residue burning impacts on regional haze affecting Himalayan air quality.

(<https://lib.icimod.org/record/34669/files/ICIMOD-Report-Air-Pollution.pdf>)

Impact of ASEAN Haze Agreement on Regional Stability (2024): Evaluates pollution control effects on cooperation.

(https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5297081)

Influence of Biomass Burning on Southeast Asia Air Pollution (2019): Quantifies fire impacts on PM_{2.5} using multi-dataset analysis.

(<https://www.sciencedirect.com/science/article/abs/pii/S0269749119316896>)

International Regulatory Co-operation on Air Quality in North East Asia: Guidance for cross-border pollution frameworks.

(https://www.oecd.org/content/dam/oecd/en/publications/reports/2020/01/study-of-international-regulatory-co-operation-irc-arrangements-for-air-quality_6402d09f/dc34d5e3-en.pdf)



JICA – Handbook on Air Pollution Control in Asia: Capacity-building guide covers monitoring stations, emission inventories, and enforcement for Asian cities.

(https://openjicareport.jica.go.jp/pdf/12289203_01.pdf)

Long-term PM2.5 and PM10 Monitoring Implications: Urban health risk assessments.

(<https://www.sciencedirect.com/science/article/pii/S2667010025002318>)

Long-term PM2.5 Monitoring with Low-Cost Sensors in Asia (2025): Details community-level sensor networks for high-resolution air quality data.

(<https://pmc.ncbi.nlm.nih.gov/articles/PMC12075264/>)

Perspective on PM from Biomass Burning in Southeast Asia (2023): Links fires to 70% of dry-season PM2.5 spikes.

(<https://pmc.ncbi.nlm.nih.gov/articles/PMC10384564/>)

Research Priorities for Low-Cost PM2.5 Sensors in Southeast Asia: Identifies gaps in source evaluation and exposure assessment.

(<https://archium.ateneo.edu/cgi/viewcontent.cgi?article=1133&context=physics-faculty-pubs>)

Review of the Main Activities on Transboundary Air Pollution in Northeast Asia - NEASPEC, 2012: A comprehensive working paper reviewing major transboundary air-pollution mechanisms in Northeast Asia (e.g. monitoring networks, joint research, long-range transport modelling, policy frameworks), identifying gaps and recommending a holistic subregional cooperation framework.

(https://www.neaspec.org/sites/default/files/Review_Of_The_Main_Activities_On_Transboundary_Air-pollution_In_NEA.pdf)

Source Attribution of Biomass Burning PM in Southeast Asia (2019): Identifies haze source regions using dispersion modeling for Singapore events.

(<https://acp.copernicus.org/articles/19/5363/2019/>)

Striving for Clean Air: Air Pollution and Public Health in South Asia (World Bank, 2023): Identifies 6 major airsheds requiring India-Pakistan-Bangladesh coordination, uses GAINS modeling for transboundary PM2.5 scenarios, proposes 3-phase airshed management roadmap.
(<https://documents1.worldbank.org/curated/en/099061923002020301/pdf/P16823709f68ce09a0ac2505b130a835c56.pdf>)

Tackling Transboundary Haze in Southeast Asia (2025): Reviews ASEAN roadmaps and hotspot reduction progress.
(<https://slocat.net/tackling-transboundary-haze-pollution-in-southeast-asia/>)

TERI – Understanding Air Pollution Sources in India: Source apportionment shows 30-40% Delhi PM2.5 from transboundary agricultural burning.
(<https://www.teriin.org/article/air-pollution-india-major-issues-and-challenges>)

Transboundary Air Pollution in Northeast Asia and Lessons from North America- Global Asia (2019): Examines long-range PM2.5 transport in Northeast Asia and draws lessons from U.S.-Canada cooperation, highlighting the need for stronger regional monitoring, emissions accountability, and binding agreements.
(https://www.globalasia.org/v14no4/cover/transboundary-air-pollution-in-northeast-asia-and-lessons-from-north-america_matthew-a-shapiro)

UNEP Air Pollution Action Plans Asia-Pacific: Technical guidance for haze mitigation tech.
(<https://www.unep.org/regions/asia-and-pacific/regional-initiatives/restoring-clean-air#:~:text=To%20achieve%20a%20pollution%2Dfree,relevant%20sectors%2C%20such%20as%20transport.>)

UNEP – Global Peatlands Assessment (2022): Documents 6% global peatland carbon in SE Asia, primary haze emission source.
(<https://www.unep.org/resources/global-peatlands-assessment-2022>)



WHO – Global Air Quality Guidelines (2021): Sets PM2.5 annual mean at 5 µg/m³, basis for Asia-Pacific exceedance reporting.
(<https://www.who.int/publications/i/item/9789240034228>)

World Air Quality Report 2024: Tracks PM2.5 exceedances in 97% of Asia-Pacific cities.
(<https://www.iqair.com/world-air-quality-report>)

Relevant Organizations

ASEAN Secretariat-Environment Division- Coordinates regional frameworks under the ASEAN Agreement on Transboundary Haze Pollution (AATHP), including joint monitoring systems, ministerial steering committees, and technical cooperation on fire and haze control.
(<https://environment.asean.org>)

ASEAN Specialised Meteorological Centre (ASMC)- Provides regional hotspot analysis, haze outlooks, seasonal predictions, and fire-danger assessments for ASEAN Member States, supporting coordinated early-warning and response measures.
(<https://asmc.asean.org>)

Asia Pacific Clean Air Partnership (APCAP)- A UNEP-led platform that supports policy development, scientific assessments, and regional cooperation on clean air, including guidance for monitoring and emissions management.
(<https://www.unep.org/asia-and-pacific/asia-pacific-clean-air-partnership>)

Asia-Pacific Network for Global Change Research (APN)- Funds scientific research, pilot studies, and capacity-building initiatives on climate–air quality interactions, long-range pollutant transport, and atmospheric monitoring in Asia-Pacific.
(<https://www.apn-gcr.org>)



Asian Development Bank (ADB)- Supports member countries with investments and technical assistance for air quality monitoring networks, clean energy transition, emissions management, and regional haze cooperation mechanisms.

