Clean Air Catalyst

Multi-Stakeholder Forum
Source Awareness in Nairobi City
Workshop

Lake Naivasha Country Club — Naivasha

(19-22 July 2022)

Rapporteur's Report


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[*"Clean air is a public good; indeed no other resource exhibits the same degree of 'publicness'. Land can be parceled and fenced; Water can be bottled; Scenery can be hidden; One can even isolate himself from noise; but man has no choice but to breathe the air around him – polluted or not"* – Anonymous]

Executive Summary

The Clean Air Catalyst multi-stakeholder forum on 'source awareness in Nairobi City', was held on19-22 July 2022 at Lake Naivasha Country Club, Naivasha. The main goal of the forum was to bring together stakeholders to share insights, knowledge and understanding of air pollution sources in the city in order to build a foundation for action. In addition, the workshop was to introduce the stakeholder to the Clean Air Catalyst (CAC) program and set a collaborative approach, through the setting up of the Nairobi air quality working group that would support in the implementation of the project.

The forum set out to achieve the following objectives:

i) gather information on what work is being done in the Air Quality (AQ) space in Nairobi;

ii) gain a current understanding of AQ in Nairobi;

iii) mobilize support for clean air action in Nairobi; and

iv) establish the Nairobi AQ working group.

These objectives are in line with Clean Air Catalyst program strategy which has three pillars: improving source awareness; identifying the most effective action; and building a strategic coalition.

To better understand previous and current projects in the AQ space in Nairobi, the participants took time (through presentations and group discussions) to: deliberate on the data that had been collected or was being collected on AQ; describe the major gaps under the current and previous AQ efforts to inform AQ action; and establish ways to build on previous actions. Under this task, the participants shared experiences from work done by key institutions through interactive and participatory group discussions and presentations. The discussions focused on key sources, drivers, impacts and current mitigation actions.

In summary, participants observed that air pollution had significant short- and long-term impacts on residents' health; and that air pollution was partly responsible for many of the respiratory-related morbidity and mortality cases in the city.

The participants identified several major contributors to air pollution, including: motorized transport, open burning of waste, such as waste from inefficient incinerators in health facilities; industries and household-related emissions. PM (Pm2.5 and PM10), CO, Hydrocarbons, Ozone, NOx, SOx, and VOCs were some of the key air pollutants named by the participants.

According to the participants, there are a couple of initiatives on AQ data collection around Nairobi and other parts of the country. However, such efforts were not well coordinated among different stakeholders. The cost of reference grade monitors, calibration and maintenance of AQ monitors, and methodologies of assuring quality of the data, emerged as a major challenge to long-term AQ monitoring in the city. Nevertheless, data collected and analyzed under the various short term monitoring studies clearly demonstrates that air pollution is an issue of concern in the city and there is a need to take action to change the trajectory and improve the AQ in the city.

Some of the other gaps and challenges raised include:

i) urgent need for AQ monitoring in the Nairobi Metropolitan region;

ii) need for capacity building of staff and Community Health Service (CHS) workforce on AQ matters; and

iii) more systematic and accurate data and mapping on air pollution sources within the Nairobi Metropolitan region.

Involving communities in addressing the AQ challenge emerged as an important factor that needs to be considered in any AQ initiative. As a critical stakeholder, communities should be involved at both the design and implementation stages of the interventions. In relation to this, the roles of Community Health Volunteers (CHV), and youth were recognized as a key consideration in any community-driven interventions. The need to enhance the capacity of CHV on AQ matters was also recognized.

Discussions on gender consideration in AQ initiatives were prominent, too. Generally, participants argued that air pollution affects genders disproportionately and often exacerbates the pre-existing gender inequalities and discrimination among women and girls. In addition, to gender, the need to consider vulnerable communities while designing AQ interventions was noted. The participants felt that pollution data tend to gloss over the disproportionate impact of poor AQ on vulnerable populations. As such, prioritization of pollutant sources that disproportionately impact the health, welfare, and economic opportunity of women and underserved populations was deemed critical.

The participants noted that a number of legislations that guide AQ initiatives existed, including: The Constitution of Kenya, 2010; EMCA, 1999 and subsidiarity legislation, e.g., Sustainable Waste Management Act, 2022; Nairobi City County Solid Waste Management Act; Public Health Act Cap 242; Nairobi City County Air Quality Act; Climate Change Act, 2016; Nairobi Air Quality Action Plan (2019 – 2023); and the Nairobi Climate Change Action Plan (CCAP), 2020-2050. The participants observed that, there were notable gaps in implementation or formulation of other relevant AQ policies.

Further, it was observed that there was a strong nexus between air pollution and climate change. Addressing air pollution and climate change simultaneously was deemed important, even during the policy formulation process and implementation. In conclusion, the forum culminated with the formation of a Nairobi Air Quality Working Group. The Working Group will support the implementation of the Clean Air Catalyst program. Within the Working Group, three sub-committees were established: community engagement sub-committee; research and data sub-committee; and, policy and regulations sub-committee.

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List of Acronyms

APHRC	African Population and Health Research Center
AQ	Air Quality
BC	Black Carbon
CAC	Clean Air Catalyst
CAP	Climate Action Plan
CHS	Community Health Service
CHUs	Community health Units
CHVs	Community Health Volunteers
EMCA	Environmental Management & Coordination Act
HAPs	Hazardous Air Pollutants
HIV	Human Immunodeficiency Virus
KMD	Kenya Meteorological Department
KNH	Kenyatta National Hospital
NCC	Nairobi City Council
NCCAP	National Climate Change Action Plan
NCCG	Nairobi City Council Government
NEMA	National Environmental Management Authority
NIUPLAN	Integrated Urban Development Masterplan for the City of Nairobi
NMS	Nairobi Metropolitan Services
PM	Particulate Matter
SEI	Stockholm Environment Institute
TB	Tuberculosis
UNEP	UN Environment Programme
USAID	United States Agency for International Development
VAW	Violence Against Women
VOCs	Volatile organic compounds
WHO	World Health Organization
WRI	World Resources Institute

Opening Remarks

The workshop was officially opened by the WRI-CAC Chief of Party, Mr. Ethan McMahon. In his opening remarks, Mr. McMahon reiterated Clean Air Catalyst's commitment in ensuring better AQ for the residents of Nairobi, and thus improved the health and living conditions of the vulnerable communities, women and city dwellers in general. Underscoring the importance of sound policy in AQ initiatives, Mr. McMahon noted that the Nairobi Air Quality Action Plan was a great step towards ensuring improved AQ, in Nairobi and a big boost to the other existing legislation.

