

Building an air quality management strategy for Hanoi

Part A – a multi-sector atmospheric emission inventory

Part B – selecting a fit-for-purpose dispersion modelling platform

Agenda

- 01 Hanoi's air quality
- 02 Part A – building the emission inventory
- 03 Part B – from inventory to dispersion modelling
- 04 Platform selection

Ambient PM_{2.5} in Hanoi

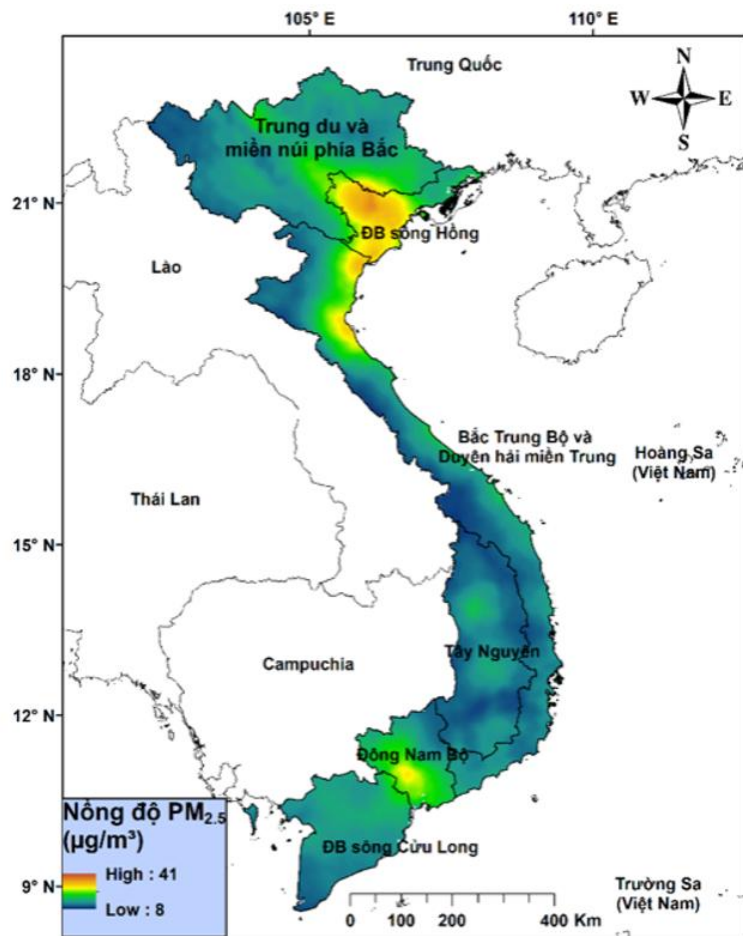


Figure: annual average PM_{2.5} across Vietnam, 2021
(VNU-UET, Live & Learn & USAID 2021)

46–49

µg/m³ annual average
across urban Hanoi

3.2 M

residents above 45 µg/m³
40% of the city

10×

the WHO annual
guideline of 5 µg/m³

- National standard 25 µg/m³ (QCVN 05:2023/BTNMT). Hanoi sits at roughly double.
- Decision 1142/QĐ-UBND commits the city to a 20% cut by 2030.

PART A

A multi-sector atmospheric emission inventory for Hanoi

PM₁₀, PM_{2.5}, SO₂, NO_x and CO from point, area and mobile sources

Inventory approach

- REAS and EDGAR-HTAP resolve no finer than 1 km
- Population-density proxies miss local conditions
- Motorcycles exceed 90% of the fleet, many pre-Euro to Euro 2
- Global defaults undervalue their real-world emission rates

Hybrid approach

Bottom-up

Traffic links and large point sources, from road camera counts and stack telemetry

Top-down

Residential combustion and open burning, allocated from fuel and activity statistics

Source categories and data strategies



Mobile

Road transport

- Road network from OpenStreetMap, motorways to tertiary collectors
- Traffic counts from four municipal studies
- Five vehicle classes; heavy vehicles banned from the centre at peak



Stationary

Industry and power

- Point registry of industrial and utility installations
- Field audits at 50 major installations, CEMS cross-referenced
- Minor facilities from secondary reports and JICA manuals



Area

Dispersed sources

- 400-household fuel-use survey, urban and rural strata
- Rice-straw burning from crop acreage and land-use maps
- Construction, quarrying and open waste burning
- 20 of 1,350 registered craft villages surveyed

Over 90% of the fleet is two wheeled



- Pre-Euro to Euro 2 engines dominate the fleet
- Population-weighted proxies cannot reproduce counts at this scale