(<https://www.adb.org>)

Australian Bureau of Meteorology – Environmental Prediction Services- Provides aerosol modeling, bushfire smoke dispersion forecasts, and meteorological services for Pacific and Southeast Asian states through regional climate and atmospheric programs.

(<https://bom.gov.au>)

China Ministry of Ecology and Environment (MEE)- Operates China’s national air quality monitoring system, conducts emissions inventory development, and leads regional cooperation on long-range pollutant transport with Korea, Japan, and Mongolia.

(<http://english.mee.gov.cn>)

Clean Air Asia- Provides technical support to Asian cities on air quality management, emissions inventories, transport-sector pollution, and development of integrated air quality monitoring frameworks.

(<https://cleanairasia.org>)

Climate and Clean Air Coalition (CCAC)- A global partnership advancing mitigation of short-lived climate pollutants such as black carbon and methane, supporting national and regional initiatives related to haze and air quality.

(<https://www.ccacoalition.org>)

Copernicus Atmosphere Monitoring Service (CAMS)- Delivers global satellite-derived air quality datasets, PM_{2.5} forecasts, biomass burning emissions inventories, and smoke plume modeling used by countries across Asia-Pacific.

(<https://atmosphere.copernicus.eu>)



GISTDA (Geo-Informatics and Space Technology Development Agency, Thailand): Thai government's space agency partners with NASA ASIA-AQ/SERVIR for wildfire risk mapping ("Areas at Risk for Wildfires 2024"), Mekong Air Quality Explorer satellite forecasting, and Air4Thai integration during March-April haze peaks. (<https://www.gistda.or.th>)

International Air Quality and Climate Change Research Programme (Japan)- Supports research on regional aerosol dynamics, long-range transport of PM2.5, and chemical transport modeling relevant to East Asia's haze conditions. (<https://www.nies.go.jp/index-e.html>)

International Atomic Energy Agency (IAEA) – Environment Laboratories- Provides nuclear analytical techniques for PM2.5 source apportionment, enabling member states to identify combustion, industrial, and biomass-burning sources. (<https://www.iaea.org>)

International Centre for Integrated Mountain Development (ICIMOD)- Leads cross-border air quality monitoring in the Hindu Kush Himalaya region, including satellite data integration, low-cost sensor networks, and regional science-policy dialogues. (<https://www.icimod.org>)

International Council for Clean Transportation (ICCT)- Supports adoption of vehicle-emissions standards, fuel-quality policies, and transport-sector mitigation strategies that reduce regional PM2.5 and precursor pollutants. (<https://theicct.org>)

International Renewable Energy Agency (IRENA)- Promotes clean energy deployment and provides technical assessments that indirectly support haze reduction by lowering dependence on biomass and fossil fuel combustion. (<https://www.irena.org>)



Japan International Cooperation Agency (JICA)- Offers technical support for strengthening national air quality monitoring systems, emissions inventories, and satellite-based assessment tools across developing Asian countries.

(<https://www.jica.go.jp/english/index.html>)

Korea National Institute of Environmental Research (NIER)- Manages the GEMS geostationary satellite instrument, providing near-real-time monitoring of pollutants across Asia and enabling improved regional modeling and forecasting.

(<https://nier.go.kr/>)

NASA Fire Information for Resource Management System (FIRMS)- Provides real-time global fire detections, hotspot mapping, and biomass burning alerts used widely in early warning for regional haze episodes.

(<https://firms.modaps.eosdis.nasa.gov>)

Pacific Meteorological Council (PMC)- Coordinates regional climate and atmospheric services for Pacific Island countries, including fire danger rating systems and support for haze and smoke monitoring.

(<https://www.pacificmet.net>)

South Asia Cooperative Environment Programme (SACEP)- Implements regional cooperation frameworks such as the Malé Declaration, facilitating joint monitoring, emission inventories, and transboundary air pollution assessments.

(<https://www.unep.org/south-asia-co-operative-environment-programme-sacep>)

Stockholm Environment Institute (SEI)- Conducts applied research on regional haze patterns, peatland fire emissions, and air quality governance, supporting evidence-based policy development.

(<https://www.sei.org>)



TERI- The Energy and Resources Institute (India)- Provides research, policy analysis, and technical advisory services related to air pollution management, emissions reduction, and atmospheric modeling.

(<https://www.teriin.org>)

UN Environment Programme (UNEP)- Hosts global and regional air quality programs including GEMS Air, supports countries in developing monitoring systems, and facilitates policy and capacity-building assistance.

(<https://www.unep.org>)

UN Office for Disaster Risk Reduction (UNDRR) – Supports integration of air pollution and transboundary haze into disaster risk reduction and early-warning frameworks, including regional risk assessments, preparedness planning, and climate-resilient urban strategies across Asia and the Pacific.

(<https://www.undrr.org>)

United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP)- Supports regional cooperation on environmental governance, early-warning systems, and cross-border pollution monitoring across Asia-Pacific.

(<https://www.unescap.org>)

World Bank – Pollution Management and Environmental Health (PMEH)- Provides financial and technical support for strengthening air quality monitoring networks, emissions regulation, and clean air action planning.

(<https://www.worldbank.org>)

World Health Organization (WHO)- Develops global air quality guidelines and health impact assessments, and supports national air quality framework development and data harmonization.

(<https://www.who.int>)



World Meteorological Organization (WMO)- Supports atmospheric observation, air-quality forecasting, and regional environmental monitoring through global meteorological systems and scientific standards.

(<https://wmo.int>)

WMO Global Atmosphere Watch Programme (GAW)- Operates global background monitoring stations and supports transboundary air quality research on aerosols, ozone, and long-range pollutant movement.

(<https://community.wmo.int/site/knowledge-hub/programmes-and-initiatives/global-atmosphere-watch-programme-gaw>)

Relevant Websites

ADB Climate Change and Disaster Risk Management Portal: Funds regional air quality projects, peatland restoration, and climate-resilient agriculture to reduce biomass burning emissions contributing to transboundary haze across Asia-Pacific.