The approach used by Clean Air Catalyst program has three major steps, according to Mr. McMahon:

i) improving source awareness;

ii) identifying the most effective action; and

iii) building a strategic coalition.

Improving source awareness helps in identifying what people know about air pollution in order to build a shared understanding of the pollution sources that affect communities. Identifying the most effective action broadens the search for clean air solutions by identifying root causes and best solutions to reduce emissions in most-polluting sectors and even considering alternatives like economic incentives for behavior change. Building strategic coalitions of public, private, and community partners encourages participants to have strategic conversations about the roles that the parties could play to reduce emissions from a key pollution source.

Mr. McMahon thanked WRI and the other partners for organizing the workshop, and the participants for taking time off their busy schedules to participate in that forum. He concluded his speech with a quote underscoring the need for a united front in tackling air pollution: "Together, we will understand the sources and impacts of air pollution, and together we will find sustainable solutions."

The second speaker was the Principal Compliance and Enforcement Officer at the National Environmental Management Authority (NEMA), Ms Selelah Okoth. In her opening remarks, Ms Okoth noted that the effort from the workshop was a step in the right direction and would be a big boost to NEMA, which was overwhelmed and constantly unable to meet citizens' expectations because of the many requirements, capacity gaps and financial challenges. She further observed that

the project would boost the implementation of AQ Regulations (2014) whose implementation was based on data from mobile sources and stationary sources in Nairobi.

Expressing optimism, Ms Okoth observed that attendance of partners from different backgrounds, presented a great opportunity for a more strategic approach to solving the air pollution problem in Nairobi. Despite the fact that AQ involves a lot of scientific activities, the voice of the community remains critical in bridging the gap between science and policy. She thanked the Clean Air Catalyst program for bringing the communities on board and creating some space for the communities' voice to be heard and to tackle the problem of AQ together.

The third speaker to give her opening remarks was the USAID Mission Environment Officer, Ms Wilkister Magangi. She mentioned that for more than six decades, the USAID partnership had advanced a number of programs on various areas, including security and democratic values, for the benefit of both the American and Kenyan people. According to Ms Magangi, these partnerships are based on shared values, interests and issues.

Ms Magangi stated that, air pollution was a major issue of concern that should be addressed urgently as it has real implication on the residents of Nairobi, currently, and for generations to come. Cities like Nairobi are at the center of a growing health crisis caused by air pollution. As such, USAID is partnering with the government of Kenya and other partners to support policy processes and other areas including environmental health issues such as clean air. Clean Air Catalyst is one of the partners in this area of AQ.

Ms Magangi noted that the Clean Air Catalyst program seeks to address the drivers of air pollution and improve air quality for three reasons:

i) clean air assures good health, saves lives, promote children's health and prevents chronic illnesses;
ii) reducing air pollution will help mitigate climate change (of 0.6 Celsius degrees of warming by 2050);
iii) reducing pollution and improving air quality assures social justice for vulnerable communities.

Ms Magangi thanked Clean Air Catalyst for organizing the forum and welcomed the participants and panelists to the workshop.

The fourth speaker was the Nairobi City County (NCC) County Executive Committee Member Hon. Larry Wambua. According to Hon. Wambua, Clean Air Catalyst program came at an opportune time for Nairobi city, because the County recently passed the AQ Act, which is a great milestone in AQ management. The County also recently launched the Nairobi Climate Change Action Plan, which outlines several initiatives that the county will carry out to combat climate change. These policies aim to offer wide benefits to residents of Nairobi and Kenya generally by assuring improved mobility and a cleaner city for residents. They also enhance AQ management and embrace clean energy options.

NCC envisions that Clean Air Catalyst will support these actions by the NCC in partnership with all partners, including NMS and NEMA, to address AQ. Hon. Wambua noted that the forum was timely also because it sought collaborative approaches in addressing AQ through listening to different partners and participants in the forum. He welcomed the formulation of the Nairobi Air Quality Working Group, which would be a vehicle for bringing together research, vulnerable communities and policy drivers on the same table to ensure the sustainability of AQ actions in the city. In conclusion, Hon. Wambua thanked USAID for supporting Nairobi City through the Clean Air Catalyst Program and assured the partners of the commitment of NCC in getting the program implemented as outlined.

The final speaker in this session was the Nairobi Metropolitan Services (NMS) Director of Health Services, Dr Ouma Oluga. Dr Oluga thanked the organizers and participants for the forum as it provided a great opportunity for a conversation that would help in improving AQ in Nairobi.

While demonstrating the seriousness of the impact of air pollution on health of the residents of Nairobi, Dr Oluga noted that the number of patients visiting hospitals annually was nearly 4 million people, almost equal to the population of the city. Majorly, the burden of the disease diagnosed are respiratory (cough and breathing issues) and skin-related diseases.

Dr Oluga was optimistic that the forum, through the collaboration of different sectors, would be successful in coming up with rich and workable solutions to the problem of air pollution in Nairobi.

DAY 1

Theme: Air Quality Sources, Driver and Actions in Nairobi City

Introduction

Dr. George Mwaniki

Head of Air Quality Africa

World Resource Institute

The conference began with an introduction of the main themes and objectives of the workshop by Dr. George Mwaniki — the Head of Air Quality Africa at the World Resource Institute. According to Dr. Mwaniki, the workshop set out to achieve the following objectives:

1. To gather information on what work is being done in the AQ space in Nairobi;
2. To gain a current understanding of AQ in Nairobi; and
3. To mobilize support for clean air actions in Nairobi.

Further, the workshop aimed at finding out what other stakeholders were doing in the AQ space; the data being collected on AQ around Nairobi; the major gaps that would inform AQ action, and how the stakeholders could build on previous actions.

To establish the current understanding of AQ in Nairobi, the participants were to explore several thematic concerns, including: sharing experiences from work done by key institutions; and discussing the major sources and drivers of air pollution in the city.

Finally, the participants were to establish how stakeholders could mobilize support for faster action. Some of the major discourses among the participants were expected to revolve around the following questions:

i) How could a strong coalition be formed to support AQ actions in Nairobi?

ii) What would the coalition look like?

iii) What would be the key priorities for such a coalition? and

iv) How could the stakeholders build on Clean Air Catalyst achievements and ambitions?