8.8 M

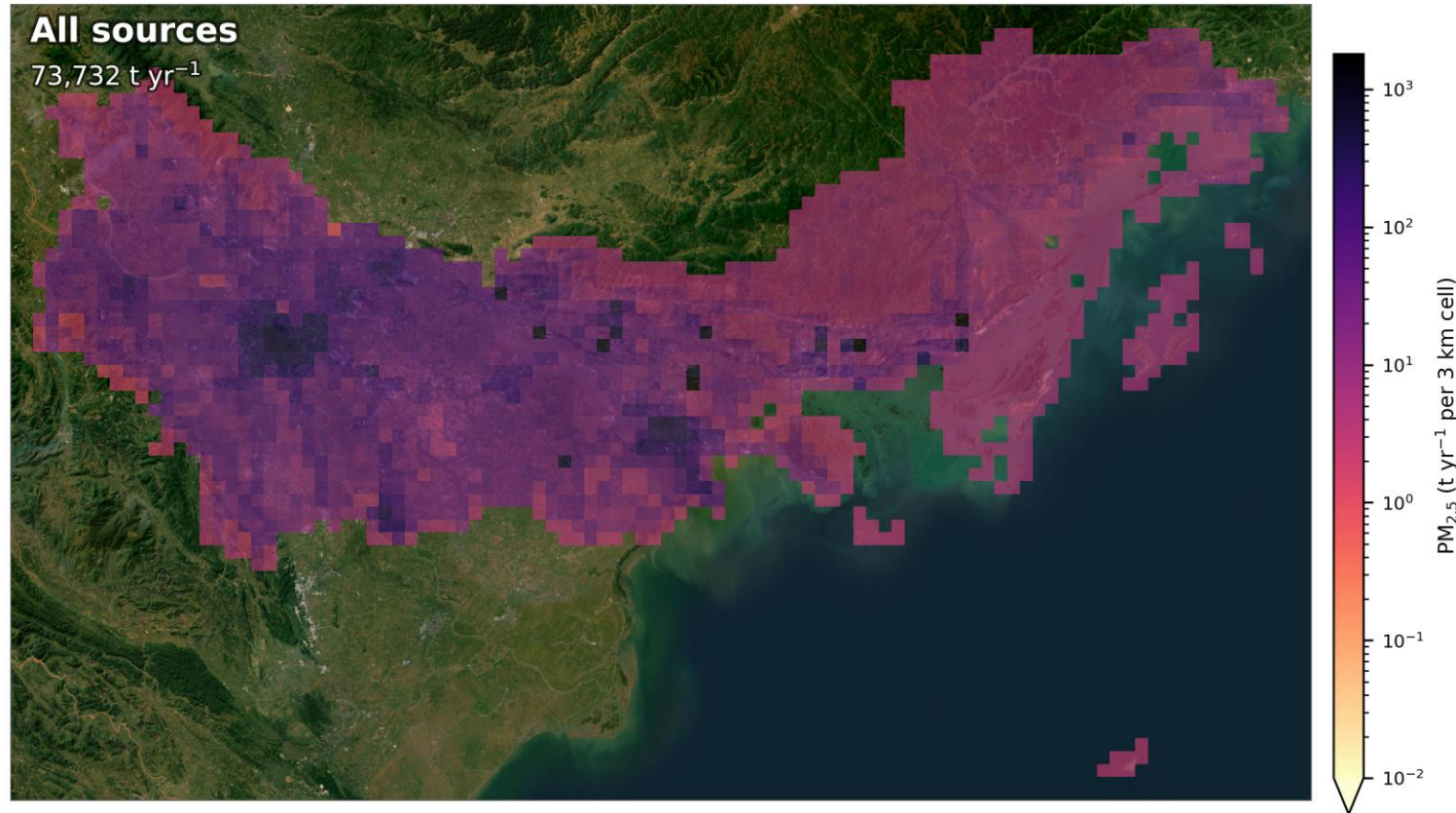
Residents of Hanoi

6.9 M

Motorbikes and scooters
in the fleet

Time-lapse: Hanoi street traffic, 2 and 3 June 2026, accelerated six times

The Hanoi PM_{2.5} Inventory



Data: INEST / Vietnam Air Pollution Map (HUST), 3 km grid, 2023 | Imagery: Esri World Imagery (Esri, Maxar, Earthstar Geographics)

PART B

From inventory to dispersion modelling

What the inventory supports, and which platform to use

Air quality management framework

Vietnam's national guidelines (Document No. 3051/BTNMT-TCMT) set out four stages.



