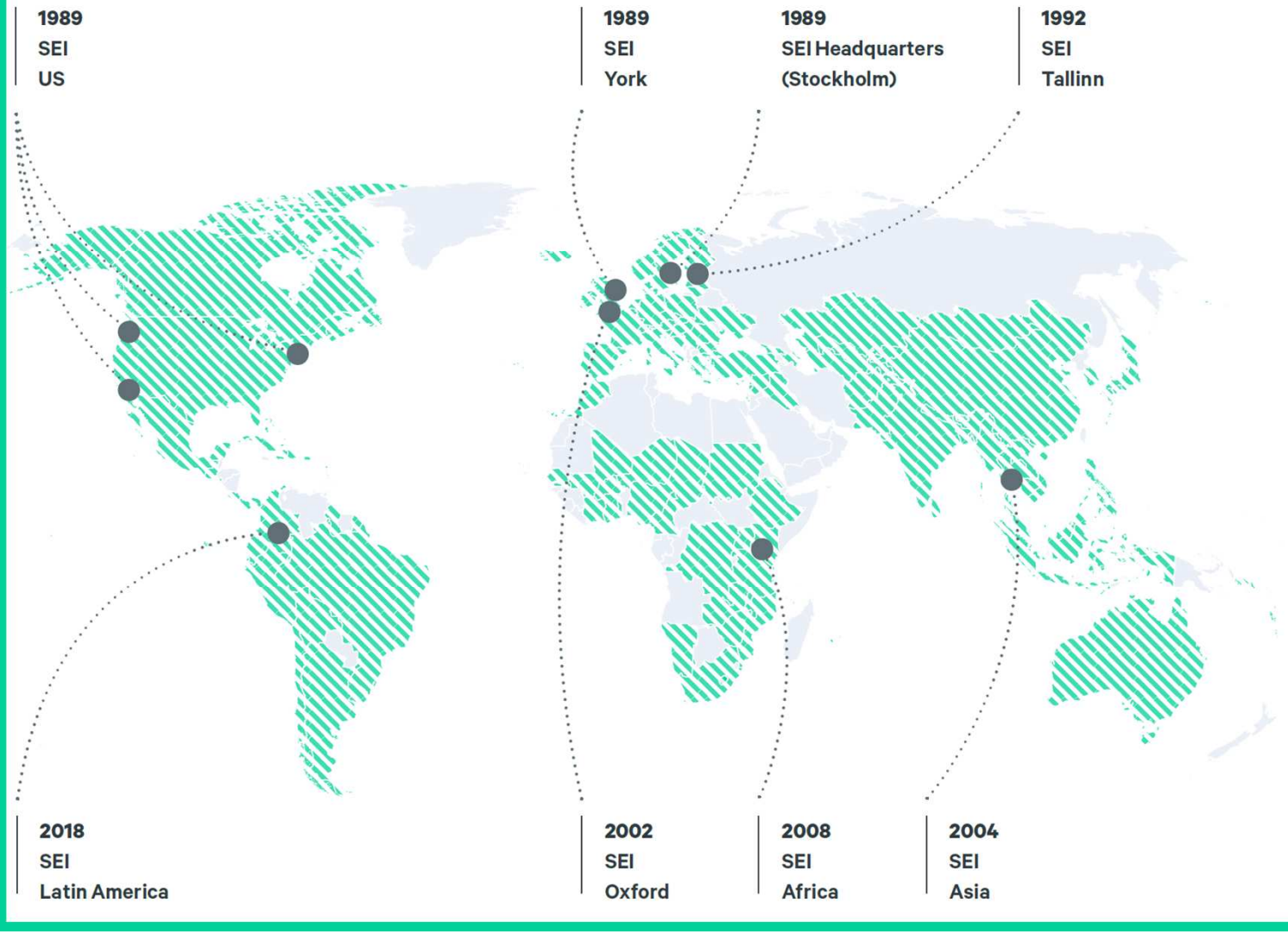
LEVERAGING ON AIR QUALITY MONITORING AND DATA MANAGEMENT TO DRIVE EVIDENCE BASED POLICY AND ACTION

NGONGANG WANDJI DANUBE KIRT
RESEARCH FELLOW
SEI AFRICA

SEI Stockholm Environment Institute

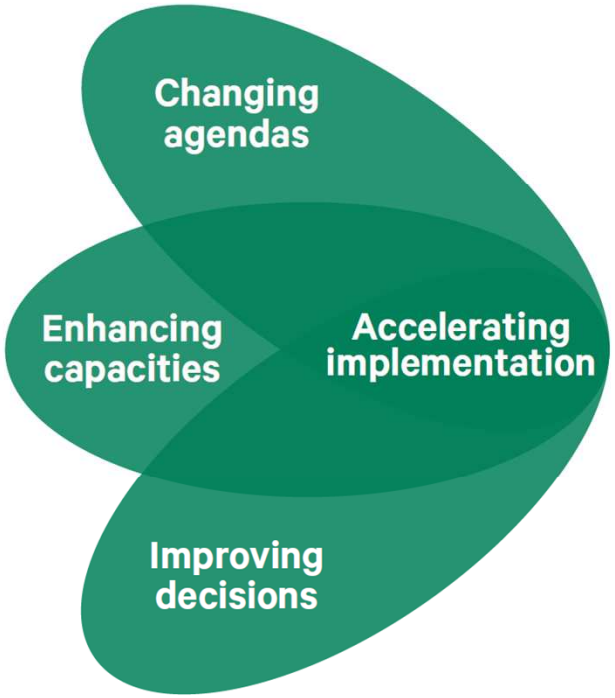
SEI'S ORIGIN AND MANDATE



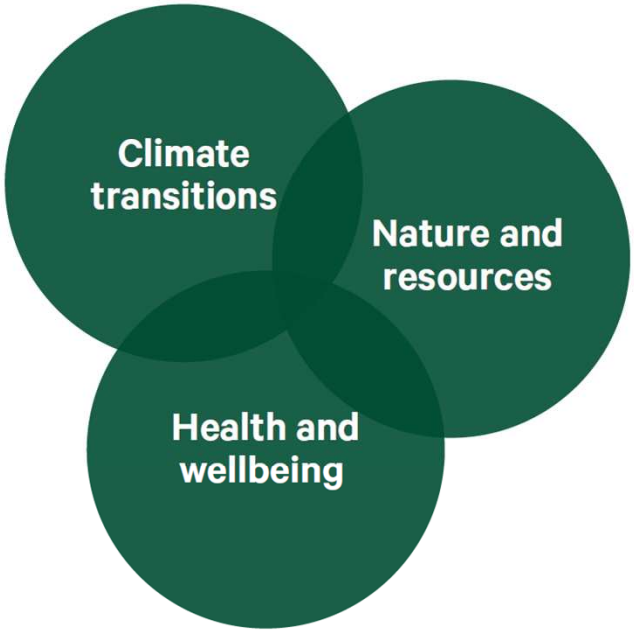
Outputs

- Scientific research
- Tools and data
- Knowledge co-production
- Networks
- Training and education
- Policy and practitioner engagements
- Communications
- Media

Outcomes



Impact



Enablers

Scientific excellence	Trusted partnerships	Operational excellence	Communications for impact
Societal relevance	Financial resilience	Competence and culture	One SEI

SEI Africa Programmes

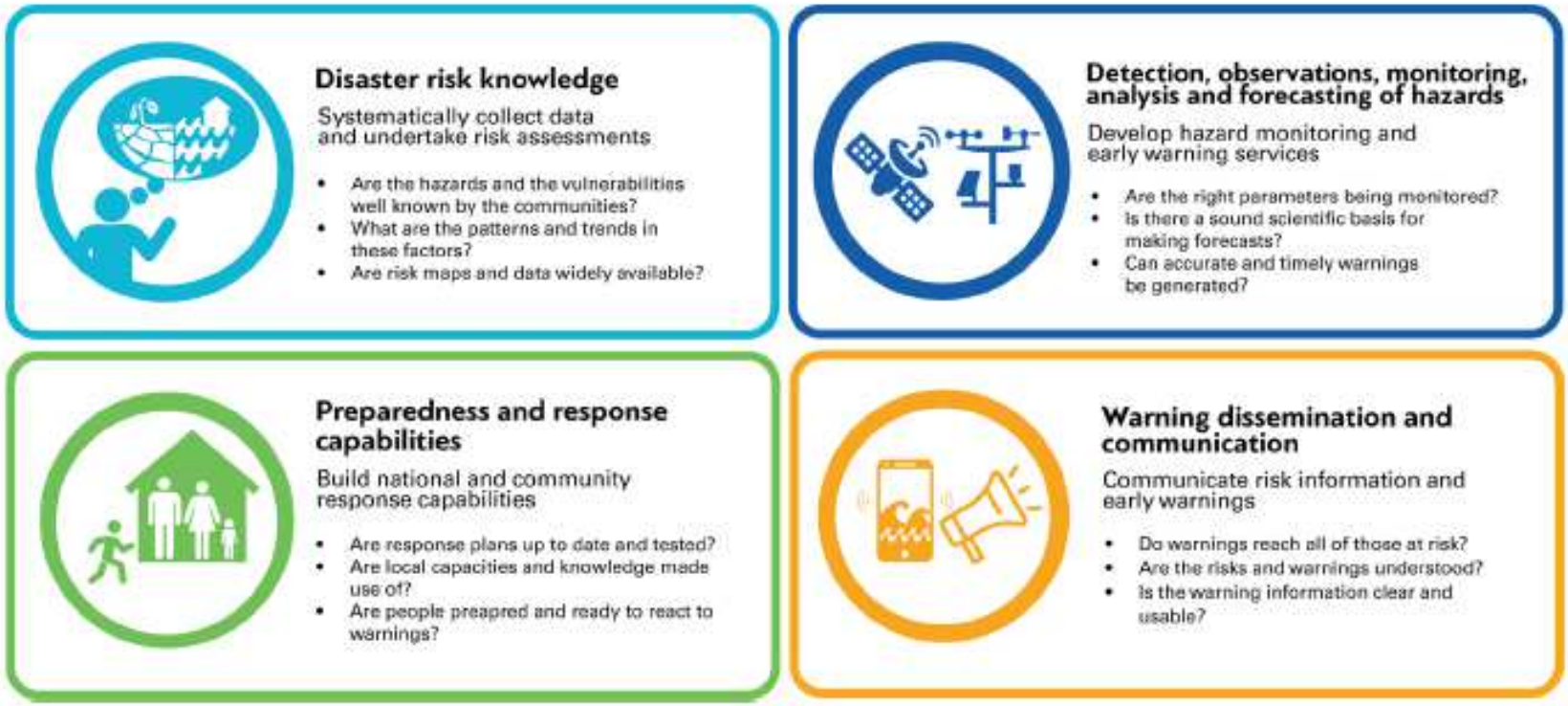
- Energy and Climate Change
- Sustainable Urbanisation
- Natural Resources and Ecosystems

Flagship Projects

- Bioeconomy for Sustainable Development
- Science for Environment and Climate Diplomacy


Photo credit: Getty / yimwow

EARALY WARNING FOR ALL INITIATIVE



GLOBAL ATMOSPHERIC WATCH

The WMO Global Atmosphere Watch (GAW) Programme

GLOBAL ATMOSPHERE WATCH

Advance and enhance science, services and infrastructure related to atmospheric composition, and support policies for society through applied research aimed at improving the understanding of the roles of aerosols, reactive gases, stratospheric ozone and greenhouse gases and their interactions in the Earth System

WORLD METEOROLOGICAL ORGANIZATION

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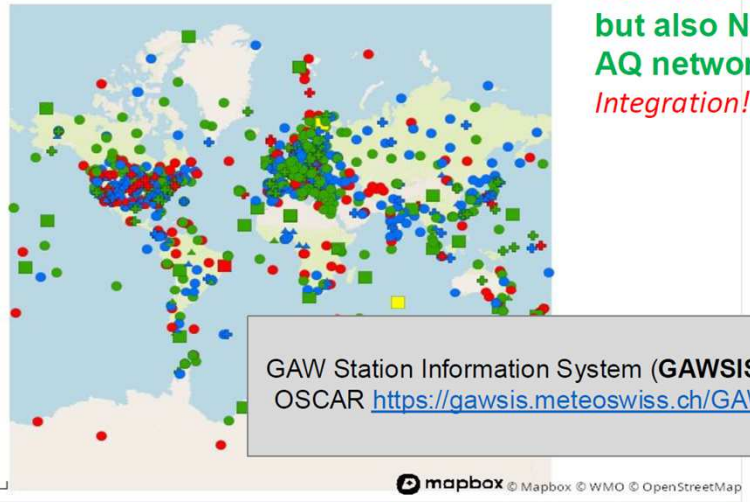
Monitoring Research Infrastructure

*Strengthen the atmospheric composition measurement and data infrastructure and contribute to **understanding trends and variability and extremes.***

- More than 200 parameters
- Intercomparisons
- Measurement guidelines
- World Data Centers

Open access with emphasis in QA and QC



GAW Station Information System (**GAWSIS**) part of OSCAR https://gawsis.meteoswiss.ch/GAWSIS/#/

Filling gaps:
LCS and satellites, but also National AQ networks
Integration!