Day 1 conference proceedings and discussions revolved around three key areas of AQ: *Sources, drivers* and *action taken* in Nairobi City. The next section provides a detailed report of the proceedings of Day 1.

Presentation 1

Impacts of Air Quality on Health in Nairobi City

Kenneth Waweru

Nairobi Metropolitan Services (NMS)

The first presentation focused on the following: air pollution issues in Nairobi; pollution sources, morbidity attributed to air pollution in Nairobi, trends of air pollution-related conditions in Nairobi; major contributors to air pollution in Nairobi; effects of pollution on health; progress on household air pollution; and areas that require support.

Introduction

Evidence has shown that exposure to high levels of air pollution has many adverse health outcomes for humans. The World Health Organization (WHO) records indicate that approximately 3.8 million deaths are recorded every year as a result of household exposure to smoke from dirty cooking stoves and fuels. Further, approximately 4.2 million deaths are recorded annually as a result of exposure to ambient air pollution. Equally, in Nairobi, air pollution is responsible for many of the health problems reported in hospitals as illustrated in Table 1.

Table 1. Top 10 causes of morbidity (over five years)

S/No	Disease (New Cases)	No. of Cases
1	Upper respiratory tract infections	768,415
2	Urinary tract infections	223,324
3	Diseases of the skin	174,797
4	Other lower respiratory tract infections	166,702
5	Hypertension	160,625
6	Diarrhea	129,045
7	Pneumonia	103,085
8	Arthritis, joint pains etc.	95,967
9	Suspected malaria	90,182
10	Eye infections/conditions	85,771

Major Contributors to Air Pollution in Nairobi City

Several major contributors to air pollution were identified. Motorized transport-related emissions were among the top on the list because the number of cars in Nairobi has been on an exponential rise annually. Open burning of waste and/or inefficient incinerators in health facilities were also highlighted as major contributors to air pollution in Nairobi. Other major contributors highlighted included emissions from industries (e.g., carbon monoxide, hydrocarbons, chemicals, etc.) and household pollution (e.g., charcoal cooking stoves).

Air Pollution Effects on Human Health

The effects of air pollution were divided into two major categories:

i) **Short-term effects** which include respiratory infections [bronchitis], pneumonia, headaches, nausea, eye, nose, and throat irritation, and allergic reactions; and

ii) **Long-term effects** which include chronic respiratory diseases [i.e., emphysema], lung cancer, heart disease, asthma, nervous, liver, or brain impairment, and premature death.

Other related impacts include decreased labor productivity (lost working days), and increased healthcare costs (hospital admissions).

Presentation 2

Involving the Community in Solving the Pollution Problem

Judy Macharia

Nairobi City Council

Involving the community in solving the air pollution problem has been at the center of the interventions rolled out by Nairobi County. These interventions mainly entail the involvement of Community Health Volunteers **(CHVs)** to provide community-based health services. CHVs are persons selected by the community, based on a set of criteria as defined by the Nairobi City Council Community Health Service Act of 2019. CHVs are expected to have undertaken some basic relevant training as per a provided curriculum that would enable them to offer community-based health services. CHVs operate within community health units (i.e., identified community health delivery structures located within the county health system comprising 1,000 households). There are 746 Community Health Units **(CHUs)** and 7,460 CHVs who operate within the CHUs. Table 3 shows the distribution of the CHUs and CHVs in NCC.

Table 2: Distribution of CHUS and CHVs in NCC

Sub-county Name	Total No. Of CHUs	No. of CHVs
Dagoreti North	56	560
Dagoreti South	44	440
Embakasi Central	27	270
Embakasi East	28	280
Embakasi North	52	520
Embakasi South	45	450
Embakasi West	37	370
Kamukunji	51	510

Kasarani	20	200
Kibra	63	630
Langata	37	370
Makadara	60	600
Mathare	49	490
Roysambu	12	120
Ruaraka	58	580
Starehe	50	500
Westlands	57	570
Nairobi County	746	7460

The role of CHVs in working with the communities to reduce household air pollution and thus reduce associated respiratory and cardiovascular diseases was recognized as important. For CHVs to be effective and efficient in working with communities, they need to be appropriately trained. As such, the CHVs' Basic Modules Handbook was developed to educate CHVs on how to conduct community mobilization [i.e., raising awareness and promoting options for both primary and secondary prevention], carry out the assessment of health-related air pollution issues in the

*Figure SEQ Figure * ARABIC 1: (From left) An ethanol cooker vendor explains how it works to CHVs; and a household using the ethanol cooker.*

community, and identify the appropriate air pollution actions at the household level.

NMS Community Health Service **(CHS),** through the national government, has trained about 50 CHVs from Kibra and Mukuru. Further, Macharia observed that, CHVs and Community Health Assistants **(CHAs)** need to be taken through the *Household Air Pollution Module 14* to enable them to serve the 746,000 informal settlement households effectively. The exposure to strategies in Module 14 would help the CHVs to raise awareness and share promotion messages among the community for primary and secondary prevention, assessment of health-related air pollution issues, and identification of appropriate air pollution actions at the household level.

The majority of the targeted households use charcoal, which is hazardous to health and in some cases fatal, as demonstrated through a tragic case in which a family in the Mukuru slums perished after falling asleep in an enclosed shelter while their charcoal *jiko*[1] was on. Adequately trained CHVs, could significantly help in reaching out to all the households assigned to them, and promote the use of clean fuels. As a way of promoting the use of clean fuels, CHVs could participate in 'community dialogue days' and 'community action days' with the key agenda being "promoting the use of clean fuels at the household level".

Gaps/Areas that require support

The following gaps/areas for support were identified.

1. There is an urgent need for Air Quality Monitoring (AQM) in the industries and health facilities within the Nairobi Metropolitan region.
2. There is a need for adequate capacity-building of NMS staff and the CHS workforce on AQ matters.
3. More should be done on the mapping of air pollution sources within the Nairobi Metropolitan region.
4. There is a need to invest in standard and modern equipment for AQ monitoring, including portable AQ monitors.
5. More efforts and resources should be put to strengthen data collection on AQ-related diseases/conditions.

[1] Jiko is a Kiswahili word that refers to a common charcoal cooking stove used by many families in Kenya

Presentation 3

County Government Action towards Addressing Air Quality and Climate Change

Margaret Kariuki

Air quality Lead

National City County (NCC)

Background

Nairobi, the largest city in Kenya, has a population of approximately 4 million people by night and more than 5 million people during the day. It is estimated that about 60 percent of this population lives in informal settlements. The city contributes over 60 percent of the GDP of Kenya. While the city is among the most urbanized in the country, urbanization occurs at a great cost to the outdoor AQ. Indoor AQ varies across households depending on the type of fuel used in each household. NCC has a limited AQM network and lacks long-term data to ascertain variations in AQ temporarily and spatially.