Target: 20% reduction in annual average PM_{2.5} by 2030

Source apportionment and chemistry

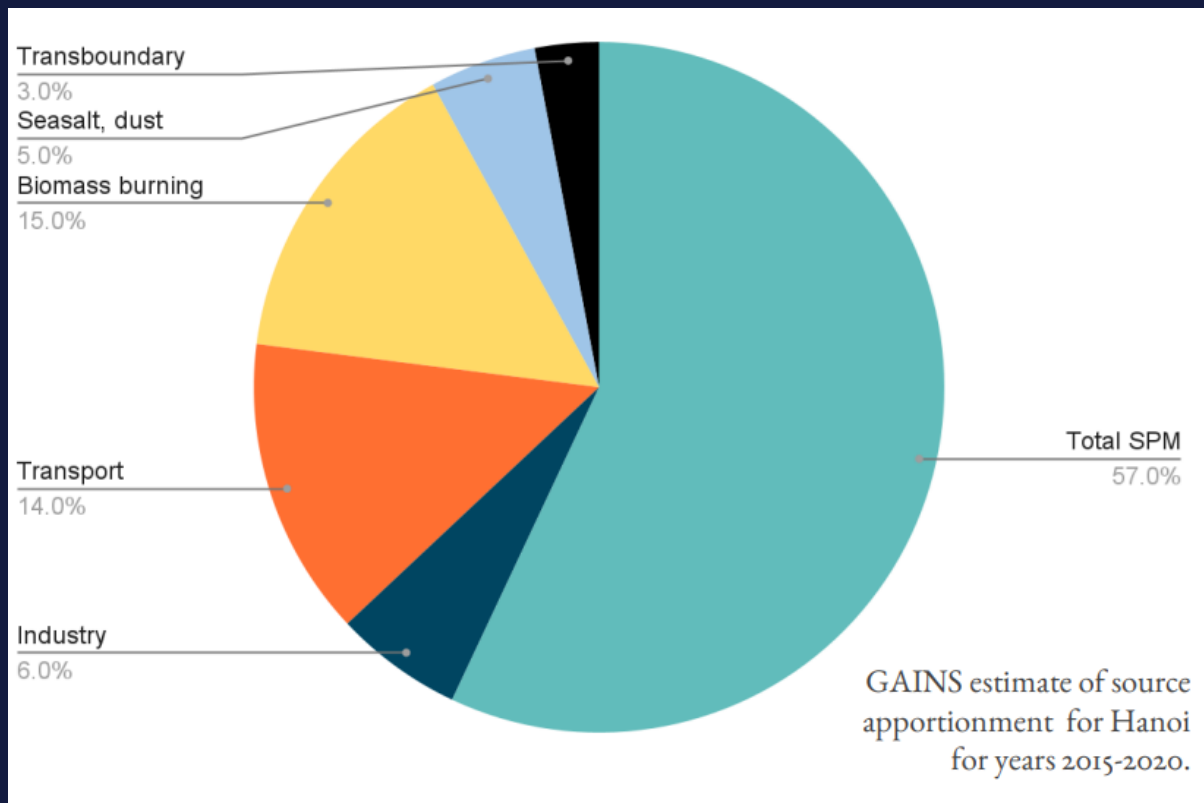


Figure: GAINS estimate of PM source apportionment for Hanoi, 2015–2020 (World Bank 2021)

Secondary inorganic aerosol

Viable now. The inventory carries disaggregated SO_2 , NO_x and NH_3 , so ISORROPIA II can compute sulfate, nitrate and ammonium.

Photochemical ozone

Constrained. VOCs and non-methane hydrocarbons are missing for some categories, so the VOC/ NO_x ratio is incomplete.

Regional haze originates outside the city boundary, so local chemistry needs a nested regional domain.

Platform capability comparison

	Peak Conc.	Near-field	Src. Apport.	Chem. Fdbks.	Met Coupling	Lic. Free
ADMS-Urban	●●	●●●	●●	●	○	●
EPISODE-CityChem	●●	●●●	●	●●	○	●●●
CAMx	●●●	●●	●●●	●●●	○	●●●
CMAQ ★	●●●	●●	●●●	●●●	●●	●●●
WRF-Chem	●●●	●●	●●	●●●	●●●	●●●
CHIMERE	●●●	●	●●	●●●	●●	●●●

●●● Full ●● Good ● Partial ○ None

Lic. Free: ●●● = open source / no fee ● = commercial licence required

- Criteria: chemistry, resolution, source apportionment, near-road gradients, boundary conditions, cost
- ADMS-Urban has strong near-field but cannot absorb regional background
- WRF-Chem couples meteorology inline but offers no sub-grid roads or source tagging
- CMAQ v5.4 fits Hanoi objectives best and is open source

Table 1: capability matrix, urban dispersion platforms

Nested WRF-CMAQ vs CHIMERE

Multi-scale nested grid

Domain 1 – 9 km

- Southeast Asia and northern Vietnam: long-range chemistry and transboundary transport

Domain 2 – 3 km

- Red River Delta: meteorological nesting step

Domain 3 – 1 km

- Hanoi urban core: full chemistry, plus RLINE sub-grid roads and Plume-in-Grid stacks

CHIMERE limitations

Near-field

CMAQ has RLINE for near-road gradients and Plume-in-Grid for stacks. CHIMERE dilutes both across a whole grid cell.

Source apportionment

CMAQ-ISAM tags sectors inline in one run. CHIMERE needs one extra run per sector, and non-linearity makes the result order-dependent.

What-if queries

CMAQ-DESID scales sectors for scenarios without reprocessing.

Conclusions

- Hanoi has a reproducible multi-sectoral emission baseline
- No single sector delivers the 2030 target
- A nested WRF-CMAQ system suits the data available
- Ozone stays constrained until VOC speciation is developed; secondary inorganic aerosol can proceed now
- ISAM and DESID run-time modules let regulators test interventions without rebuilding the inventory



Thank you

Questions and discussion welcome

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