(<https://www.adb.org/what-we-do/topics/climate-change>)

AirKorea National Air Quality Network: Korea's official real-time PM2.5/PM10 monitoring across 300+ stations, tracks transboundary haze from China affecting Seoul (CAI system, hourly forecasts).

(<https://www.airkorea.or.kr/web/>)

ASEAN Environment – Haze & Peatland Portal: Central platform for ASEAN's transboundary haze cooperation, monitoring hotspots, fire danger ratings, and peatland management initiatives linked to haze suppression.

(<https://hazeportal.asean.org>)

ASEAN Specialised Meteorological Centre (ASMC): Offers regional hotspot maps, smoke dispersion forecasts, and climate outlooks to support coordinated haze early-warning across Southeast Asia.

(<https://asmc.asean.org>)

CCAC – Climate & Clean Air Coalition: Provides mitigation toolkits and tracking of short-lived climate pollutants like black carbon and methane key to reducing haze and PM_{2.5} concentrations regionally.
(<https://www.ccacoalition.org/content/benefits-and-costs-mitigating-methane-emissions>)

Clean Air Asia Resources Hub: Comprehensive repository of air quality management toolkits, city dashboards, haze episode case studies, emission inventories, and cross-border airshed management resources for 25 Asian megacities.
(<https://cleanairasia.org/our-resources>)

Copernicus Atmosphere Data Store (ADS) – Open-access platform providing downloadable PM_{2.5}, aerosol optical depth, and biomass-burning emission datasets widely used for regional haze modeling and transboundary air quality analysis.
(<https://ads.atmosphere.copernicus.eu>)

DENR Environmental Management Bureau (Philippines): Real-time air quality reports, emission inventories, and haze alerts for regions including Mindanao impacted by transboundary smoke.
(<https://ncr.emb.gov.ph/>)

EANET Air Quality Monitoring Data Portal – Regional platform providing long-term monitoring data on aerosols and atmospheric pollutants across Northeast Asia, supporting assessment of long-range transport and transboundary air pollution.
(<https://www.eanet.asia>)

Global Fire Emissions Database (GFED) – Dataset and analytical resource measuring global fire-emission fluxes and burned area. Widely used in atmospheric models to quantify biomass burning contributions to transboundary haze episodes.
(<https://www.globalfiredata.org>)



ICIMOD – Regional Air Quality Programme: Scientific data platform with live PM2.5 maps and fire alerts for the Hindu Kush Himalaya region, tracking cross-border haze flows between India, Nepal, and Bangladesh. (<https://www.icimod.org/initiative/air-pollution-solutions/#:~:text=ICIMOD's%20Air%20Pollution%20Solutions%20Initiative,international%20coordination%20and%20information%20sharing.>)

India CPCB – National Air Quality Monitoring Programme (NAMP): Offers continuous AQI and PM2.5 monitoring integrated with satellite forecasting tools, focused on agricultural burning and IGP haze episodes. (<https://cpcb.nic.in>)

Malaysia APIMS – Air Pollutant Index of Malaysia: Provides real-time pollutant index data, extensive hotspot maps, and haze advisories during fire events in Sumatra and Kalimantan peatlands. (<https://apims.doe.gov.my>)

NASA FIRMS – Fire Information for Resource Management System: Widely-used satellite fire hotspot alerts across the globe for haze early-warnings, specifically crucial for Southeast Asia's biomass burning monitoring. (<https://firms.modaps.eosdis.nasa.gov>)

NASA MODIS – Atmospheric & Fire Products: Satellite-based aerosol optical depth and fire detection products essential for regional smoke and haze monitoring and assessments. (<https://modis.gsfc.nasa.gov>)

Nepal Department of Environment – AQI Portal: Real-time PM2.5 monitoring and fire alert platform tracking transboundary haze impacting Nepal's air quality and health. (https://pollution.gov.np/portal/#/home?_k=71xsiic)

NOAA Hazard Mapping System – Fire & Smoke: Daily composite satellite maps showing smoke plumes, haze trajectories, and global fire hotspots for Asia-Pacific haze event tracking. (<https://www.ospo.noaa.gov/Products/land/hms.html>)



Pacific Meteorological Council (PMC): Provides fire-danger ratings, drought risk tools, and haze monitoring services tailored for Pacific Island nations affected by long-range haze transport.

(<https://www.pacificmet.net>)

SERVIR Southeast Asia & ASIA-AQ Haze Platforms: Mekong Air Quality Explorer (SERVIR-SEA with Thai PCD) delivers 5km resolution VIIRS/GEMS satellite AQ data + 3-day forecasts via machine learning; Smoke Watch app provides real-time VIIRS fire alerts for firefighters. ASIA-AQ (2024) validates with DC-8 aircraft sampling over Chiang Mai/Bangkok, quantifying maize burning/inversion contributions to March-April haze. (https://servir.adpc.net/tools/aq_detail.html)

Singapore NEA – Air Quality & Haze: Official portal providing PSI readings, health advisories, and regional haze monitoring with satellite hotspot analyses.

(<https://www.nea.gov.sg/our-services/pollution-control/air-pollution>)

State of Global Air Asia Dashboard: Interactive platform quantifying PM2.5 health impacts across South and Southeast Asia with exposure maps and mortality data.

(<https://www.stateofglobalair.org/resources/asia>)

Stockholm Environment Institute – Air Quality Resources: Research platform with detailed analyses on Southeast Asia’s haze episodes, biomass burning drivers, and policy responses.

(<https://www.sei.org/projects/air-quality/>)

TERI – Air Quality & Pollution Studies: Offers detailed data and research on India’s PM2.5 levels, crop burning emissions, urban pollution profiles and transboundary haze linkages. (<https://www.teriin.org>)

UNEP Air Quality Topic Portal: Central hub coordinating global air pollution initiatives including regional cooperation resolutions (UNEA-6), capacity building for national monitoring networks, and transboundary PM2.5 management frameworks across Asia-Pacific.