*Figure SEQ Figure * ARABIC 3: A picture of waste burning in one of the dumping sites in Nairobi.*

Nairobi City Council Government (NCCG) mandate on environmental management is derived from Part II of Schedule IV of the Constitution of Kenya, 2010 which includes: refuse removal, refuse dumps and solid waste disposal; control of air pollution, noise pollution, and other public nuisances; implementation of specific policies on natural resources and environmental conservation; county parks and recreation facilities; electricity and gas reticulation and energy regulation; as well as water and sanitation services.

Sources of Air Pollution in the City

There are several major sources of air pollution in Nairobi — including transport, solid waste mismanagement, crude incineration, industries, biomass burning both indoors and outdoors (wood, charcoal, etc.), and dust from unpaved roads and construction sites.

Air Pollution Status in Nairobi

Generally, the information on air pollution in Nairobi is from short-term measurements conducted after the year 2000. However, many of the existing studies show that ambient air concentration exceeds the national standards and the WHO guidelines limit of ($PM_{2.5}$) $\mu g/m^3$ 24-hour mean. Therefore, AQ in Nairobi is largely considered "unhealthy".

The city has several locations for AQ monitors as illustrated by the Table 3, which shows both active and inactive sites around Nairobi County.

Table 3:Active and Inactive Sites around Nairobi County

S/NO.	LOCATION	AREA WITHIN NAIROBI	OWNERSHIP	COMPONENTS MEASURED	STATUS
1	Braeburn School	Roysambu-Maruiui	UNEP/NMS/NCCG	PM10&CO2	Down
2	Kasarani Stadium	Kasarani Stadium	UNEP/NMS/NCCG	PM10&CO2	Working
3	Nyayo Stadium	Nyayo Stadium	UNEP/NMS/NCCG	PM10&CO2	Down
4	Bins Services	Industrial area	UNEP/NMS/NCCG	PM10&CO2	Working
5	Chandaria Foundation	Baba Ndogo	UNEP/NMS/NCCG	PM10&CO2	Working
6	Kenya Wildlife Services (KWS)	Southern Bypass	UNEP/NMS/NCCG	PM10&CO2	Working
7	Naivas -Waiyaki Way-Westland's	Westlands	UNEP/NMS/NCCG	PM10&CO2	Working
8	Luthuli Avenue-Starehe	CBD-Luthuli Avenue	UNEP/NMS/NCCG	PM10&CO2	Working
9	UNEP-HQ-MAIN ENTRANCE	Gigiri	UNEP/NMS/NCCG	PM10&CO2	Working
10	UNEP-HQ-NOFI OFFICE	Gigiri	UNEP/NCCG/NMS	PM10&CO2	Working
11	MBAGATHI HOSPITAL	Mbagathi road	UNEP/NCCG/NMS	PM10&CO2	Working
12	Safaricom care-Hqs	Off Waiyaki Way	UNEP/NCCG/NMS	PM10&CO2	Working
13	Eagle plains Estate	Industrial Area	UNEP/NCCG/NMS	PM10&CO2	Working

14	KARA Offices	Dagoretti North	UNEP/NCCG/NMS	PM10&CO2	To be commissioned

Impacts of Air Pollution in Nairobi

Air pollution has many adverse impacts on the residents' health, many of them respiratory. This is because pollutants like PM2.5 go directly into the lungs when breathed in. Table 4 shows different top causes of morbidity and mortality as reported by different hospitals in Nairobi County.

Table 4: Top Causes of Morbidity and Mortality in Nairobi County.

No.	Top Causes of Morbidity <5 Years	Top Causes of Morbidity >5 YEARS	Top Causes of Mortality <5 YEARS	Top Causes of Mortality >5 YEARS
1	Diseases of Respiratory System	Diseases of Respiratory System	Pneumonia	Diseases of Respiratory System
2	Diarrhea	Diseases of the skin (including wounds)	Asphyxia	Accidents
3	Diseases of the skin (including wounds)	Urinary Tract Infection	Respiratory Diseases	TB/ HIV
4	Pneumonia	Diarrhea	Malaria	Heart Diseases
5	Clinical Malaria	Clinical Malaria	Diarrhea	Cancer

Governance in AQ Management

Policies and Programmes

There are several policies and programs already in place to guide AQ management in Nairobi City. They include the Integrated Urban Development Masterplan for the City of Nairobi (NIUPLAN); the County Integrated Development Plan (2018-2022); sector-based policies and regulations (e.g., on waste management [e.g., control of open burning], non-motorized transport, energy, etc.); Climate Change Action Plan; and public awareness and sensitization programs.

The Nairobi City Air Quality Action Plan

The overall purpose of the Nairobi Air Quality Action Plan (2019 – 2023) is to build the capacity of relevant national and city officials to develop, implement and enforce improved policy and regulatory frameworks for AQ management and support the development of strategies for AQ management in Nairobi City. There are four key actions in this plan:

i) Build scientific evidence for policy interventions for AQ management, including: improving the capacity of the city staff, installing a network of AQ monitors and a reference station, estimating the health and environmental/climate change impacts of the city and future trends, and updating the existing Greenhouse Gases (GHG) inventory.
ii) Raise public awareness about the health and environmental impacts of air pollution through developing awareness materials and preparing a communication strategy.
iii) Develop effective approaches for AQ management through the implementation and legislation of an AQ policy and build a roadmap towards an effective implementation and enforcement program for AQ legislation.

Climate Action Plan (CAP), 2020-2050

The launch of the Climate Action Plan (CAP) 2020-2050 in June 2022 marked a great milestone for Nairobi City in its efforts to improve the AQ in the city. The adoption of the policy will help Nairobi City to create green jobs, restore parks and open spaces that will improve mobility options for citizens, enhance air pollution management, and embrace clean energy options. Figure 5 demonstrates the steps of the implementation of CAP and the various contexts of its operation.