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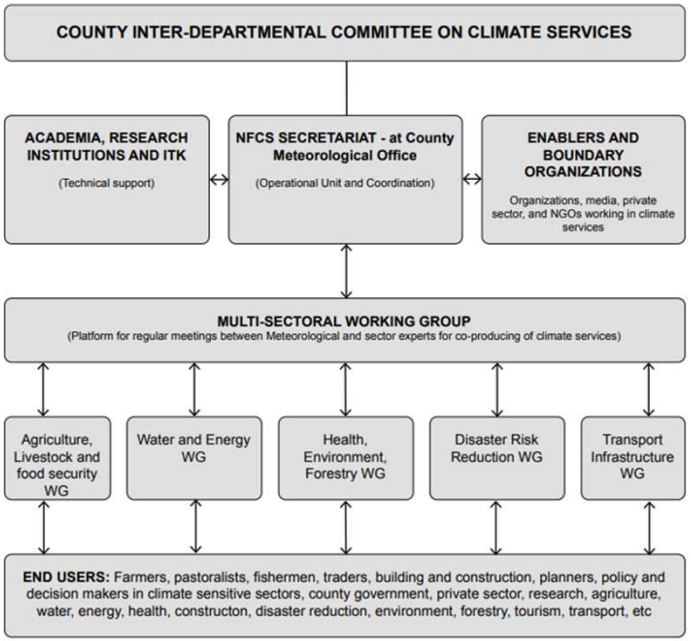
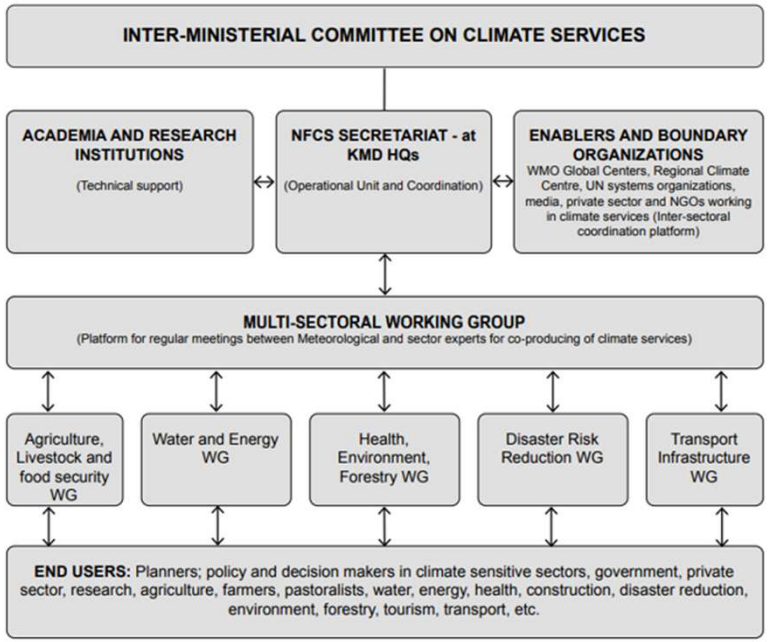
NATIONAL FRAMEWORK CLIMATE SERVICES



CAN WE IDENTIFY THE INTERSECTION OF AIR QUALITY DATA AND CLIMATE SERVICE INFORMATION?



NFCS COUNTY STRUCTURE

NFCS NATIONAL STRUCTURE

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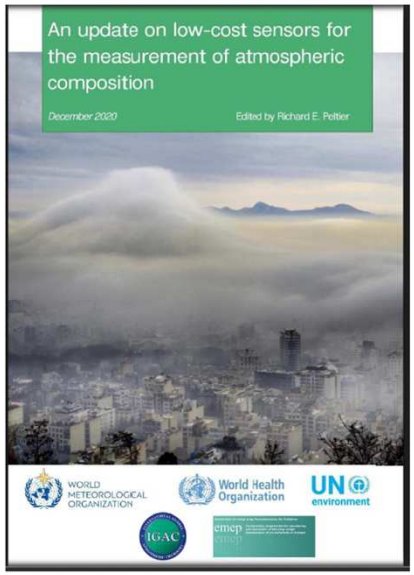
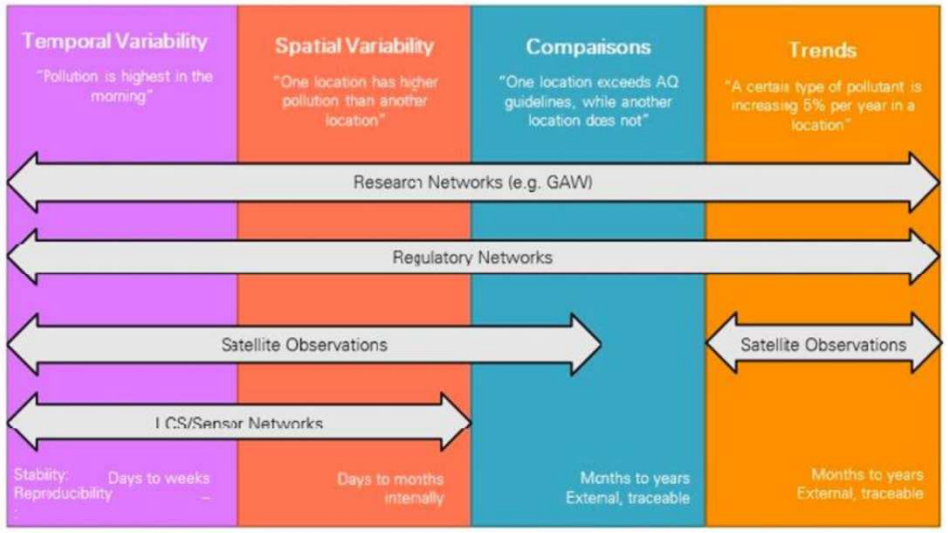
Integrating Other Sources of Information: Air Quality Sensors





WMO, WHO, UNEP, IGAC and EMEP (2020)
https://library.wmo.int/idurl/4/37465

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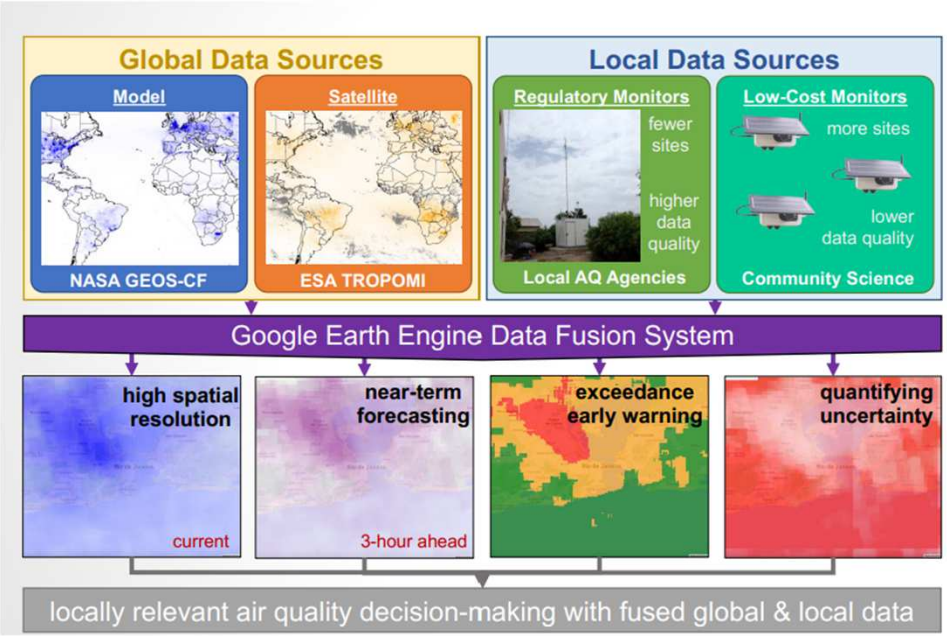
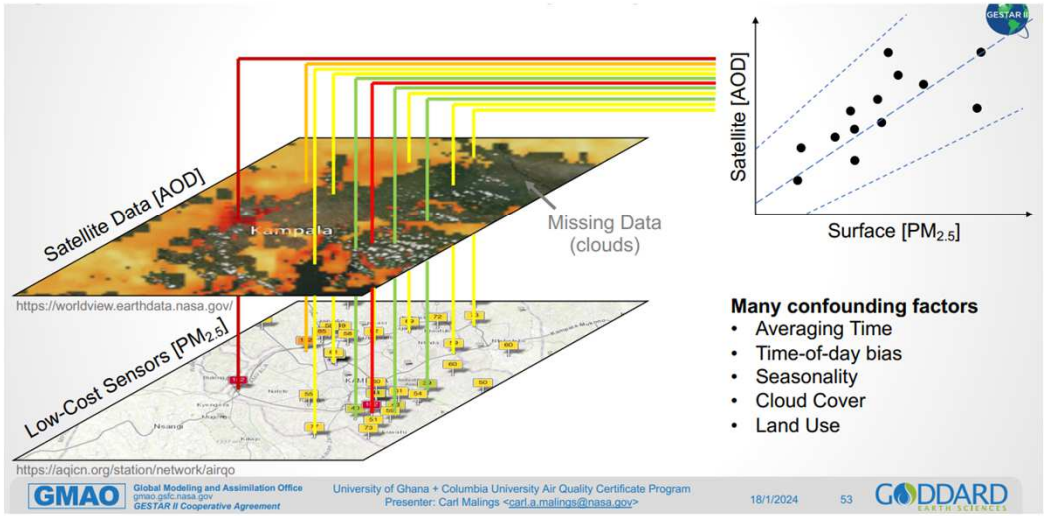
Do Satellites Capture Patterns?





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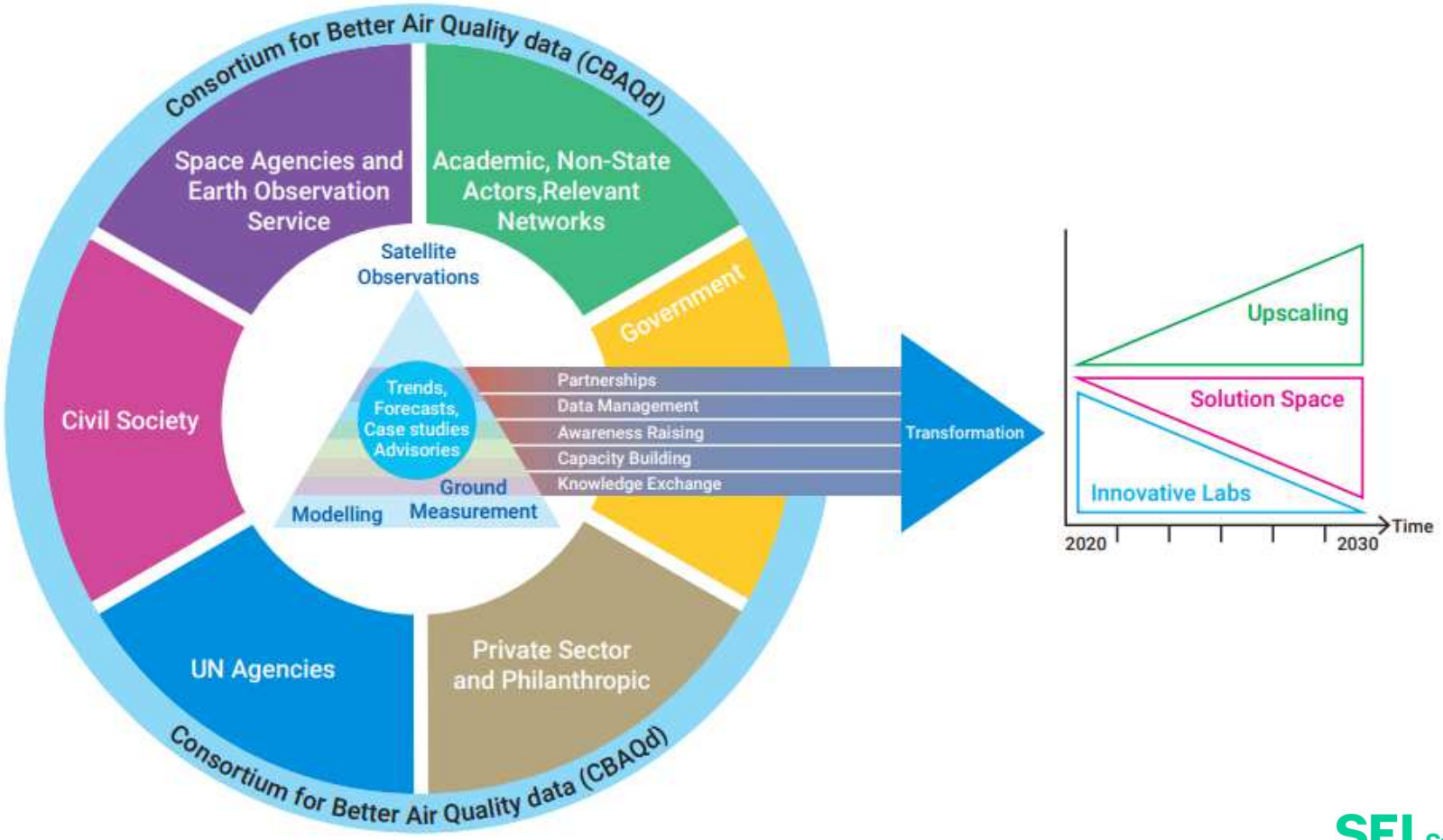
Strategy for Air Pollution and Climate Change Mitigation for Decision Making