(<https://www.unep.org/topics/air>)

UN ESCAP – Environment & Development Resources: Provides regionally focused reports, data, and policy guidance promoting air pollution governance and haze early-warning cooperation.
(<https://www.unescap.org>)

UNEP Global Peatlands Initiative: Offers peatland mapping, water-table restoration tools, and haze prevention strategies focused on reducing peatland-driven haze.
(<https://www.globalpeatlands.org>)

VEA Viet Nam – Air Quality Portal: National platform delivering PM2.5 concentration maps, emission trends, and haze forecasting tailored for Vietnam’s air quality management.
(<https://www.iqair.com/vietnam>)

WHO Air Quality Data Portal: Global PM2.5 monitoring database, city-level pollution comparisons, and health impact assessments to inform haze mitigation policies.
(<https://www.who.int/data/gho/data/themes/air-pollution>)

WMO – Global Atmosphere Watch (GAW): Global aerosol and trace gas monitoring network providing critical long-range haze transport observations and air quality datasets.
(<https://community.wmo.int/site/knowledge-hub/programmes-and-initiatives/global-atmosphere-watch-programme-gaw>)

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) – Regional early-warning and forecasting platform for dust and aerosol transport, supporting transboundary particulate pollution monitoring across West, Central, and South Asia.
(<https://sds-was.aemet.es>)

4. Responses in Full

1. Md Selim Reza, System Analyst, Ministry of Finance, Bangladesh
2. Sohail Akhtar, Senior Scientist, Pakistan Council of Scientific & Industrial Research (PCSIR) Lab Complex, Karachi, Pakistan
3. Rushaa Badaloo, Analyst (Advocacy Economy Department) at the Mauritius Chamber of Commerce and Industry (MCCI), Research Scholar in Applied Statistics, Mauritius
4. Saeed Eshraghi, Head of Technology, Valuation and Documentation, Iranian Research Organization for Science and Technology, Tehran, Islamic Republic of Iran
5. Irum Tariq, Member Standing Committee (SC) for Smog and Climate Lahore Chamber of Commerce and Industry (LCCI), CEO at Exodus Green Pvt. Ltd., Pakistan
6. Prabhakar S.V.R.K., Principal Policy Researcher (adaptation) at Institute for Global Environmental Strategies (IGES), Yokohama, Kanagawa, Japan
7. Vinita Kumari, Individual Consultant, New Delhi, India
8. Dr Helena Varkkey, Associate Professor of Political Ecology, Universiti Malaya, Kuala Lumpur, Malaysia
9. Eric Zusman, Ph.D., Research Director, Center for Sustainability, Governance Institute for Global Environmental Strategies (IGES), Kanagawa, Japan
10. Sandhya, M.Sc Resource Management and Design Application, Specialization in Environment Management and Sustainable Development, University of Delhi, India
11. Inputs from APCTT
12. Inputs from APCTT
13. Inputs from APCTT

Responses:

1. Md Selim Reza, System Analyst, Ministry of Finance, Bangladesh

Bangladesh recognizes that transboundary haze poses serious public health, environmental, and economic risks, particularly in densely populated and industrially active regions. Effective monitoring and management require an integrated approach involving technology, governance, and regional cooperation.

Key Experiences and Practices:

1. Early Warning and Monitoring Systems:

- Deployment of satellite-based remote sensing and ground-level air quality monitoring stations to detect haze-prone areas.
- Integration of AI and predictive analytics to forecast haze events and pollutant dispersion patterns.

2. Regional Cooperation:

- Collaboration with neighbouring countries through data-sharing agreements, joint monitoring programs, and regional forums (similar to ASEAN's Haze Agreement framework) to enhance timely response.
- Participation in international knowledge-sharing platforms to adopt best practices for haze mitigation.

3. Policy and Regulatory Measures:

- Enforcement of stricter land-use policies, controlled burning bans, and sustainable agricultural practices to minimize haze sources.
- Promotion of cross-sectoral policies linking forestry, agriculture, energy, and disaster management agencies.

4. **Community Engagement and Awareness:**

- Public awareness campaigns highlighting health risks and preventive measures during haze events.
- Use of mobile alerts and digital platforms to inform citizens in real-time.

5. **Innovation and Technology Integration:**

- Incorporation of AI-driven remote sensing, IoT air quality sensors, and drone surveillance for real-time haze detection.
- Development of decision-support dashboards for authorities to coordinate timely interventions.

Outlook:

Bangladesh emphasizes that transboundary haze management requires a **multi-level approach combining technology, policy, and community participation**. Strengthening regional collaboration and sharing data, experiences, and innovative solutions will be key to reducing health risks and environmental impacts across the Asia-Pacific region.

2. Sohail Akhtar, Senior Scientist, Pakistan Council of Scientific & Industrial Research (PCSIR) Lab Complex, Karachi, Pakistan

Transboundary Haze Monitoring and Management in the Asia-Pacific Poses an international frontier and multi countries challenge to existing monarch idea-logy of national jurisdiction. It urges and necessitates international agreements not only limited to bilateral coordination for countries but unto a regional level to mobilize solution and disseminate key findings between the stake holders for transboundary pollution management and controlling its effect. Indeed, the regions like ASEAN, SAARC, GCC, PAN, Pacific Island, all have been in furious condition due to pollution hazards like haze, acidic rain, fog and many more, and all these include many cuts and control beyond borders. Yet legal frame work, regulation by agreement and policy, mutual trust among neighbor countries all are needed to be on inter government panel and via government support for any plan to be implemented with practical approaches.



3. Rushaa Badaloo, Analyst (Advocacy Economy Department) at the Mauritius Chamber of Commerce and Industry (MCCI), Research Scholar in Applied Statistics, Mauritius

Recent years have shown how air pollution in Asia and the Pacific has shifted from a localised issue to a regional one. PM_{2.5} peaks often coincide with crop-residue burning, long dry seasons, and changing wind patterns, which means national systems must now combine real-time monitoring with cross-border information flows.

Several technological advances have made monitoring more responsive. Low-cost sensor networks, supported by AI calibration models, are now used in many cities to supplement reference-grade stations. These sensors send data directly to national databases and public dashboards, providing street-level readings that were not available a few years ago. Satellite tools such as MODIS and VIIRS have also improved early detection of fire hotspots, helping track biomass-burning events that lead to haze episodes. Digital forecasting tools are becoming more reliable. Machine-learning models now integrate meteorological data with pollutant measurements to predict PM_{2.5} surges hours in advance. These systems help agencies issue health advisories and prepare emergency responses more effectively. Some countries have also introduced automatic shutdown systems in factories based on threshold breaches recorded by continuous emission monitors.