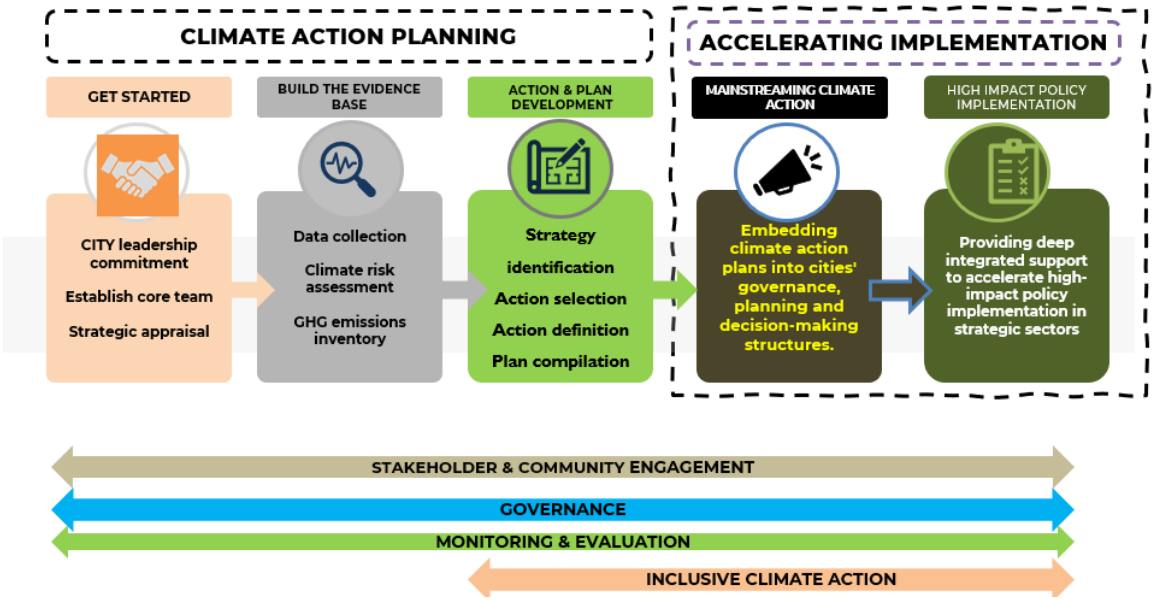


Figure 4: Steps of the Implementation of CAPs

Way forward

The city is focused on implementing the Actions Plans in AQ and climate change and will continue mainstreaming climate change in city governance structures and processes, engaging and partnering with more stakeholders to ensure impactful implementation, and welcoming stakeholders to collaborate in the development of AQ regulations.

Presentation 4

Gender and Equity Dimensions and Air Pollution in Nairobi County

By

Jane Wambugu

and

Roselyne Mkabana

Nairobi City Council

Climate change and air pollution do not affect genders in the same way. Most often, they exacerbate pre-existing gender inequalities and discrimination among women and girls. Evidence shows that women and girls depend on climate-sensitive work and have limited access to economic resources, which increases their vulnerability to adverse climatic events that threaten their livelihoods.

Generally, during the conflict and displacement resulting from natural disasters like environmental degradation, the likelihood that women, girls, and marginalized groups will be exposed to Violence Against Women (VAW) increases exponentially. In addition, gendered and systemic inequalities limit women's access to requisite information, decision-making, choices, mobility, safety, and economic opportunities.

The following are effects of air pollution from a gender perspective as highlighted by the presenters:

1. An increased health burden intensifies resource allocation to marginalized people with pre-existing conditions and access to further management as it exacerbates the conditions with co-morbidities.
2. It limits access to basic services for the urban poor as infrastructure is focused on elimination as opposed to preventing and decentralizing healthcare co-morbidities.
3. It intensifies the rationalization to whom and when health becomes a priority at the household level as livelihoods and vulnerability are intertwined.
4. It creates a limited appreciation for health and well-being and increases tension (mental issues) and coping skills (abuse and violence), as well as management outcomes for health services (vicarious trauma).
5. It increases women and girls' vulnerability to pollution during cooking through the use of firewood, charcoal, etc. The expenses involved are normally left to the woman.

Nairobi County Initiatives

Nairobi County has invested in various projects and initiatives to ease the implication and burden of air pollution and environmental degradation on marginalized people and women.

1. **Early warning and response hubs —** Institutionalizing gender-responsive solutions during disasters.
2. **Education** — Investing in strengthening curriculum on climate change and allowing an early understanding of air pollution.
3. **Establishment of water points —** Addressing women's traditional household roles of fetching water, which exposes them to GBV.
4. **Launching of accessible health facilities —** Supporting health needs of vulnerable members of society.
5. **Social protection programs** — Helping women alleviate economic stress and addressing their needs.

Questions and Comments

Comment 1: One of the participants advocated for the inclusion of men during the design and implementation of the sensitization campaigns because, in most households, men are the decision-makers. The participants further urged the implementers of such gender-based campaigns should view men as "protectors", and not as "perpetrators" to reduce gender-based violence.

Comment 2: Another participant added that there was an urgent need for sufficient strategic sensitization campaigns on air pollution for women as they are more exposed to indoor air pollution.

Comment 3: There is need to focus on how limited resources and information lead to gender-based violence, and how important it is to address this issue in the context of air pollution.

Comment 4: CHVs could play a significant role in the implementation of air pollution interventions. Therefore, CHVs need to be equipped with the necessary information and requisite training on air pollution.

Question 1: *When do we consider the gender perspective in air pollution initiatives*?

The presenter clarified that a gender-based solution applies to all genders (men and women alike). Further, she noted that where the distribution of the population affected by air pollution is equal, then the issue cannot be considered a gender issue.

Presentation 5

Clean Air Catalyst Theory of Change — Nairobi

Ethan McMahon

CAC Chief of Party

WRI

Overview

According to Mr. **Ethan McMahon,** Chief of Party-Clean Air Catalyst (CAC)**,** the CAC program is a five-year flagship program launched by the United States Agency for International Development (USAID) and a global consortium of partners led by the World Resources Institute (WRI) and Environmental Defense Fund (EDF). The CAC aims to advance locally-tailored, self-reliant solutions for clean air, climate, and improved human health in cities. CAC is working in three pilot cities over five years — Jakarta-Indonesia, Indore-India, and Nairobi-Kenya.

Program Strategy

The CAC program strategy has three major areas:

1) improving source awareness;
2) identifying the most effective action; and
3) building a strategic coalition.

These three areas are expounded below.