Source: UNEP GEMS/Air Strategy, 2022

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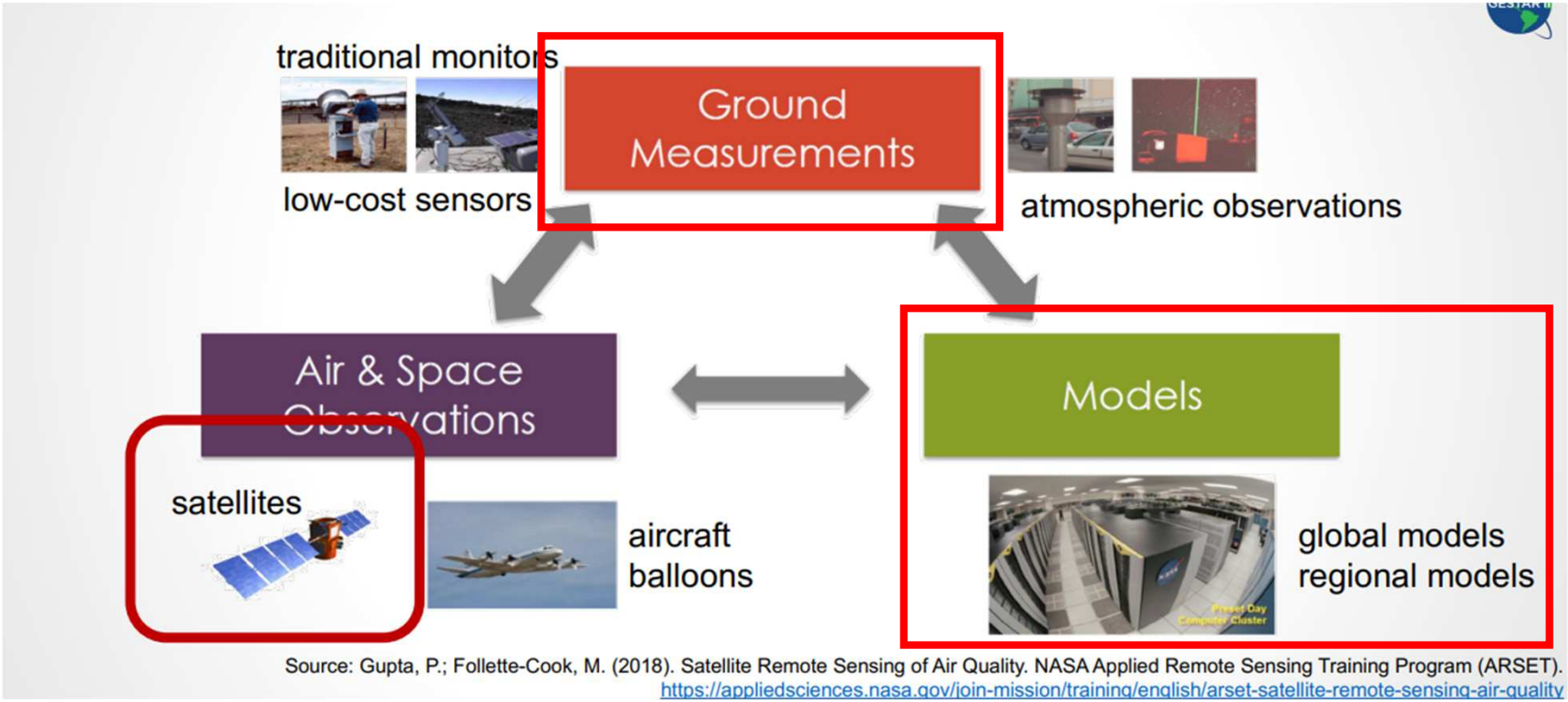
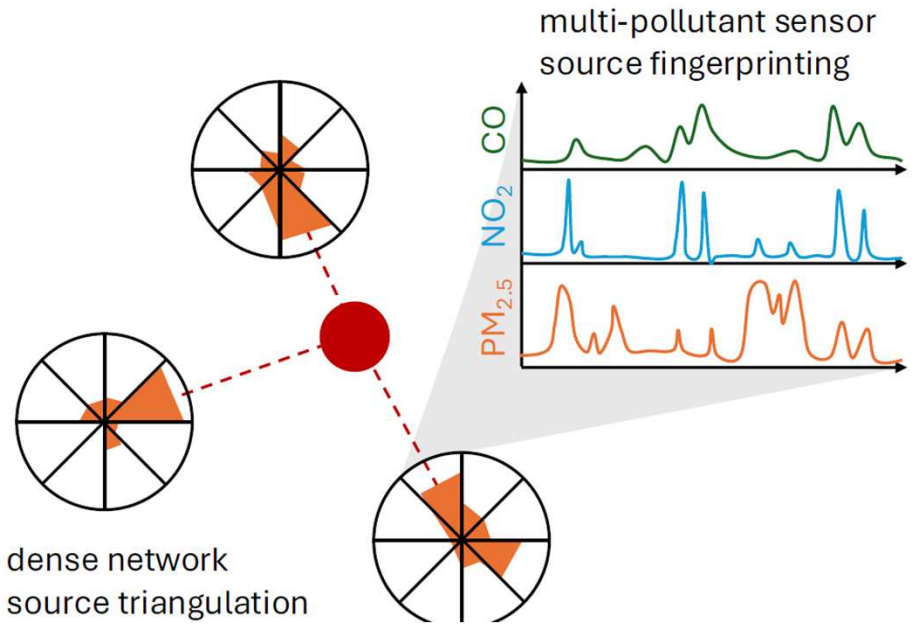
How do we measure and Understand Air Quality?



Source: Gupta, P.; Follette-Cook, M. (2018). Satellite Remote Sensing of Air Quality. NASA Applied Remote Sensing Training Program (ARSET). https://appliedsciences.nasa.gov/join-mission/training/english/arset-satellite-remote-sensing-air-quality

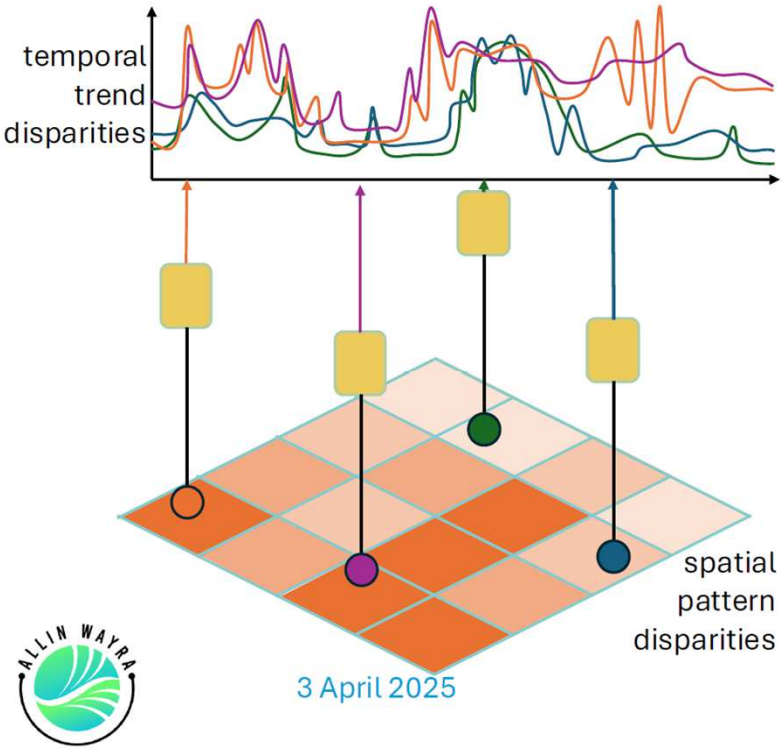
Source Identification and Attribution

- Dense networks of LCS allow for source triangulation, especially when combined with wind data, and allow for detection of more ***local sources***.
- ***Multi-pollutant*** LCS can isolate the "fingerprints" of many sources; even qualitative data have been used to produce robust source attributions.
- LCS networks can cost-effectively ***track*** the outcomes of ***mitigation activities*** and pollution control policies at local scales.



LCS Sensor Opportunities

- LCS can ***identify disparities*** in air pollutant exposure within and between communities, enabling environmental justice advocacy.
- This requires first demonstrating that the LCS have ***high inter-unit consistency*** (i.e., precision).
- ***Independent data sources*** (e.g., satellites) can corroborate disparities identified by LCS.
- ***Community involvement*** in LCS network design, deployment, data collection, and analysis can also support mitigation activities based on the data collected.



WORLD METEOROLOGICAL ORGANIZATION

UN environment programme

IGAC

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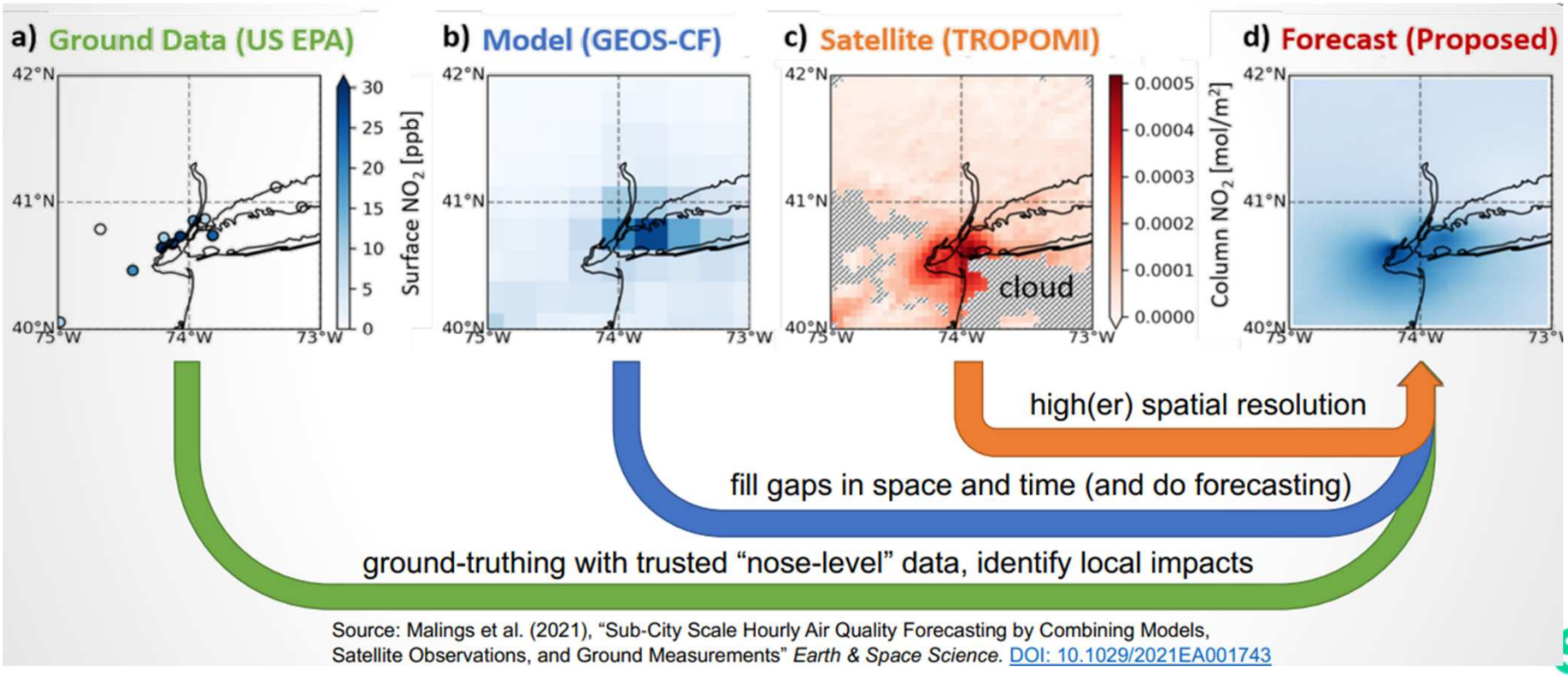
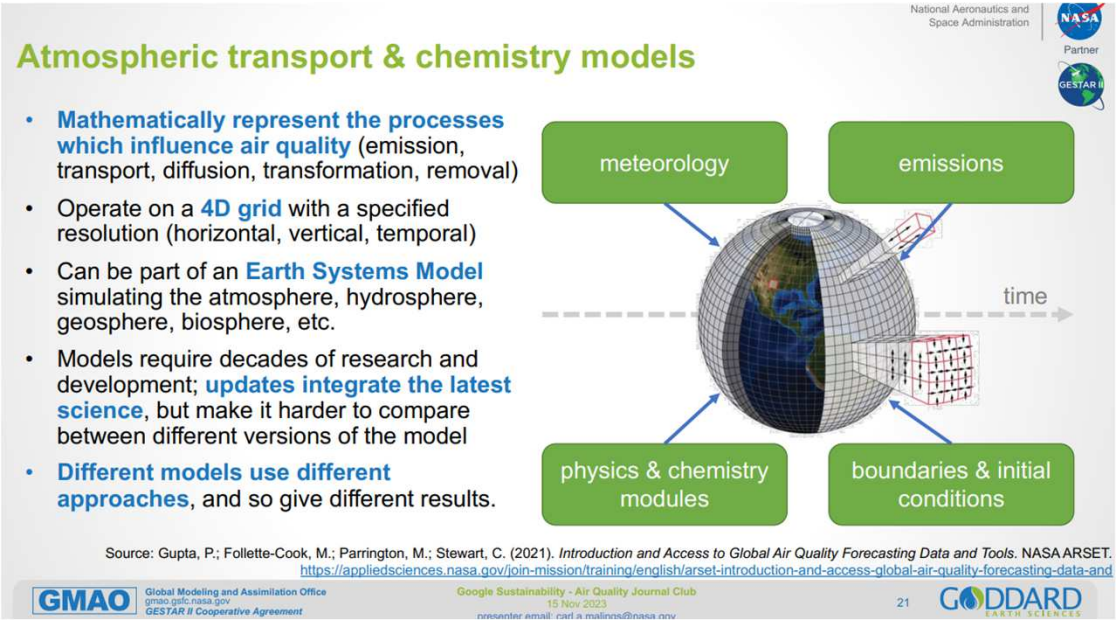
DATA FUSION SYSTEM……



Source: Malings et al. (2021), "Sub-City Scale Hourly Air Quality Forecasting by Combining Models, Satellite Observations, and Ground Measurements" *Earth & Space Science*. DOI: 10.1029/2021EA001743

Global and Regional Models….