On the regional front, cooperation is growing, though at different speeds. The most active initiatives involve shared satellite-data platforms, coordinated enforcement days, and cross-border hot-spot verification teams.

There is also a shift toward shared emission inventories and uniform reporting standards. These help countries compare data, identify seasonal patterns, and align enforcement strategies. Some regions have created bilateral technical committees dedicated to haze episodes, allowing environmental, agricultural, and meteorological agencies to coordinate responses more quickly.

Newer partnerships are testing early-warning exchanges, where alerts on biomass-burning events or industrial upsets are passed across borders within hours. These systems rely on open APIs and cloud-based platforms, allowing both national agencies and local researchers to interpret the same information. The rise of citizen-science networks, linked to university laboratories, has strengthened public participation in monitoring and provided additional data during peak haze periods.

Experience across the region suggests that technology works best when paired with a culture of information-sharing. Reliable monitoring, open datasets, and clear communication protocols help countries act faster and reduce health impacts when haze crosses borders.

4. Saeed Eshraghi, Head of Technology, Valuation and Documentation, Iranian Research Organization for Science and Technology, Tehran, Islamic Republic of Iran

Transboundary haze in Iran refers almost exclusively to **Sand and Dust Storms (SDS)**, rather than the forest-fire smoke "haze" common in Southeast Asia. Monitoring and managing this issue are a top priority for Iran because a significant portion of the dust is "transboundary," originating from neighboring countries.

The "haze" in Iran is technically suspended mineral dust (particulate matter like PM10 and PM2.5).

- **External Sources (The Majority)**: Research indicates that roughly **%80-70** of SDS events in western and southwestern Iran originate outside its borders. The primary hotspots are in **Iraq**) dried wetlands and abandoned farmlands, (**Syria**, **Saudi Arabia**, and increasingly **Turkmenistan** and **Afghanistan** in the northeast.

Monitoring Systems

Iran's monitoring relies heavily on satellite data, as ground-based cross-border networks are not yet fully integrated with its neighbors.

- **Satellite & Remote Sensing:** This is the most effective tool currently used. The Iranian Space Agency and Meteorological Organization use data from satellites to track the formation and movement of dust plumes before they cross the border.
- **Ground Monitoring:** Iran has a domestic network of air quality monitoring stations in border provinces. However, these stations measure pollution *after* it arrives.
- **The Gap:** There is no real-time, shared data network with Iraq or Syria. Iranian officials have repeatedly called for a "regional early warning system," but as of late 2024/early 2025, this remains a goal rather than a fully functioning reality.

Management & Diplomacy

Iran has attempted to position itself as a regional leader in environmental diplomacy to solve this crisis, but results have been mixed.

- **Diplomatic Agreements (MoUs):** Iran has signed multiple Memorandums of Understanding (MoUs) with **Iraq, Syria, Kuwait, and the UAE**. These agreements theoretically cover knowledge exchange, joint technical committees, and soil stabilization projects.
- **The "Tehran Conference" (2023) & UN Resolutions:** In September 2023, Iran hosted an international conference on SDS, leading to a UN resolution. Iran proposed establishing a **regional organization** and a **regional fund** specifically for combating dust storms.

Now, for better conditions to improve our activities, we need Funding to rely on standard UN channels and diplomacy rather than a new, robust regional pot of money.

5. Irum Tariq, Member Standing Committee (SC) for Smog and Climate Lahore Chamber of Commerce and Industry (LCCI), CEO at Exodus Green Pvt. Ltd., Pakistan

Pakistan has national policies and programs (National Clean Air Policy / Pakistan Clean Air Programme) that set sectoral targets (brick kilns, transport fuel, industrial emissions) and encourage monitoring and smog management. The NCAP and related national documents push for upgrading brick kilns, controlling open burning and strengthening monitoring.

Punjab province, the Punjab Clean Air Program (PCAP) / Smog Mitigation Action Plan ,Punjab has launched a province-level program (Punjab Clean Air Program, PCAP) supported by a ~US\$300 million World Bank operation. Key, concrete measures in the approved PCAP/Smog Mitigation package include:

Expansion of regulatory-grade air quality monitoring across Punjab (adding more fixed stations and integrating sensor networks) to get higher spatial coverage; **Sectoral abatement measures:** procurement/support for ~5,000 “super-seeders” and alternative crop-residue management to reduce seasonal agricultural burning, retrofit and phase-out programs for brick kilns, actions on industrial and transport emissions; **Transport interventions:** support for 600 electric buses to shift modal share and reduce vehicular emissions; **Strengthening lab capacity:** establishing/enhancing fuel testing labs and institutional capacity for enforcement and inspections; **Public awareness, early warning and smog action plans** (operational Smog Mitigation Action Plan with seasonal response measure) **Monitoring & early-warning specifics for Punjab**, The PCAP explicitly finances expansion of regulatory air-quality stations and integration of monitoring, plus investments in information systems for public alerts and decision support i.e., better data feeding into early-warning and smog-action triggers. The Smog Mitigation Strategy and PCAP documents identify data-driven triggers for temporary measures (traffic restrictions, construction controls, advisories) during high-pollution episodes.

On-the-ground mitigation pilots- The program also finances deployment of crop-residue equipment (super-seeders), electrification of bus fleets, brick-kiln upgrades and other targeted investments that reduce emissions at source, all measures that lower the frequency and intensity of winter smog and agricultural-burning episodes.

Cross-border / transboundary aspects for Pakistan, the World Bank PCAP analysis acknowledges transboundary contributions (it estimates a share of PM_{2.5} originates outside Punjab) and emphasizes regional airshed approaches, but Pakistan currently relies mostly on scientific data (satellite products, modeling) and multilateral platforms for attribution rather than formal cross-border enforcement agreements comparable to ASEAN's AATHP. In practice, Pakistan's strategy combines domestic source control (agriculture, transport, industry, brick kilns) with better monitoring and modeling to understand and communicate transboundary influence.