1. **Improve source awareness:** Improving source awareness entails identifying what people know about air pollution to build a shared understanding of the pollution sources that affect communities in each city. This area has three main activities:
    i) *Building capacity to identify key pollution sources* — this includes identifying major data gaps and disputed knowledge about air pollution sources.
    ii) *Strengthening scientific understanding* — this includes deploying a strategic monitoring campaign and science plan to increase shared understanding of the sources of pollution that damage health and climate.
    iii) *Deepening community understanding* — this includes training journalists and influencers to disseminate information and correct misinformation findings.

2. **Identify most effective action:** This step necessitates broadening the search for clean air solutions by identifying the root causes and best solutions to reduce emissions in the most-polluting sectors. This entails two main steps:
   i) *Root cause analysis* — Root cause analysis will involve evaluating the underlying drivers of emissions activities in the local context, including social, political, and behavioral factors.
   ii) *Priority action* — This refers to working with community stakeholders to determine the most effective way to disrupt the root causes of emissions in order to develop novel and high-impact solutions at the intersection of health, climate change, and equity.
3. **Build strategic coalition:** This includes building a coalition of public, private, and community partners to reduce emissions from a key pollution source. Three key activities will be undertaken.
   i) *Identifying critical decision makers* — This will necessitate prioritizing public officials, private sector representatives, and community leaders who have the authority and influence to implement the identified interventions.
   ii) *Outreach on solutions* — This will entail conducting evidence-based outreach of clean air solutions to private and public stakeholders.
   iii) *Coalition building* **—** This involves convening a coalition to influence the critical decision makers to enact solutions that reduce emissions, exposure, and pollution.

More about Source Awareness

Commenting further on source awareness, McMahon noted that *source awareness is a politically relevant and shared understanding of pollution sources.* The program's overarching hypothesis is that building a more widely shared understanding of pollution sources will create a political climate that is more favorable to effective, sustained clean air action in the pilot cities. Further*, the program's emphasis on source awareness complements the more typical AQ advocacy campaigns* built around the impacts of air pollution. It does not replace them. *"We cannot expect people — civil society or leaders — to care about addressing the sources of pollution if they do not see pollution as a problem in the first place,"* McMahon explained. Therefore, source awareness is meant to help build support and momentum for: i) the pilot city's overall AQ action plans, and ii) the coalition to be built around a subset of pollution sources.

Co-creating Solutions

The program is founded on the principle of co-creating the solution and, as such, pilots lead the way because they understand the local AQ, air pollution sources, what has been tried before, and key parties to work with. The Catalyst team has experts who can help in many ways — including AQ modelling and AQ analyses, communications, health impacts, root cause analysis, etc.

Be Part of the Solution

The presenter concluded by appealing to the participants to become part of the solution by contributing data to explain AQ and sources, evaluating data from modeling and new monitoring, analyzing impacts on health, climate, and gender, as well as identifying key parties to collaborate with.

Session 2

Group Discussions

During this session, the participants were divided into eight groups. The participants explored five major sectors to establish the most significant pollutants in Nairobi. These sectors were: Waste, transport, industries, health, and energy. In addition, the participants also discussed the outputs from AQ research, the AQ impacts, and any other sources of pollutants in Nairobi. The discussions were guided by the following questions:

1. What are the most significant pollutants from the sectors?
2. What are some of the sectors' specific drivers of the emissions?
3. How does emission from these sectors affect different groups (gender, income levels, and vulnerable groups)?
4. What are some of the actions being undertaken to reduce emissions from the sectors?
5. How important will these sectors be in terms of air pollution emissions in the next 10 years?
6. Where can we get more information on the sectors?

Table 5 presents a summary of the outcomes of the deliberations from the groups' plenary sessions and discussions.

Table 5: Outcomes of the Deliberations from the Groups and Plenary Sessions and Discussions

	Q1. What are the most significant pollutants from the sectors?	**Q2. What are some of the sectors' specific drivers of the emissions?**	**Q3. How does emission from these sectors affect different groups (gender, income levels, vulnerable groups)?**	**Q4. What are some of the actions being undertaken to reduce emissions from the sectors?**	**Q5. How important will these sectors be in terms of air pollution emission in the next 10 years?**	**Q6. Where can we get more information on the sectors?**
GROUP 1 **WASTE**	- Carbon dioxide - Carbon monoxide - Sulphur dioxide - Nitrogen dioxide - Dioxins	- Budget constraints - Inadequate collection - Poor waste disposal - Poor waste management practices	- Activities run by the youth — make them more vulnerable - Low-income populations more exposed	- Sustainable waste management - Linear approach - Nairobi City County - Stakeholder forums - -Advocacy for behavior change	- Waste management very key in reducing emissions in the city	- Seminars - Social media - Community - Relevant website (NMS)
GROUP 2 **TRANSPORT**	- Carbon dioxide - Carbon monoxide - Sulphur dioxide	Road transport	- Affects men more because they travel more, private vehicles - Road side vendors, most are women are expose to long - Poor people use old vehicles - Street children and people living with disability	- High quality of fuels - Standards for vehicles being imported and regulations on inspection - NEMA policies on control of emissions - Electric automobile - Investments in mass rapid transport - Rail and encourage non-motorized transport	- Awareness is low - Capacity building of staff at SAGAs and Regulators - Economic interests - Enforcement challenges and conflicts - Synergy between actors lacking e.g., NEMA vs NTSA vs Police - Silo mentality between agencies - Political goodwill for transformational change - Lack of equipment to test environmental compliance by ICE	- Constitution 2010 - EMCA - Air Quality Regulations 2014 (EMCA) - Climate Change Act - Public Health Act (Cap 242) - Bylaws of Nairobi City County; superseded by County Assemblies Transport Act - Traffic Act - NTSA Act
GROUP 3 **INDUSTRY**	- Carbon emission - Chemical - Particulate matter	- Obsolete technology - Energy (fuel) source - Infrastructure - Choice of raw materials	- Low-income earners next to the industries - Both men and women	- Replacing the old technology - Preventive maintenance - Automation of processes	- Very important — the country is industrializing. - Increasing population	- Ministry of industrialization - KAM - NACOSTI