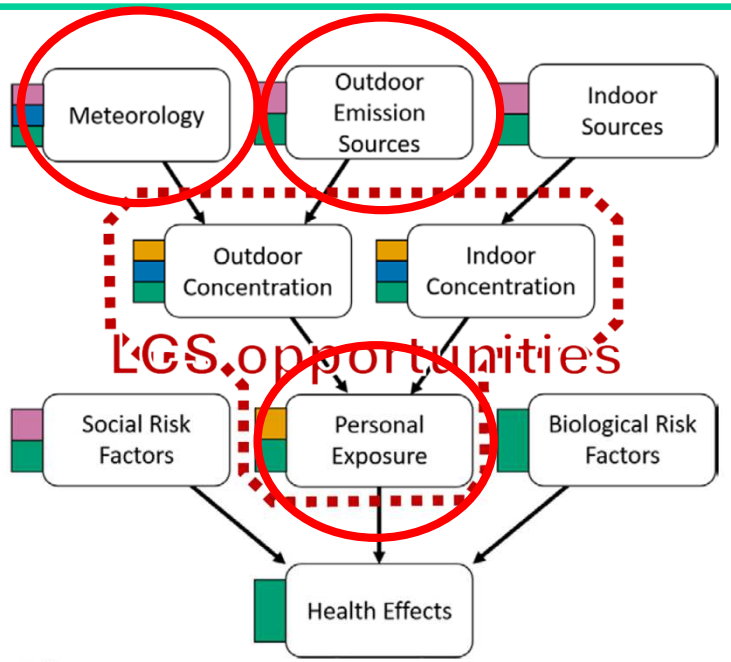


"garbage in, garbage out"; model outputs are only as good as the emissions data, model assumptions, and initial conditions that are used.

- Out of date and/or coarse resolution emissions inventories cause uncertainty.
- Model outputs are not directly comparable to ground or other data sources due to the scale mis-match; the model estimates average concentrations across its grid, which are not the same as measurements at specific locations.
- Large amount of data requires expertise & software to interpret and visualize.

Health Studies and Personal Exposure Monitoring

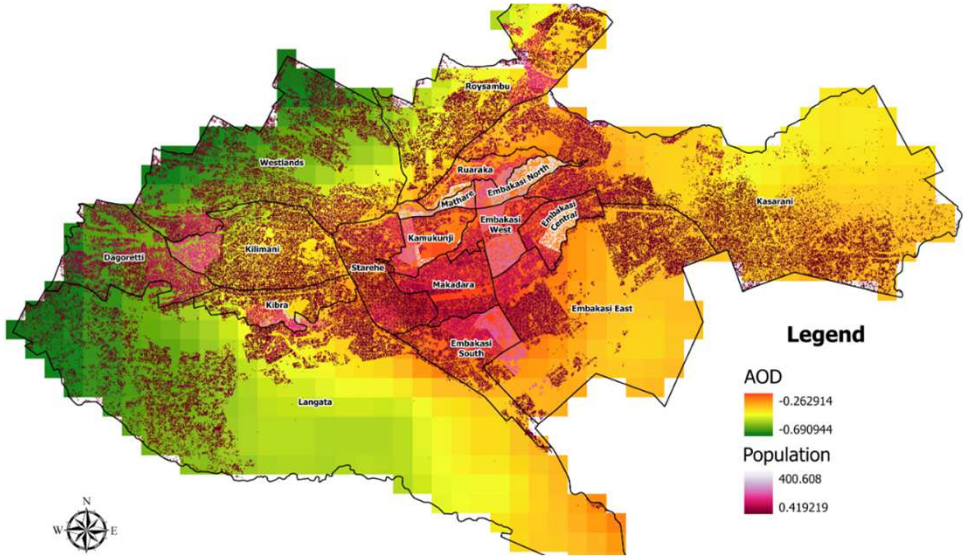
- ***Lack of in-situ data*** for epidemiological studies is a critical issue for low- and middle-income countries which LCS can begin to address.
- Quality-controlled LCS data combined with other information may support more spatially ***focused, short-term*** health studies.
- Qualitative insights from portable and wearable ***LCS can help individuals take action*** to reduce their personal exposure and risks.
- Ensuring the ***privacy*** of personally identifiable health data is needed in such applications.



Gardner-Frolick et al. (2022)

AOD Analysis Nairobi 2025 – Informed Deployment Strategies

Sentinel 5P 2024 – 2025 For Nairobi



Air Quality Data Monitoring Network in Nairobi 04th December 2025

Source: Rose Mary – SEI Researcher

Filling the Gaps: Air Quality Sensor Deployment Across Africa by UNEP and SEI

DAKAR, Senegal: 2 AQ Sensors deployed and 18 additional sensors to be deployed in Sept 2023

KAMPALA, Uganda: 12 Air Quality Sensors installed in September 2023

KENYA: 43 Air Quality Sensors installed in Kenya (30 in Nairobi, 8 Sensors in Nakuru, 3 sensors in Eldoret and 2 Sensors in Kilifi.)

Djibouti: 4 Air Quality Sensors deployed in Djibouti

ADDIS ABABA: Ethiopia: 11 Air Quality Sensors deployed in Addis ABABA

TANZANIA: 25 Air Quality Sensors deployed in Dar-es Salaam and Zanzibar.

ZAMBIA: 3 Air Quality Sensors deployed in Ndola and Lusaka.

- Two of the four sensors that were handed over to the AU ZONE 5 Sport Commission to cover all the sports venues of the African Games have been deployed

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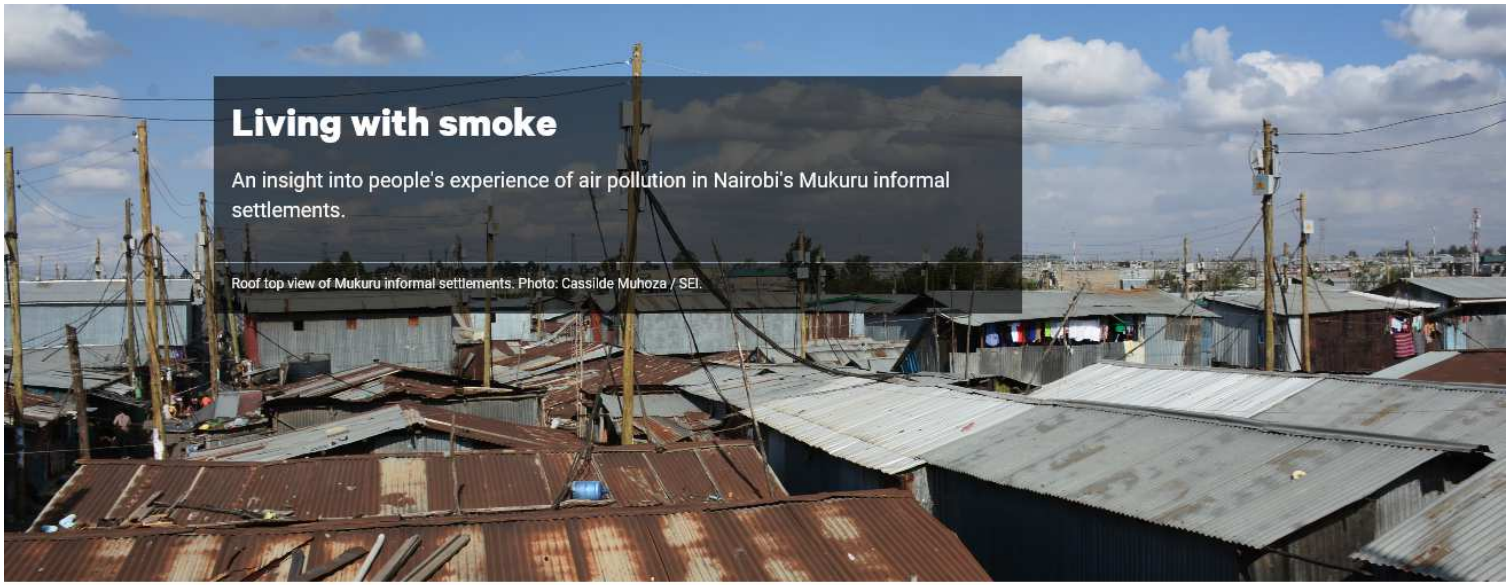
SENEGAL: FILLING DATA GAPS ON AIR QUALITY

- **Deployment and Expansion of Air Quality Monitoring Infrastructure**
- **New Monitoring Stations**: Deploy low-cost air quality sensors in key locations, including urban centers (e.g., Dakar), industrial areas, and vulnerable communities.
- **Calibration and Quality Assurance**: Ensure that deployed sensors meet international standards through regular calibration and validation with reference-grade equipment.
- **Integration with Meteorological Systems**
- **Data Synchronization**: Integrate air quality monitoring data into Senegal's meteorological systems for combined analysis of weather patterns and air pollution trends.
- **Early Warning Mechanisms**: Develop automated early warning systems that use real-time meteorological and air quality data to alert communities during high-pollution events.


KIVUKONI
Dar-es-Salaam Bus Rapid System
Baseline for assessment of impact of BRT implementation on air pollution from road transport – first case in Africa?

Community science for air pollution in Nairobi informal settlement



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Date published

29 May 2018

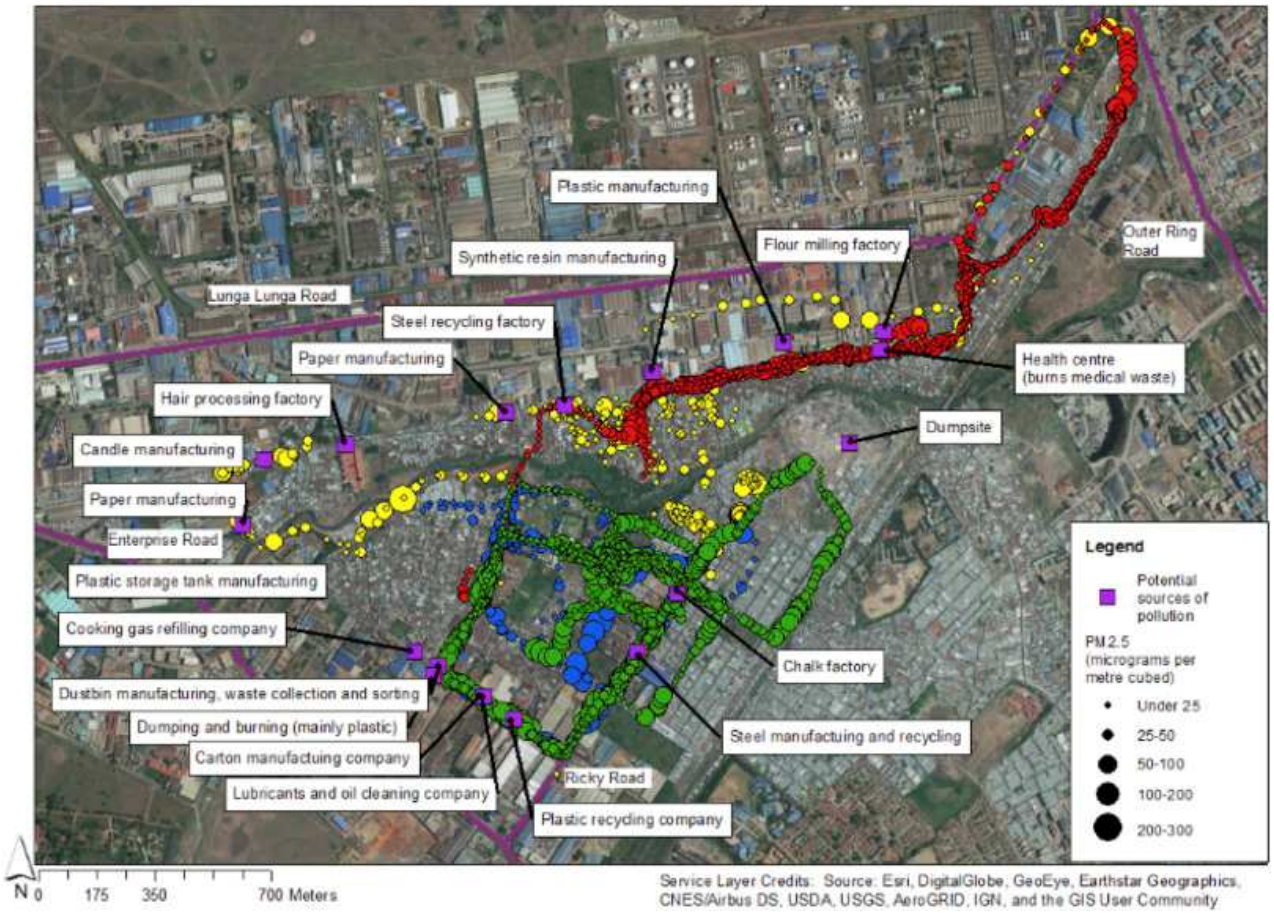
A story from

Mukuru informal

SEI Stockholm Environment Institute

Photostory: https://www.sei.org/featured/living-with-smoke/

Community science for air pollution in Nairobi informal settlement



ELSEVIER

Applied Geography
Volume 114, January 2020, 102133

Particulate matter pollution in an informal settlement in Nairobi: Using citizen science to make the invisible visible

Sarah E. West [a], Patrick Büker [a], Mike Ashmore [a], George Njoroge [b], Natalie Welden [a], Cassilde Muhoza [b], Philip Osano [b], Jack Makau [c], Patrick Njoroge [c], William Apondo [b]