Push data sharing with neighbours through technical channels (shared use of satellite/forecast products, joint workshops and scientist-to-scientist exchange) even if formal legal mechanisms are limited, it's faster and builds the evidence base for later policy coordination.

Q: Dear members, thanks for your comments. I am wondering if there are any inter-governmental mechanisms for planning for and resolving trans boundary haze and pollution. Any inputs from members?

ASEAN Agreement on Transboundary Haze Pollution (AATHP) is an inter-governmental mechanism for planning for and resolving trans boundary haze and pollution.

-The **first legally binding regional agreement** of its kind (in force since 2003).

-Focuses on **prevention, monitoring, early warning, and emergency response.**

-Includes mechanisms like:

1-Regional haze monitoring systems

2-Joint emergency response

3-Information and data sharing

4-Challenges remain around **enforcement and national implementation,** but it is still the most structured model globally.

6. Prabhakar S.V.R.K., Principal Policy Researcher (adaptation) at Institute for Global Environmental Strategies (IGES), Yokohama, Kanagawa, Japan

I will address these questions using my experience of Delhi, and these experiences can provide valuable insights into how countries are combating transboundary haze on both technological and political fronts. These experiences are also applicable elsewhere. I think the first step is to recognise that transboundary haze is the problem behind the local pollution experienced, and that is where producing sufficient technical evidence matters.

1. Advances in technology and innovative air-pollution control systems in the Asia-Pacific region. India's experience, especially in Delhi, shows how recent technological advancements are changing PM2.5 and transboundary haze monitoring throughout the Asia-Pacific. Delhi now uses extensive networks of affordable sensors, ISRO's satellite-based fire and aerosol tracking, real-time forecasting via SAFAR, and AI-driven alerts for stubble-burning incidents, all of which provide strong evidence of local pollution sources and effects. Similar innovations are being implemented across the region: ASEAN countries are enhancing remote-sensing systems, hotspot detection tools, digital fire-risk dashboards, and online emission-reporting platforms to improve monitoring of industrial pollution, agricultural burning, and long-range haze transport. These technologies improve the accuracy of early warnings and aid in quicker, targeted mitigation, although India's experience indicates that their success still relies significantly on enforcement and cooperation across jurisdictions. I believe these experiences and technologies are scalable throughout the region and applicable elsewhere.

2. Enhancing cross-border collaboration in the Asia-Pacific to tackle transboundary air pollution. Delhi's haze events, often affected by pollution from neighbouring states, show the need for joint governance to address transboundary air pollution. In India, air-shed

management discussions, coordinated stubble-burning control initiatives, and shared monitoring systems among Delhi, Punjab, Haryana, and Uttar Pradesh illustrate how data sharing and collective enforcement can lead to better results. Regionally, similar initiatives are developing throughout the Asia-Pacific: the ASEAN Agreement on Transboundary Haze Pollution has bolstered institutional collaboration, while nations are increasingly implementing bilateral data-sharing systems for hotspot alerts, emission inventories, and seasonal haze predictions.

New regional projects backed by UNESCAP and other organisations are encouraging standardised monitoring practices, cooperative early-warning systems, and coordinated mitigation efforts. Collectively, these actions emphasise that strong cross-border collaboration, rooted in clear data sharing and synchronised enforcement, is crucial for lessening the intensity and frequency of transboundary haze.

Having said this, I must also say that I am not very optimistic about the possible effectiveness of any regional cooperation in addressing transboundary haze or for that matter, on any environmental issue that we are facing today, and we have ample evidence for it. This is because each country tends to prioritise its own short-term interests. Like in the Prisoner's Dilemma, countries often gain more by delaying action, under-reporting emissions, or shifting responsibility, while hoping neighbours will act first. Past examples, from river pollution control to regional fisheries management, show that even well-designed agreements struggle when enforcement is weak and trust is low. Without strong incentives and credible monitoring, countries may cooperate on paper but not in practice. This makes optimism difficult, even though cooperation remains essential.

7. Vinita Kumari, Individual Consultant, New Delhi, India

Air pollution in the Asia-Pacific region increasingly reflects transboundary dynamics, where emissions generated in one location affect air quality far beyond political borders. According to the WHO

World Air Quality Report 2024, over 97% of cities in the region exceed recommended PM_{2.5} limits, making haze a shared public-health and climate challenge rather than a localised environmental issue.

For instance, Delhi's recurring winter haze represents one of South Asia's most studied examples of transboundary air pollution. Scientific studies consistently show that post-monsoon crop residue burning in Punjab and Haryana, combined with local emissions and unfavourable meteorology, leads to extreme PM_{2.5} concentrations in Delhi between October and December. Atmospheric modelling published in *Nature Communications* confirms that during peak episodes, regional agricultural fires can contribute 30-50% of PM_{2.5} levels in Delhi, highlighting the regional nature of the problem rather than a city-only failure.

Satellite observations from MODIS and VIIRS have documented tens of thousands of fire incidents annually across northwest India during harvest seasons. Research in *Science of the Total Environment* demonstrates that smoke plumes from these fires are transported across state boundaries into Delhi-NCR within 24–72 hours under prevailing wind conditions. Despite policy interventions, economic constraints faced by farmers, limited alternatives, and uneven enforcement continue to sustain this practice.

In this regard, India has made significant progress in monitoring haze through the SAFAR (System of Air Quality and Weather Forecasting and Research) platform, developed by IIT Madras under the Ministry of Earth Sciences. SAFAR integrates satellite data, emissions inventories, and meteorological models to provide 72-hour air-quality forecasts, supporting proactive measures such as the Graded Response Action Plan (GRAP). These systems reflect best practices in science-policy integration but remain largely national in scope.

Apparently, the global scientific literature confirms that biomass burning emissions can travel thousands of kilometres, contributing to background aerosol concentrations across continents. A landmark Nature study (2023) quantified the global health burden of fire-sourced PM_{2.5}, noting Africa as the world's largest contributor to biomass burning emissions. However, it is important to clarify that no peer-reviewed evidence directly attributes a specific recent African fire event as the primary cause of Delhi's pollution episodes. Instead, African fires contribute to hemispheric background aerosol loading, which can compound regional pollution under certain atmospheric conditions.