		- Poor urban planning - Cutting production cost	- In the textile, flour industries — more women affected - Vulnerable groups also affected	- Monitoring of emissions - Use of cleaner energy sources and fuels. - Capacity building on air pollution - Research and development	- Increased demand for commodities.	- NEMA -
GROUP 4 **ENERGY**	- Carbon monoxide - Carbon dioxide	- Income levels - Availability of resources - Accessibility - Infrastructure - Affordability	- Both genders affected - Low Income levels - Elderly most affected as they are more vulnerable	- Clean energy - Cultural education to —reduce cultural bias - Drive awareness - Supporting better policies - Promoting renewable energy	- Increased population leading to demand on energy	- Research output from universities - Companies dealing with innovative energy ideas - Community - Research - NGOs, e.g. UNEP
GROUP 5 **Air quality research**	- PM 2.5 - PM 10 - Carbon dioxide	- Data standards - Calibration of data - Average, duration and location of data collected - Consistence in data collection - low quality sensors	- All in terms of health - Vulnerable children	- Set up information management system - Capacity building - Set up AQ policy plan	- Improved health - Reduced pollution, e.g. vehicle emissions	- Research institutions - Private entities - Documentaries
GROUP 6 **Air quality impacts**	- SOx - NOx - PM - VOC - COX - BC - PAH - Toxic metals	- Vehicles - Industries - Waste burning - Households - Institutions - Energy sources - Medical facilities – incinerators	**Gender**: Generally, both female and male are equally affected - **Outdoor** pollution affects both genders - **Indoor** pollution affects women more than men **Some of the Health impacts:** respiratory diseases, eyes irritability, headaches, cancers, deaths	- Enforcement of existing laws, EMCA 2014 - Bill for the county - Climate action plan - Capacity building - Creating awareness and sensitization - Stakeholder workshops	- Improved health - Improved AQ - Better living conditions - Responsible citizens due to sensitization - Clean city - Better world	- Peer-reviewed publications - Health facilities - NGOs - Government institutions e.g. NEMA, KEMRI

			Effects by Income Levels: Low-income earners — high negative impacts Middle income earners — medium negative impacts High income — low negative impact **Highly Vulnerable groups** - Children — organs are still developing - Elderly — health complications and pre-existing condition - Sickly — Low immunity - Pregnant women — Low immunity			
GROUP 7 **OTHER SOURCES**	- Construction and demolition - Street food vendors - Petrol Stations - Agriculture — rice paddies, Livestock rearing (greenhouse gases) - Dust (street sweeping, unpaved roads) and pollen — seasonal pollen monitoring - Waste oil recycling - Burning of office waste	- **Inadequate enforcement** of the law - **Blatant ignorance** of the construction environment monitoring plans (mostly men; and low-income earners are more involved) **Street food vendors:** - No laws to govern street vendors — informal business	- More women at the pump stations — mostly youth - Lower–middle income earners	- Regulations to govern the sectors - Policies in place - Weak enforcement - Sensitization of the public — common citizens are key	- Construction will increase — dust etc. - More people will be aware — citizen awareness policies - Better technologies, better equipment and machineries - Regularization of street vendors	- Online - Stockholm Environment Institute (SEI) - Climate works Foundation - Treasury — green policy - EPRA

	- Synthetic paints and spray - Venting of refrigerants — ozone depleting gases, GHGs - Dry inland port	- Type of fuel used — sawdust, charcoal - Increased demand for fresh food (more women involved in this business; and low-income earners) **Petrol Stations** - Carelessness at the pump — switch off your car! - Lack of/non-compliance to appropriate standards. More women and youth work at the pump stations; as well as lower–middle income earners - Vulnerable groups				
HEALTH	- Dioxins (CO) - Methane - Sulphur dioxides - Particulate matter - Microorganisms - Carbon - Radon gas -	- Fossil fuel - Radioactive diagnostic materials - Chemicals from solvents, reagents used in laboratory preparations, disinfectants - Chemicals used in prevention of diseases e.g., IRS - Laboratory specimens - Patients	- Gender (equal risks) - Vulnerable groups (pregnant women, children below 5years, elderly, and immune-compromised individuals - Premature birth, low birth weight, birth defects, respiratory illnesses - Income levels (absenteeism)	- Gradual movement from burnt to non-burnt technology (autoclave & microwave - Instead of using firewood some facilities are using gas - Training Module 14 'Air Pollutions' - Nairobi City County Medical Waste Management, Nairobi City County Waste Referral Policy - TWG for air pollution, Climate change	- Community Health Structures (community engagement and involvement) - Centre of Excellence in Africa (KEMRI) - Kenya Specific AQ guideline - Contribute in evidence-based solutions -	- MOH Website - Nairobi County Assembly Website - KEMRI - Clean Africa Website - WHO -

				- Controlled use of volatile lab substances		

DAY 2

Theme: Source Awareness — A Deep Drive on Shared Understanding of Sources of Air Pollution in Nairobi City

Presentation 1

Source Awareness: Air Quality Monitoring in Sites within Nairobi City

by

Selelah Okoth

Principal Compliance and Enforcement Officer

National Environment Management Authority (NEMA)

The first presentation on source awareness and AQM within Nairobi City was made by Ms. Selelah Okoth from NEMA. Okoth began by highlighting the existing legal and institutional frameworks including the Constitution of Kenya, 2010; and the Environmental Management and Coordination (EMCA) Act, 1999. EMCA provides the legal basis for AQ management (sec. 78-82) and establishes NEMA. Indeed, NEMA has the mandate on air pollution control legislation, standards, compliance assistance, promotion, and enforcement of the legislation and monitoring.

In terms of the scope of the AQ regulation of 2014, the overall objective is to provide for the prevention, control, and abatement of air pollution. Currently, the focus is on ambient air pollution from stationary sources, mobile sources e.g., internal combustion engines, premises, and places of work — to which provisions of the Act and regulations may apply, and any other activity the Cabinet Secretary may order in the Gazette.

Stationary Sources

As far as the scope of the stationary sources is concerned, NEMA focuses on the following:

a) requirements for emission licensing based on stack emission reports, full and provisional;
b) emission standards — PM, SO_x, NO_x, CO, CO_2, HC, VOCs, H_2S, HCl, O_3, Hg vapor, Pb & its compounds, dioxins, and furans for various sectors;
c) air pollution control system;

d) prohibitions on fugitive emissions — impact on ambient and outside property boundary

e) fugitive emission control plan, including reduction measures;

f) requirements for dispersion modelling; and

g) requirements for ambient air monitoring

Mobile Sources

As far as the scope of the mobile sources is concerned, NEMA:

a) regulates internal combustion in general from vehicles, tricycles, motor bikes, aircraft, ships, etc.;

b) provides emission standards - PM, SO_x, NO_x, CO, HC, VOCs;

c) provides methods of test — according to Kenya Standard 1515:2019;

d) provides guidelines for motor vehicle inspection — annual test for commercial; every two years for private vehicles; and

e) oversees the implementation of emission reduction measures, e.g. canisters, exhaust gas reticulation valves, diesel particulate filters, and flow through filters (12^{th} Schedule of AQ Regulations).