Air–Noise Pollution Linkages: Testing Innovative Community-Based Adaptation and Mitigation Strategies in Kenya

Annals of Global Health

BOSTON COLLEGE

Reading: Air–Noise Pollution Linkages: Testing Innovative Community-Based Adaptation and Mitigation Strategies in Kenya

Collection: Lessons from the field: Case studies to advance research on climate adaptation strategies and their impact on public health

Original Research

Air–Noise Pollution Linkages: Testing Innovative Community-Based Adaptation and Mitigation Strategies in Kenya

Manasi Kumar, Ngongang Wandji Danube, Vincent Nyongesa, Lucas Kalama, Carol Ngunu, Hassan Leli, Albert Tele, Edith Apondi, Josphat Asande, Osman Warfa, Ayub Macharia, Beatrice Madeghe, Obadia Yator, Darius Nyamai, Philip Osano

Kangemi Health Center

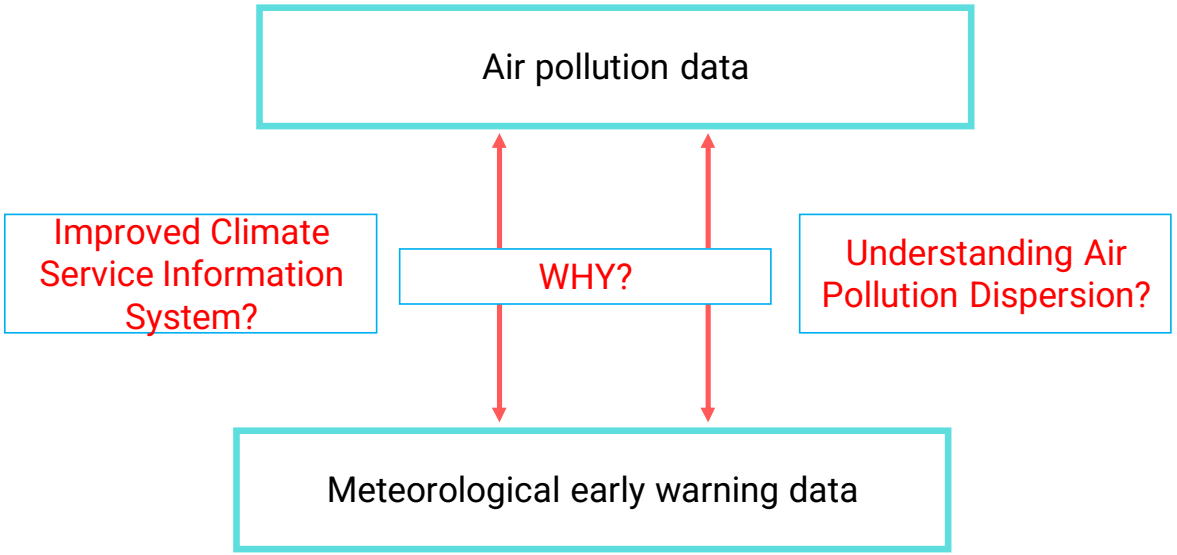
Mtwapa Health Center

Vipingo Health Center

Kariobangi Health Center

SEI

Strengthening Air Pollution Observation



Increasingly innovative approaches are being applied to unlock early warning systems for air pollution This builds on the advances of established early warning systems that focus on climatological and meteorological risks. Specifically, this is in three levels.

Methodology of Framework

The KMD weather station at JKIA has integrated low-cost air quality monitoring sensors to co-create a hybrid air quality monitoring network

Air Quality Data

Meteorological Data

Combine → Increase → **the reliability and accuracy of air pollution early warning information**

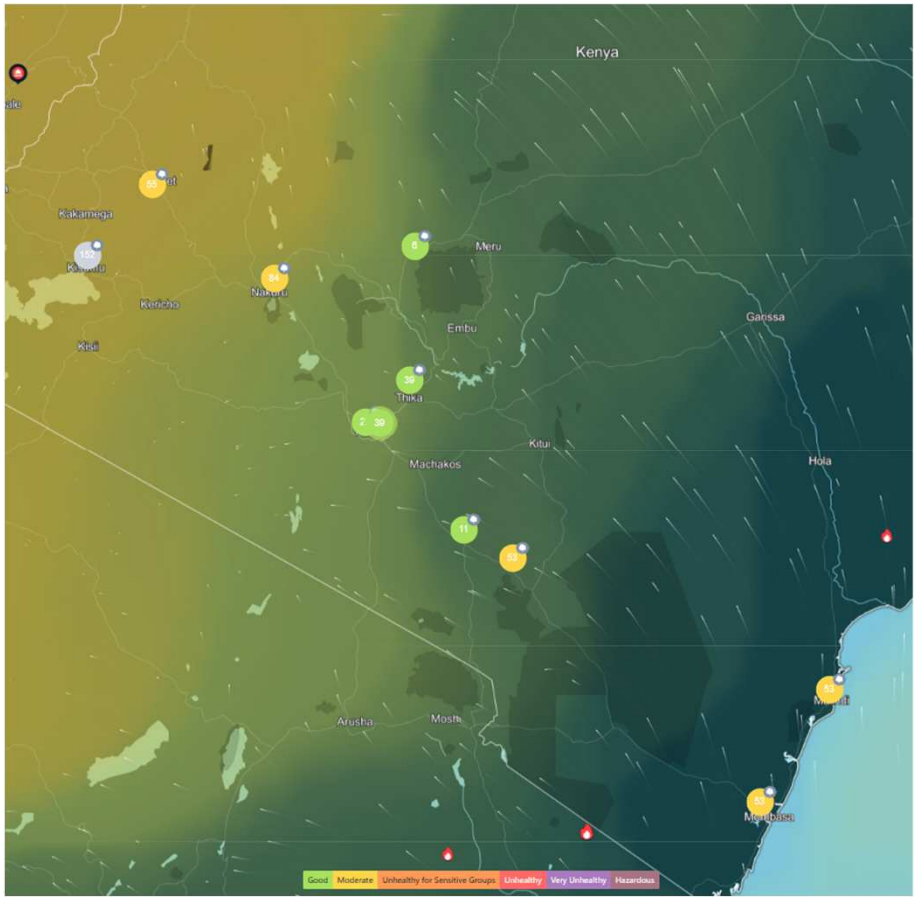
SEI

Strengthen observational networks and improve climate services, and the National Framework for Climate Services (NFCS)

Devices

Environment | Connection | Data publication | Mode | + Add filters

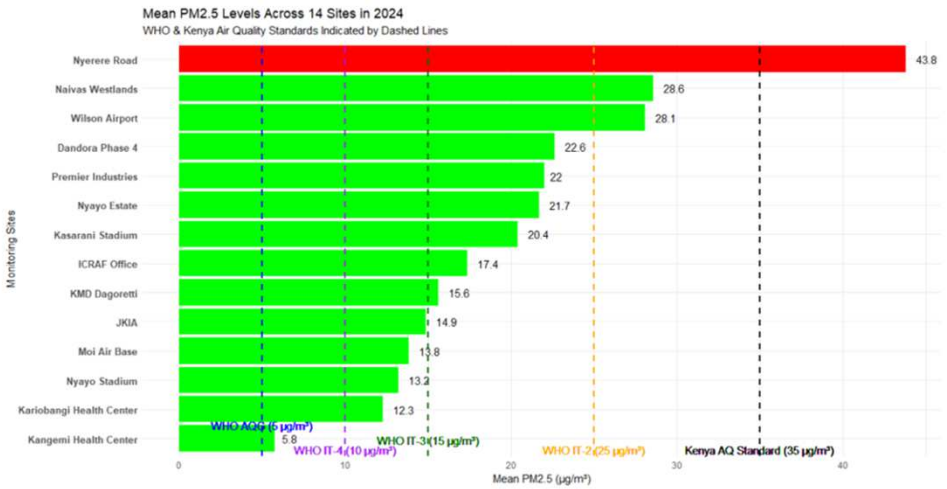
Device	Connection	Environment	Fan speed	Particle count (/L)	AQI* (US)	PM2.5 (µg/m³)	PM10 (µg/m³)	PM1 (µg/m³)	CO_2 (ppm)
Eldoret International Airport 5NG61T6UH6B		Outdoor	--	46939	55	11	18	8	473
▲ Isiolo Office MET V5CW01KYDBI		Outdoor	--	--	--	--	--	--	--
Mt. Kenya G.A.W MET STATION BUTA886JGZM		Outdoor	--	6798	6	1	2	1	405
NAKURU MET STATION UPSQZ74Z3QL		Outdoor	--	137313	84	27	44	20	486
▲ KISUMU AIRPORT MET STATION F5GFXFIZX0M		Outdoor	--	285569	152	57	96	44	464
MACHAKOS MET. STATION JICH95GP9VD		Outdoor	--	10072	11	2	4	2	405
Thika MET - KARLO 38RCW82KUHA		Outdoor	--	14480	22	4	7	2	413
MAKINDU MET STATION 9ZEOJRE9YQ9		Outdoor	--	38128	56	12	26	7	410
MALINDI INTERNATIONAL AIRPORT 39C0T68UCGD		Outdoor	--	34313	58	13	28	6	408
MOI INTERNATIONAL AIRPORT SBS6UHD19A2		Outdoor	--	25516	55	11	26	5	421
JKIA Airport BY5YGQQH3G6		Outdoor	--	20968	39	7	14	3	419
Moi Airbase BKS34VO6VMM		Outdoor	--	59341	60	14	23	10	405
WILSON AIRPORT ACCHJMUXTGP		Outdoor	--	10270	11	2	3	2	414
KMD SENSOR HQ QQ4X8ZRBRHX		Outdoor	--	12316	17	3	5	2	406



Partnership between UNEP, SEI and KMD

https://www.sei.org/about-sei/press-room/kenya-meteorological-department-begins-analysis-of-air-pollution-after-sensor-installed/

Inclusion of Air Quality into the *State of the Climate Report Kenya 2024*



STANDARDS	ANNUAL VALUES
WHO AQG: World Health Organization Air Quality Guidelines	**5 ug/m3**
WHO IT4: World Health Organization Interim Target 4	**10 ug/m3**
WHO IT3: World Health Organization Interim Target 3	**15 ug/m3**
WHO IT2: World Health Organization Interim Target 2	**25ug/m3**
KENYA Air Quality Standards = WHO IT1	**35 ug/m3**

TECHNICAL PATHWAY TO INTEGRATE AIR POLLUTION INTO NFCS : KENYA AS A CASE STUDY

- Co-location of AQ sensors at KMD weather stations.
- Joint AQ-climate forecasting products.
- Real-time AQ alerts via mobile (Safaricom, Airtel).
- KMD to lead AQ+Climate modeling protocols.

This state of the climate report Kenya 2024 like its predecessors, provides a snapshot of the state of the climate in Kenya during the year 2024. It examines key weather events during the year, puts them in the context of 1991-2020 climatology and highlights the impacts of the same on key socioeconomic sectors in Kenya.

This complete report can be found at www.meteo.go.ke

Lead Authors: Patricia Nying'uro, Dr. Joyce Kimutai, Chris Ngetich

Contributing Authors: Zablon Shilenje (WMO), Claire Ransom (WMO) Sarah Kimani, Dr. Philip Okello, Christine Mahonga, Pamela Muange, Dr. Willis Ochieng' (KENGEN), Reuben Ngessa (WRA) Philip Osano (SEI), Ngongang Wandji Danube (SEI), Kehbila Anderson (SEI)

Reviewers: Claire Ransom (WMO), Dr. David Gikungu (KMD)
Editing & Design: Claire Ransom (WMO), Harriet Wanjiku (Strathmore)

Cite as: KMD. 2025. State of the Climate Kenya 2024

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1

MANUAL ON SPORT AND THE ENVIRONMENT

International Olympic Committee

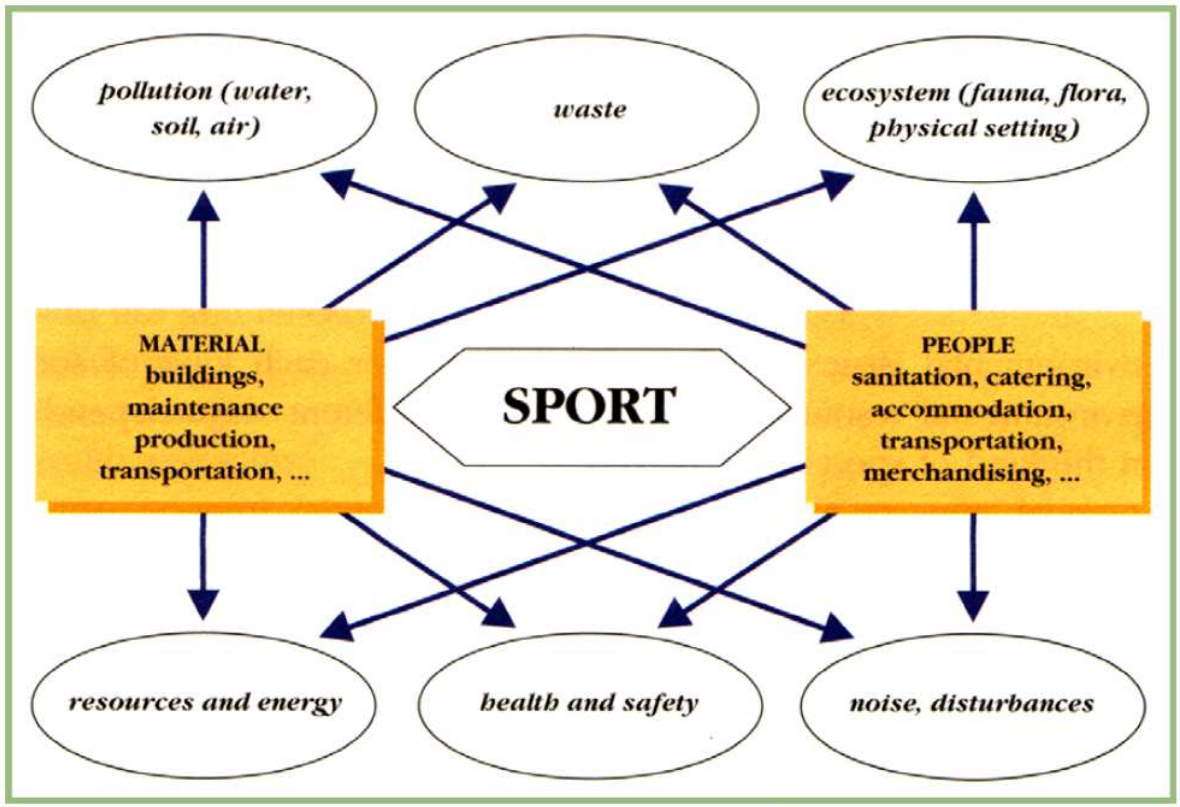

Figure 2: Potential impact of sport events on the environment

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Environment and Climate Change poses Risks to Sports