Additionally, countries such as Nepal and Bangladesh experience similar seasonal haze patterns linked to transboundary transport from the Indo-Gangetic Plain. Remote sensing and trajectory analysis published in Remote Sensing (MDPI) show that emissions from northern India influence winter PM_{2.5} levels in Kathmandu Valley and parts of Bangladesh, reinforcing the need for air-shed-based governance rather than national silos.

Further, technological interventions across India include in-situ crop residue management tools such as Happy Seeders, bio-decomposer sprays, and residue-to-bioenergy pathways. Evidence from Punjab indicates that sustained incentives and machinery access reduce fire counts, although scale remains a challenge. Low-cost sensor networks and AI-enabled source apportionment pilots are improving spatial understanding of pollution, while satellite-model integration is strengthening early warning capabilities.

Unlike Southeast Asia's ASEAN Transboundary Haze Agreement, South Asia lacks a formal, binding framework for haze management. Current cooperation remains limited to data sharing among meteorological agencies and ad-hoc scientific collaboration. The absence of harmonised emission inventories, shared response triggers, and joint enforcement mechanisms limits collective effectiveness.

The way forward to address transboundary haze requires regional airshed governance, shared early warning thresholds, and coordinated response actions. Investments in clean agricultural transitions, regional data platforms, and climate-aligned financing mechanisms are essential. Integrating haze into disaster risk reduction and climate resilience planning rather than treating it solely as an environmental issue can significantly strengthen preparedness and response across the Asia-Pacific.

8. Dr Helena Varkkey, Associate Professor of Political Ecology, Universiti Malaya, Kuala Lumpur, Malaysia

1) Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.15/MenLHK/Setjen/Kum.1/2/2017 requires companies with fire-prone peatland concessions to install water table monitors, with data loggers compiling and transmitting data to the government, however there are limitations to real-time reporting.

2) In ASEAN, the newly introduced Roadmap (2023-2030) supports the operationalisation of the ASEAN Agreement on Transboundary Haze Pollution. It is aligned with the ASEAN Peatland Management Strategy (2023- 2030), where peatland management is an important part of haze mitigation in the region. Of particular importance in the roadmap is the process of establishing the ASEAN Coordinating Centre for Transboundary Haze Pollution Control (ACC THPC), which has been pending for many years. There is also the ASEAN Specialised Meteorological Centre (ASMC), based in Singapore, which has an important role in regional early warning and reporting. It also serves as a support system for other ASEAN countries with less advanced meteorological capabilities. However, discrepancies between national meteorological data and ASMC data has complicated coordination.

Way Forward: A standardised Air Quality Index across ASEAN would be useful in ensuring that all ASEAN countries are interpreting the issue of air (haze) pollution in the same way, with similar parameters and definitions. Currently each country has its own air quality index, which means they are not speaking the same language when it comes to air pollution mitigation.

9. Eric Zusman, Research Director, Center for Sustainability, Governance Institute for Global Environmental Strategies (IGES), Kanagawa, Japan

1) When it comes to forest and land fires, I think we have seen progress with stronger enforcement mechanisms in some parts of the Southern Mekong and provisions of carbon finance and alignment between climate pledges that have generated incentives for sustainable forestry. In the Northern Mekong region, we have seen some progress with the adoption of circular economy models for the productive use of biomass (that have discouraged open burning of agricultural residues). Companies that purchase rice have also encouraged farmers to curtail burning and have provided stronger incentives for non-burning crops and sustainable use of rice straw. In all regions, advances in satellite monitoring have helped to assess progress and track hotspots.

2) On a regional/subregional basis, countries in ASEAN agreed to a new haze free roadmap in 2024 that outlines a series of nine strategies that are intended to help the region eliminate haze from land and forest fires. The roadmap includes targets related to PM2.5 concentrations and have provisions encouraging countries to work across different sectors and levels of decision making to reach its targets. ASEAN has also adopted an investment framework to attract resources to help implement the roadmap. Finally, we are seeing some evidence of subregional cooperation under, for instance, Thailand's Clear Sky Strategy.

10. Sandhya, M.Sc Resource Management and Design Application, Specialization in Environment Management and Sustainable Development, University of Delhi, India

India is addressing haze and PM_{2.5} through a mix of national policy, monitoring, and emergency controls, with the National Clean Air Programme (NCAP) as the backbone, targeting up to a 40% reduction in particulate pollution by 2026 across 130+ polluted cities. The government has expanded real-time air quality monitoring through the Central Pollution Control Board, making PM_{2.5} data publicly available and actionable. In high-pollution regions like Delhi-NCR, the Graded Response Action Plan (GRAP) triggers automatic measures—such as construction bans, vehicle restrictions, and industrial shutdowns—when air quality deteriorates. India has also tightened vehicle emission standards (BS-VI), promoted electric vehicles, regulated brick kilns and industries, and taken steps to reduce crop-residue burning through subsidies and enforcement. While seasonal haze remains a challenge, especially in northern India, studies by CPCB, World Bank, and independent researchers show that cities implementing NCAP and GRAP measures have begun to see measurable PM_{2.5} reductions, indicating that India’s approach is shifting from reactive crisis management toward longer-term, data-driven air quality governance.

11. Inputs from APCTT

Dear Members,

Thank you very much for your nuanced responses. I wish to add a few points directly in answer to the two questions asked to strengthen our response to Ms. Irum.

Question 1 : Technological advancements and innovative air-pollution control systems

As members responses have shown, air quality management is slowly evolving from discrete monitoring systems to integrated regional structures. Satellite-based fire data are now regularly combined with emission and atmospheric transport models to generate 72-to-96-hour smoke and PM_{2.5} forecasts, and disseminated through national meteorological agencies and regional air-quality networks.

The increased deployment of low-cost PM_{2.5} sensor networks, integrating AI-based calibration and data integration, has enhanced the coverage of monitoring and capability of countries to credibly tag haze episodes to regional biomass burning. Simultaneously, industrial emissions and stubble burning are being addressed through innovations such as biodecomposers and waste-to-energy technologies.