VOA

Athletes Fight Heat, Humidity at Tokyo Olympics

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29 Jan 2018

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Golf clubs' water plans under spotlight ahead of Day Zero

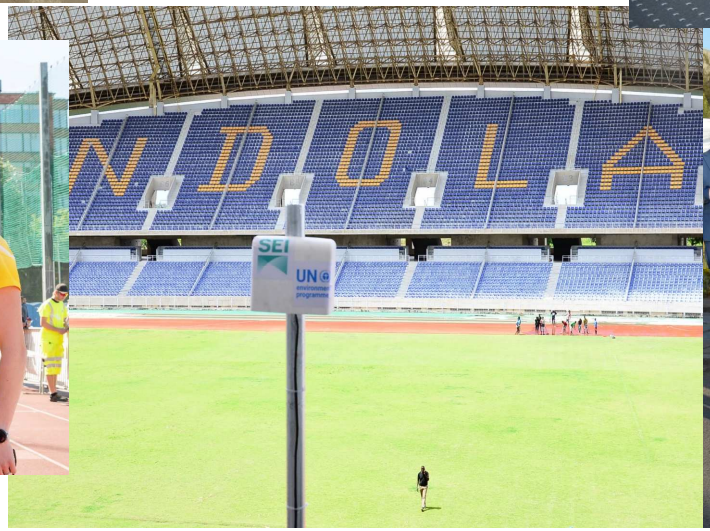
Jenni Evans

Comments Bookmark

Cape Town - A Stellenbosch golf club manager who went to great lengths to keep his struggling greens alive ahead of Day Zero, had to explain himself on Monday amid heightened sensitivity over water consumption during the drought in the Western Cape.

"It is not potable water. You can't do anything with it," said Ryno Bernardo, manager of Devonvale Golf Club outside Stellenbosch, after an outcry over his post that he secured 100

AK Sustainability Leadership in Athletics Globally



SUSTAINABILITY AND SPORT FRAMEWORK

SEI Stockholm Environment Institute

SUSTAINABILITY FOR CLIMATE ACTION

Implementation Framework:

- **Partnerships:** Collaborate with NEMA | Athletics Kenya | ROAM | UNEP | SEI Africa | Nairobi City County| CIFOR ICRAF
- **Data Integration:** Combine air quality, climate, and health data for decision-making.
- **Community Engagement:** Include schools, local clubs, and civil society in sustainability initiatives.
- **Legacy Planning:** Ensure environmental benefits extend beyond the event—improving urban air, mobility, and resilience.

Expected Outcomes:

- Reduced exposure of athletes and spectators to harmful pollutants.
- Lower carbon footprint of events through sustainable transport and energy choices.
- Enhanced awareness and community ownership of environmental issues.
- Stronger policy and practice linkages between sport, environment, and climate action.

UN environment programme | CIFOR | World Agroforestry | Kenya Meteorological Department | ROAM | Athletics Kenya | SEI Stockholm Environment Institute

Sustainability in Sport:
Building a Legacy Beyond the Game

Sport is more than competition—it is a stage where teamwork, endurance, and dedication inspire communities and bring people together. But the arenas, roads, and tracks where athletes perform are not isolated from the world's environmental challenges. From the air we breathe to the waste we generate, sport is deeply connected to our environment. A strong sustainability strategy ensures that athletic excellence can thrive without compromising the health of our planet or future generations.

Vision:

To embed environmental sustainability and climate resilience into the planning, delivery, and legacy of sporting events and infrastructure, ensuring health, equity, and environmental integrity for athletes, spectators, and host communities.

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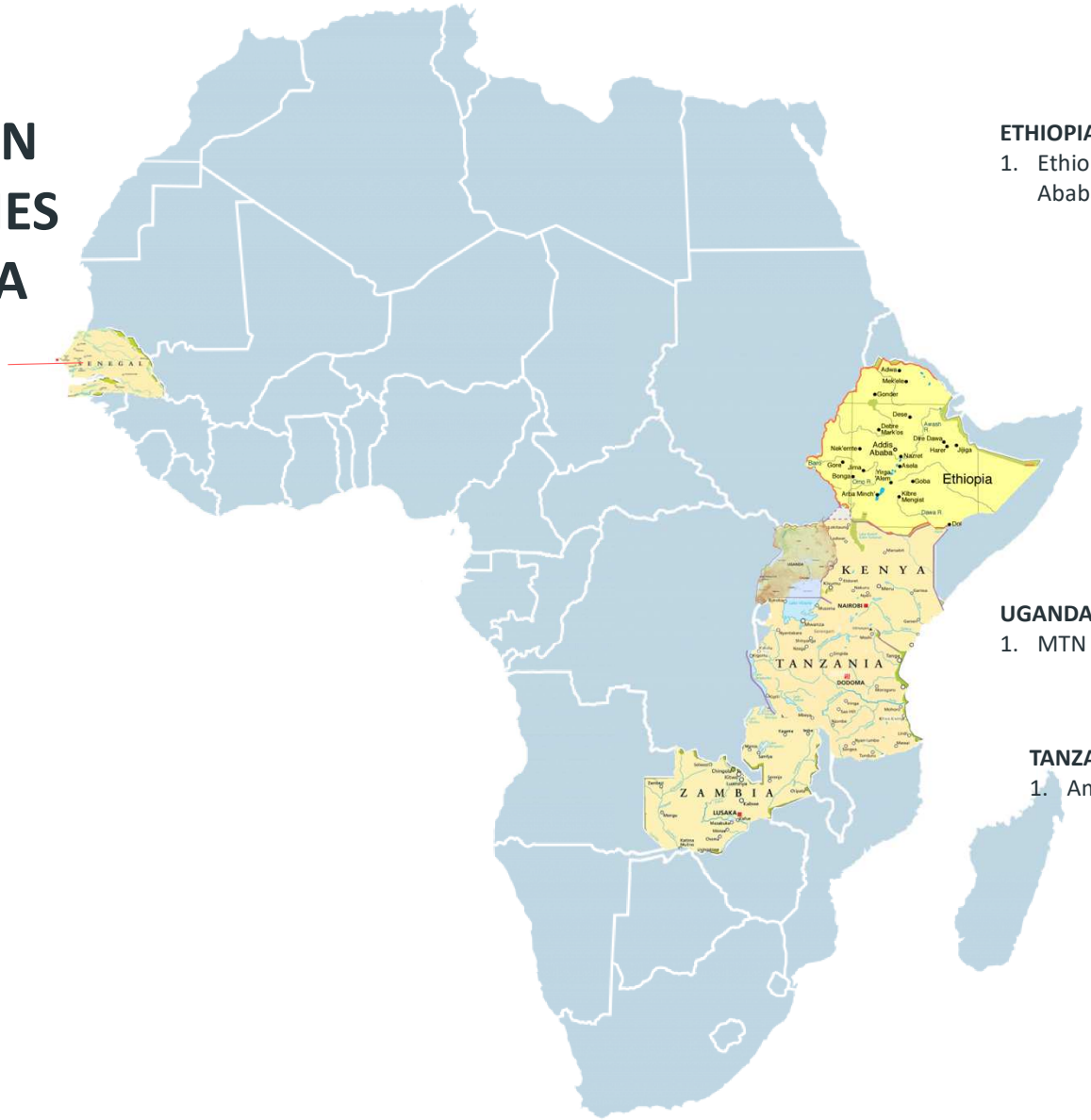
AIR QUALITY MONITORING IN SPORTS FACILITIES ACROSS AFRICA

DIAMNIADIO OLYMPIC STADIUM
Diamniadio



ETHIOPIAN

1. Ethiopian Youth Sports Academy (Addis Ababa)

KENYA

1. Moi International Sports Complex (MISK) Kasarani (Nairobi)
2. Nyayo National Stadium (Nairobi)
3. Ngong Racecourse (Nairobi)
4. Nakuru Athletics Club (Nakuru)
5. Butwani Waterfront Park (Malindi)
6. Raila Odinga Stadium (Homa Bay)
7. Lobo Village (Eldoret)

UGANDA

1. MTN Philip Omondi Stadium (Kampala)

TANZANIA

1. Amaan Stadium (Zanzibar)

ZAMBIA

1. National Heroes Stadium (LUSAKA)
2. Levy Mwanawasa Stadium (Ndola)

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Gender Considerations for Air Quality Exposure within the Sport Industry

- By providing empirical evidence from Nairobi's largest cycling event, This project led to strengthen the case for the UNEA-7 resolution's call for sustainable, inclusive, and gender-responsive sport systems. It demonstrates how real-time environmental monitoring, cleaner mobility infrastructure, and air quality–aware

WOMEN AS ACTORS OF CHANGE TO AIR QUALITY DATA TO IMPROVE MOBILITY IN NAIROBI

METHODOLOGY OF DATA COLLECTION

Portable sensors mounted on bicycles measured **$PM_{2.5}$**, PM_{10}, CO_2, CO, **temperature**, humidity, and pressure across three periods: **before the event** under normal weekend conditions; **during the Sunday race**, when **roads were closed**; and **after the event** during weekday morning peak traffic (**7:00–9:00 AM**). This temporal design provides a rare opportunity to quantify how urban air pollution fluctuates across sporting and non-sporting conditions—and how these fluctuations differentially affect **male and female athletes**.

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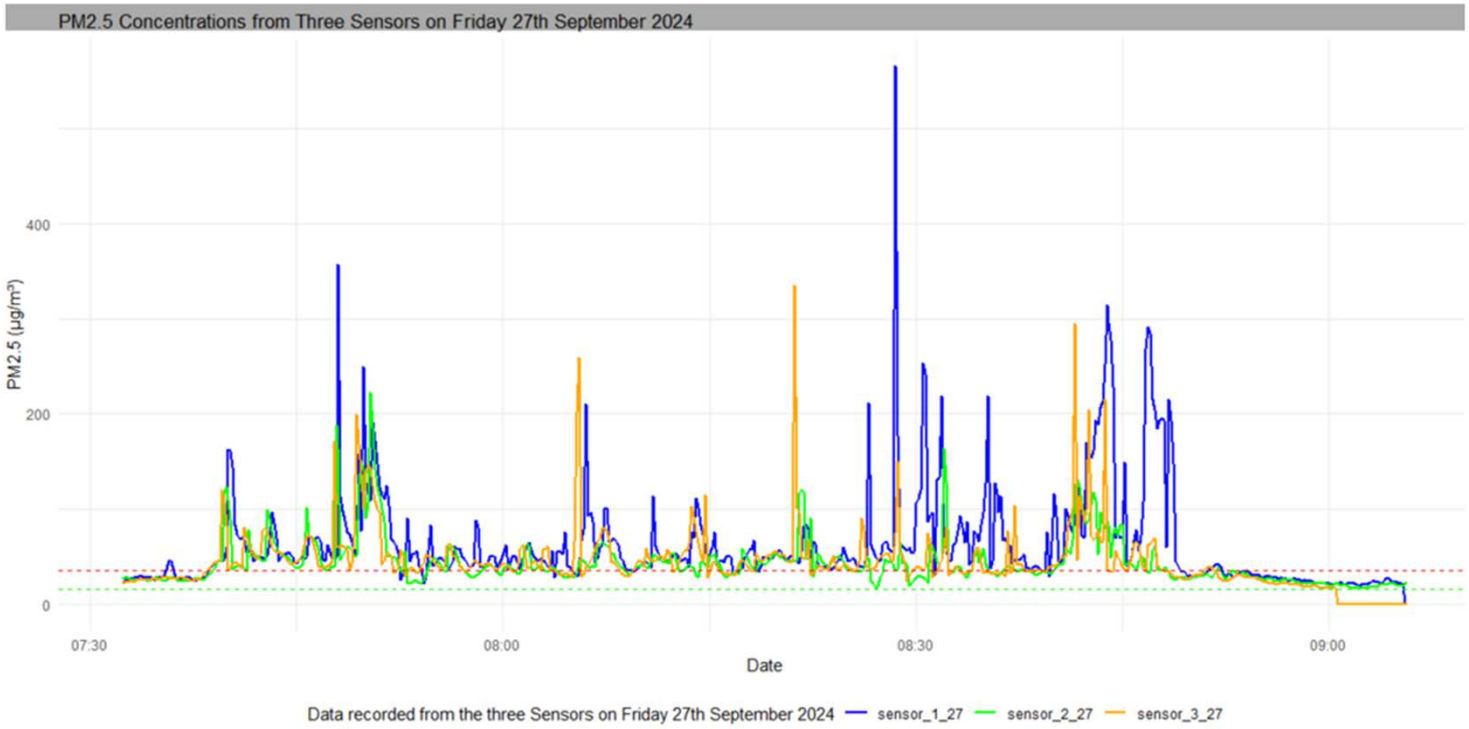
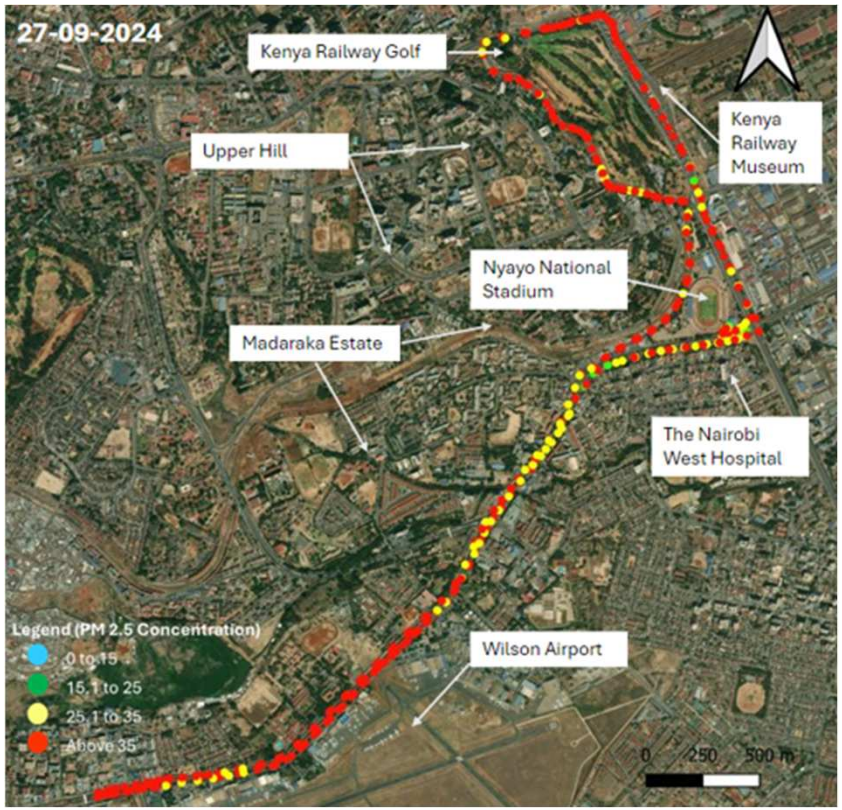
DATA VALIDATION ACROSS THE THREE PORTABLE SENSORS

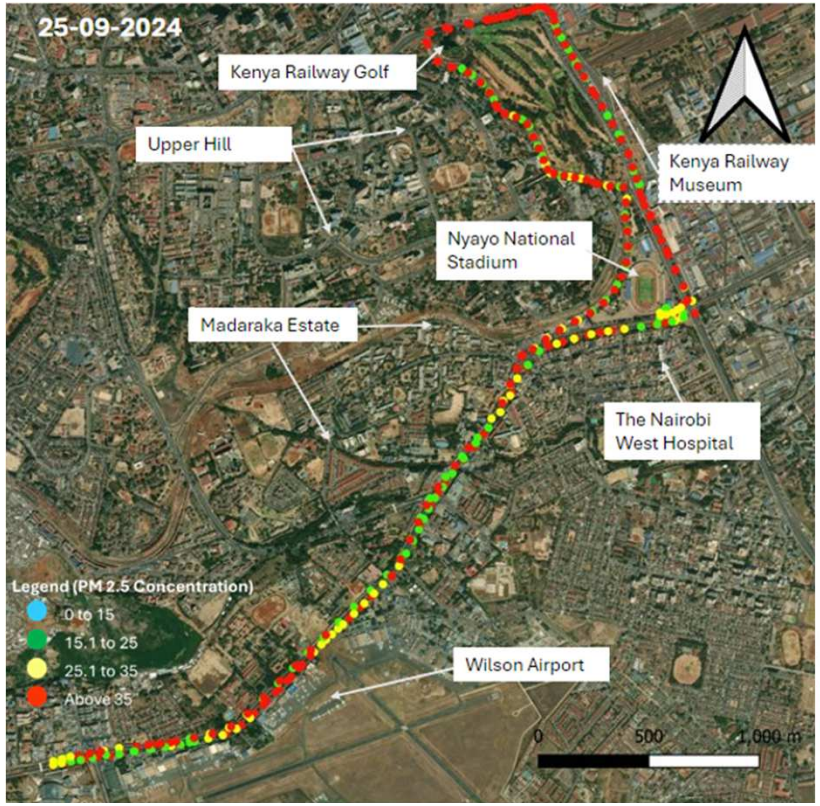


Mapping Pollutant Concentrations along the routes

- Before the event : Friday 27th September 2024, 7-9am

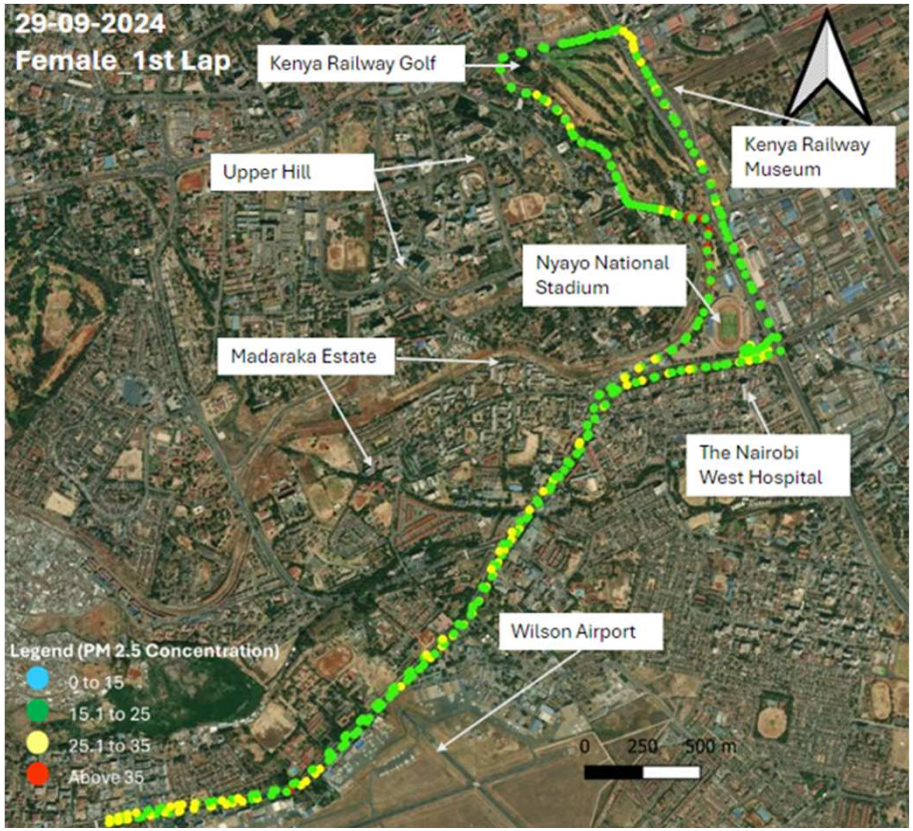


- Wednesday 25th September 2024, 7am-9am

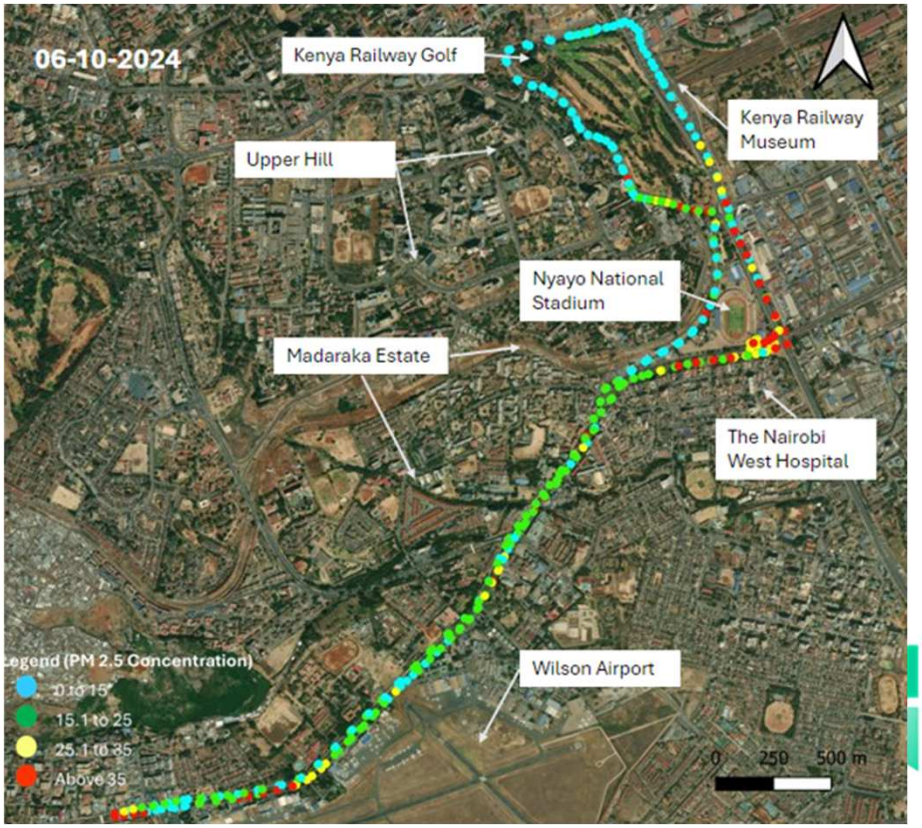


Mapping Pollutant Concentrations along the routes

- Day of Event: Sunday 29th September 2025



- After the Event: Sunday 06th October 2025



ENGAGING COMMUNITY OF CYCLISTS TO DRIVE ENVIRONMENTAL SUSTAINABILITY

MINISTRY OF YOUTH AFFAIRS, SPORTS AND THE ARTS

REPUBLIC OF KENYA

Great Rift 10-a-side Rugby tournament (20-21 May 2023)

ATHLETICS KENYA

Nakuru Athletics Club

STAR

SPORTS BUSINESS COUNTIES SIASA S

KCB forwad Festus Shiasi in action during the Great Gift Rugby 10-aside tournament at Nakuru Athletics Club on May 20, 2023. Image: /EVANS OUSURU

May-2023

29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9

- UNHEALTHY FOR ATHLETES (WHO GUIDELINES : Above 35 ug/m3)
- MODERATE FOR ATHLETES (WHO GUIDELINES: 25 - 35ug/m3)
- GOOD FOR ATHLETES (WHO GUIDELINES: 15 - 25 ug/m3)
- EXCELLENT FOR ATHLETES (WHO GUIDELINES : 0 - 15 ug/m3)

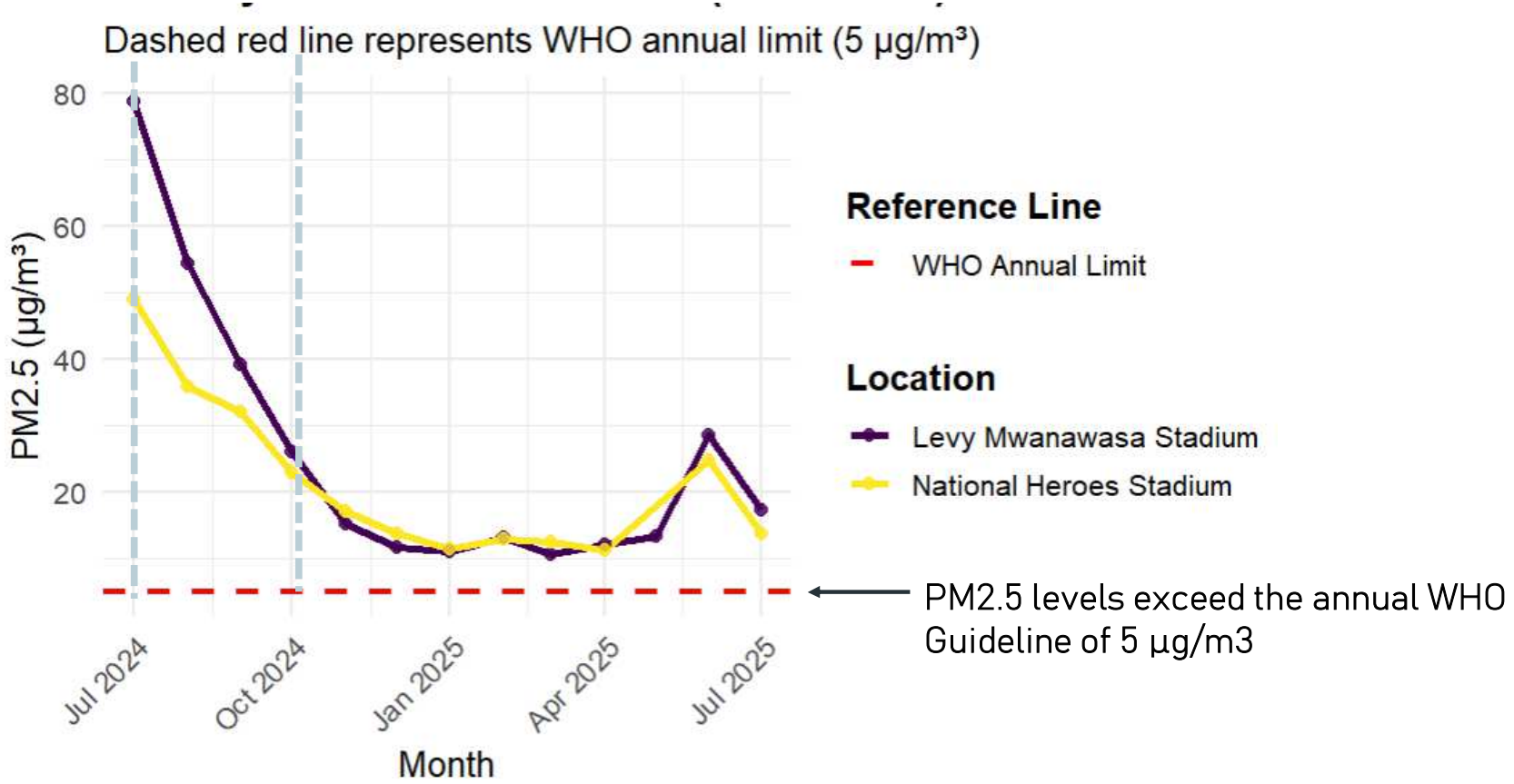
24 HOUR AVERAGE FOR FINE PARTICULATE MATTER(PM 2.5)