I feel the technological response should be seen as an end-to-end sequence from fire detection to emission estimating to plume modelling to local exposure mapping and the mitigation measures to be enforced.

Question 2: Regional Cooperation examples

Significant among the regional frameworks would be the [ASEAN Agreement on Transboundary Haze Pollution \(2002\)](#) and the [Second Haze-Free Roadmap \(2023–2030\)](#). Sadly, South Asia does not have such a regional framework, even as collaboration on shared airsheds and scientific analyses of trans boundary PM_{2.5} contributions has increased. The next logical step would be to put in place streamlined standards, regular emission inventories and inter-country data sharing.

In this context, the Geo-Informatics and Space Technology Development Agency ([GISTDA](#)) project may merit a mention. The project integrates MODIS and VIIRS data sets with aerosol indices and ground data to create real-time maps of stubble burning and movement of haze across boundaries. these are helpful to create cross-create haze management plans especially in the Greater Mekong Region.

Some more additional points that need to be mentioned on the topic:

- a. The critical role that civil society-based monitoring is playing in creating awareness and strengthening policy based on ground reality.
- b. Financing: As always, we come across the bottlenecks in financing of sustainable management interventions such as restoration of peatlands, climate smart agriculture and transition to low carbon technologies.
- c. Standardisation and inter-operable data sets and structures for smoother cooperation to meet [WHO Air Quality Guidelines](#) on air pollution.

Thank you

12. Transboundary haze in the Asia-Pacific mainly comes from forest, peatland, and farm fires. The smoke crosses borders, harming air quality, health, ecosystems, and economies. Multilateral frameworks like the ASEAN Agreement on Transboundary Haze Pollution (AATHP) exist, but the challenges remain to be effectively addressed. These include weak governance, lack of binding enforcement, slow response, and uneven technical capacity for fire detection, air monitoring, and early warnings.

Nevertheless, there are promising initiatives at the regional and national level to address the challenges of transboundary haze:

- The ASEAN Specialised Meteorological Centre (ASMC) provides daily hotspot and weather analyses.
- The ASEAN Haze Portal shares data and guidance.
- The Second ASEAN Haze-Free Roadmap (2023–2030) focuses on prevention through sustainable land use, cross-sector coordination, and financing.
- Singapore enforces its Transboundary Haze Pollution Act.
- Indonesia has stepped up actions against illegal burning.
- Malaysia and others are improving monitoring and preparedness.

Overall, effective haze management requires strong national measures combined with regional cooperation. Progress has been made in monitoring and early warning, but enforcement, data sharing, and investment in sustainable land and peatland management remain key gaps.

13. Transboundary haze creates major economic costs across the Asia Pacific region that goes far beyond environmental damage. World Bank and government assessments show that the 2015 haze crisis in Indonesia alone caused economic losses of about USD 16 billion. Regional models further indicate that annual losses from health impacts, tourism disruption, aviation delays, and agricultural damage now reach tens of billions of dollars across South and Southeast Asia. These costs are not evenly distributed. Small and medium enterprises bear a disproportionate burden, especially in tourism and agriculture. Tourism-dependent cities such as

Chiang Mai have seen sharp drops in hotel occupancy during severe haze episodes. At the same time, agricultural supply chains in Malaysia and Indonesia face repeated disruptions due to fire bans and land-use restrictions.

From my perspective, this economic dimension is still underrepresented in many haze management discussions, even though it is highly relevant for mobilizing private sector engagement and investment.

Role of the Private Sector in Haze Mitigation

Available evidence shows that private actors are playing a growing role in haze mitigation through supply chain controls, operational responses, and digital tools.

- Large agribusiness companies have adopted satellite-based monitoring and traceability systems to support zero-deforestation commitments. Company disclosures and independent assessments indicate that these measures have led to substantial reductions in fire incidents within monitored concession areas.
- Several plantation firms have set up dedicated fire response units with trained staff, drones, and early warning systems. These efforts have reduced response times during fire outbreaks and helped limit haze spread during peak dry seasons.
- In tourism and service sectors, technology firms have partnered with hotels and workplaces to provide real-time indoor air quality monitoring. These tools guide operational decisions during haze periods and help protect worker health while maintaining business continuity.

I believe these examples show that the private sector can make a meaningful contribution when economic incentives align with environmental outcomes.

Financing and Incentive Mechanisms

Recent developments also point to emerging financing mechanisms that connect haze reduction with private investment.

- Indonesia has introduced peatland restoration credits under its carbon market framework. These credits direct private finance toward rewetting degraded peatlands, which are a major source of transboundary haze in Southeast Asia.
- Results-based incentive programs backed by development banks have compensated farmers for adopting zero-burning practices. Similar approaches have supported mechanized residue management in parts of Viet Nam and show potential for broader regional adoption.

At the same time, available evidence suggests that these mechanisms remain limited in scale and unevenly implemented across countries.

Opportunities for Further Action

Based on observed data and regional experience, I see several opportunities to strengthen haze management efforts.

- Developing standardized tools to quantify the economic and health costs of haze could strengthen policy advocacy and investment decisions at regional forums.
- Platforms that encourage voluntary private-sector commitments to haze-free supply chains could complement existing regulatory measures.
- Targeted support for SMEs, including access to affordable air quality monitoring and risk-reduction tools, could improve resilience in the most affected sectors.

In my view, integrating economic cost assessment with private sector incentives into transboundary haze strategies would strengthen existing government-led monitoring and cooperation efforts. It would also help convert early warning systems into sustained and effective mitigation outcomes.

Many thanks to all who contributed to this query!

The Community of Practice on Climate Technologies aims to foster technology cooperation and transfer through enhanced knowledge exchange and cross-border collaboration in Asia Pacific.

If you have further information to share on this topic, please send it at apctt@un.org.

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This Consolidated Reply is a systematic compilation of all responses received and additional desk research. It has been compiled by the Research Team at APCTT: Pankaj Kumar Shrivastav, Programme Management Officer, APCTT and Jigyaa, Intern, APCTT.



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