SEI Stockholm Environment Institute

WORLD ATHLETICS

UN environment programme

Monthly PM2.5 Concentration (2024 - 2025) at Stadiums in Zambia



- Recurrent pollution events observed during the dry season (July–October) are attributed to:
- Dust resuspension from dry soils and unpaved roads
- Open waste burning and agricultural biomass burning
- Local transport emissions around stadiums during events and peak hours

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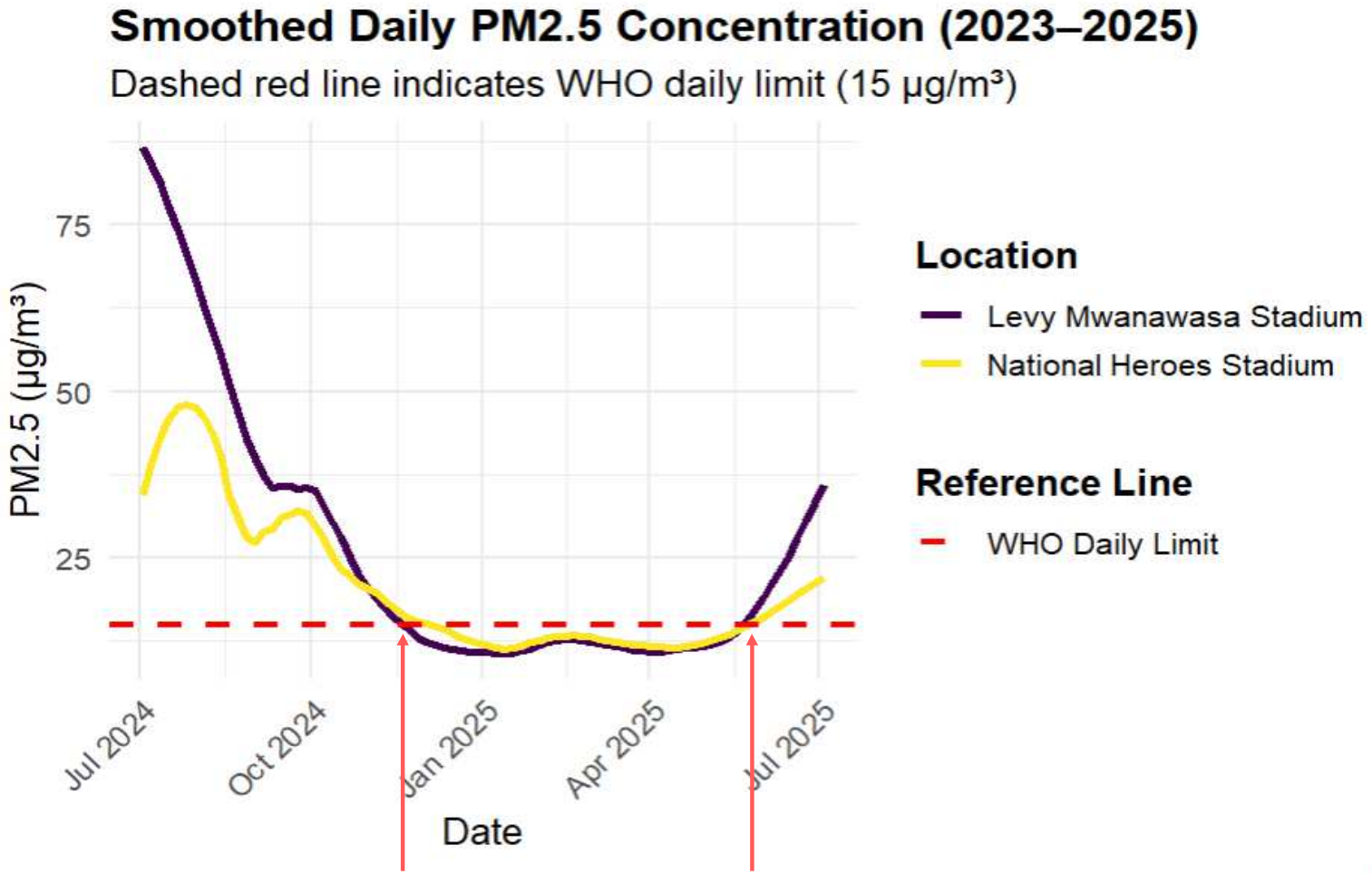
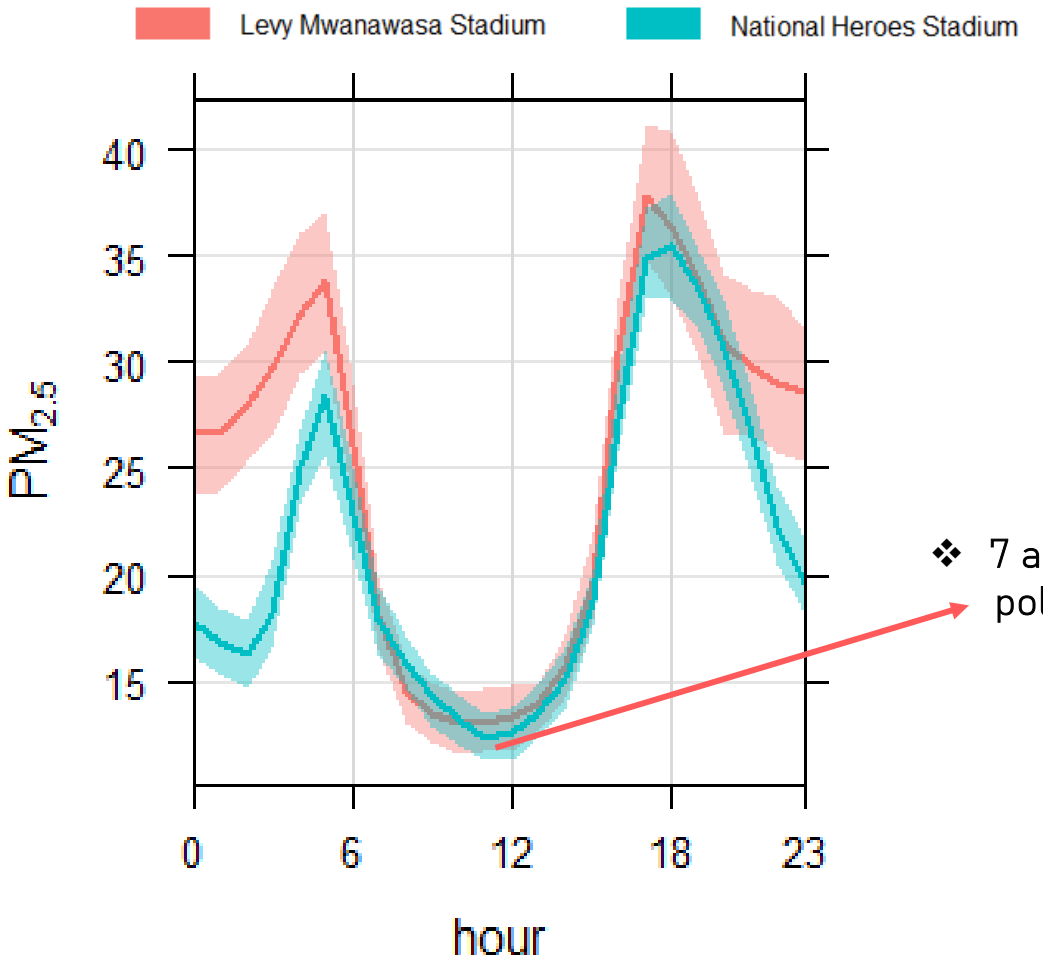
Monthly PM2.5 Concentration (2024 - 2025) at Both Stadiums



PM2.5 levels between December and May are below the Daily WHO Guideline of 15 µg/m3

Time Variation of PM2.5 at both Stadiums



- 7 am – 12 pm has the lowest pollution levels at both stadiums.

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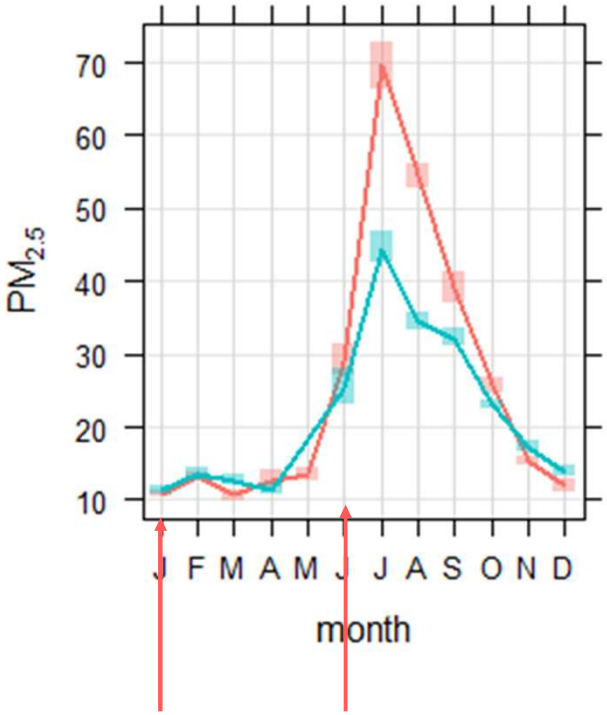
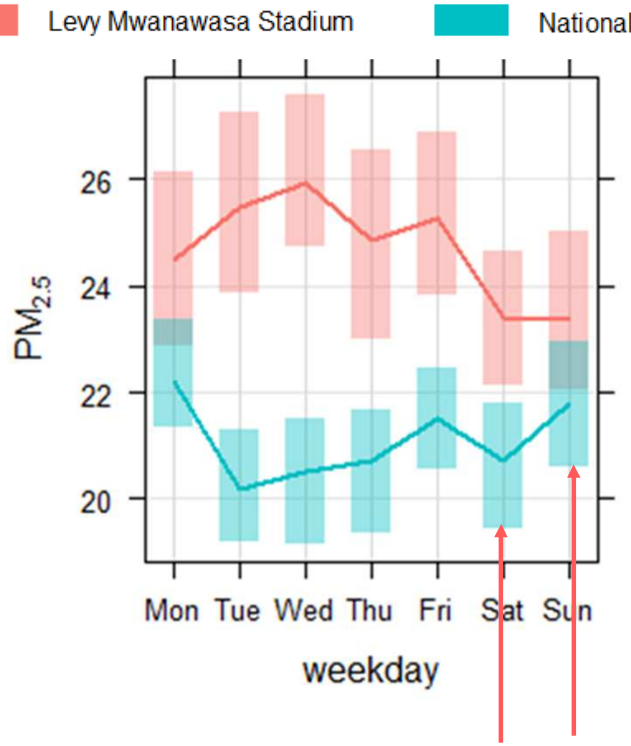
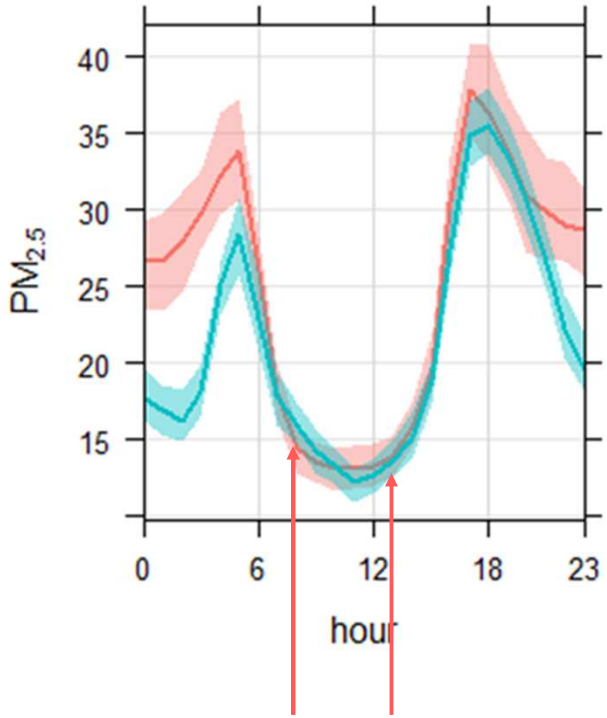
Policy Implications: Air Quality-Health-Sport Nexus



- Exposure during sporting events during July–October poses severe health and environmental risks
- Jan–June and Nov–Dec recommended for sporting activities at both stadiums.



- Saturdays and Sundays with lower PM2.5 concentrations recommended for training activities at both stadiums



- 7 am- 12 pm with low PM2.5 concentrations recommended for training and sporting activities at both stadiums