Inspection and Monitoring

For ambient AQM, NEMA has a mobile Air Quality Monitoring laboratory equipped with the following:

a) ECOTECH Serinus for Gases-CO, CO2, Ozone, Nox, Sox, total VOCs;

b) GRIMM for $PM_{2.5}$ and PM_{10}; and

c) Gas Chromatography (GC) for BTEX.

According to Okoth, although NEMA does not have a large pool of current data, it uses data from the mobile lab to get indicative data.

Data Usage

The AQM data is used for policy direction and regulatory compliance — as a trigger for review of AQ regulations, dissemination, development of AQ management plans, partnerships, and collaborations.

Challenges

NEMA faces numerous challenges in its effort to achieve its mandate. They include:

a) technical capacity gaps in AQ monitoring and review of reports (i.e., data interpretation);
b) inadequate equipment tied with high maintenance costs — for instance, the calibration of equipment is done annually by a firm from South Africa;
c) the weak linkage between science and policy; and
d) scattered efforts in AQ-related activities.

Presentation 2

Community Science as a Methodology of Understanding Air Pollution Challenges at the Community Level

Dr Romanus Opiyo

Research Fellow

Stockholm Environment Institute (SEI)

Stockholm Environment Institute (SEI) (A Brief Background)

The second presentation was by Romanus Opiyo**,** research fellow at Stockholm Environment Institute (SEI)**,** an international non-profit research and policy organization that covers a wide range of knowledge-related activities. Founded in 1989, SEI focuses on environmental dimensions of human development and aims to contribute to better living conditions around the world, including for poor and vulnerable groups, through better "policies, technologies and related management techniques and strategies for an environmentally sustainable development of society". SEI recognizes that poverty and the environment are interconnected and need to be addressed together. People in poverty are usually the most vulnerable. In some contexts, poverty contributes to environmental

degradation, because people lack knowledge, resources, and basic services and end up over-exploiting the local environment on which they depend.

As such, the one goal of SEI is to connect science and decision-making to develop solutions for a sustainable future for all. Stakeholder involvement is at the heart of SEI's efforts to build capacity, strengthen institutions, and equip partners for long-term change.

According to Opiyo, SEI's Strategy 2020-24 on Knowledge for Action focuses on three impact areas — reduced climate risk; sustainable resource use and resilient ecosystems; and improved health and wellbeing.

Background

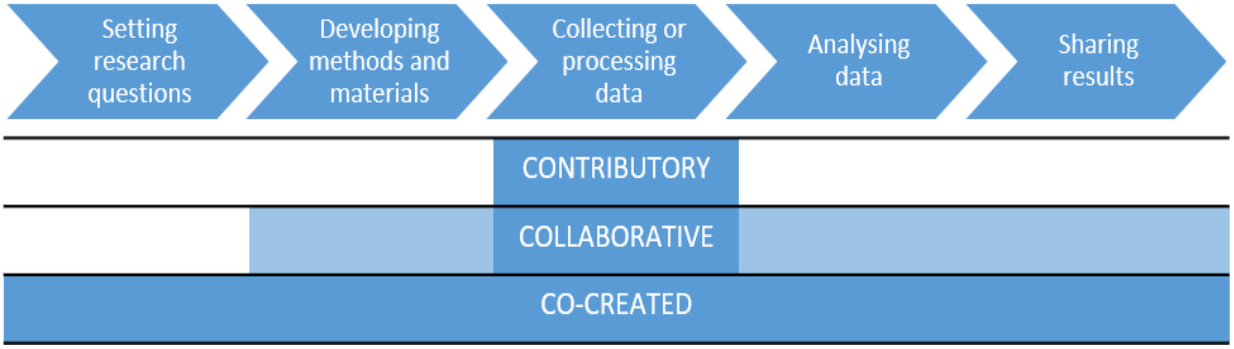
Opiyo noted that the mosaic nature of the urban landscape, including the informality (i.e., location, unpaved tracks, and use of biomass fuel), exacerbates the problem of air pollution. The problem is compounded by the little measure of air pollution exposure among different communities of African cities. Otherwise, AQ is becoming a global concern, and scientists are working with all affected communities because sustainable AQ strategies require joint effort.

Citizen Science

SEI champions the use of Citizen Science in coming up with strategies for solving AQ issues. According to Opiyo, Citizen Science is the partnering of citizens and scientists to answer real-world scientific questions through the **active** participation of citizens in one or more stages of the scientific process. The data are **used** in scientific research and decision-making, among other processes.

Types of Citizen Science Projects

There are three types of approaches to Citizen Science: *contributory, collaborative, and co-created.* All the three approaches utilize a similar research path that entails five steps: setting research questions; developing methods and materials; collecting or processing data; analyzing data, and; and sharing results.



Opiyo used a case from Mukuru (one of the largest informal settlements in Nairobi) to demonstrate the utility of Citizen Science. In Mukuru, an "Engagement–Collaboration" approach, which was demand-driven, was used. The project entailed the use of Dylos monitors to measure variations in their exposure to fine PM2.5 within the settlement over a day. Questionnaires were also used to collect data before and after the monitoring campaign to assess any changes in knowledge or attitude in the wider community. A total of 193 respondents filled out the questionnaire. Finally, two workshops were conducted, which facilitated the Citizen Science approach and brought together members of the community, local policy makers, and researchers. Up to 47 participants took part in the two-day workshop.

Some of the key findings indicated that there were spatial variations of scores of PM2.5; and there were highly significant personal exposures in the evening periods — especially for indoor pollution. The use of mobile exposure sensors and GPS trackers by the community helped in understanding the variations and exposure levels associated with different locations and functions, and the results encouraged more conversations and interests among various players, including the community.

There are other SEI AQ activities — including partnering with the NCCG, *Muungano wa Wanavijiji,* APHRC, and residents in Mukuru SPA. SEI is also working with the Nakuru City Residents, Athletics Kenya, the United Nations Environment Programme (UNEP), NCCG, and the SMB.

Opiyo concluded, by noting that Citizen Science is a useful tool for engaging communities. It is an engagement that requires developing trust with the community. In Nairobi County, priority for Citizen Science ought to be given to vulnerable people and hotspot locations (e.g., informal settlements) due to the high population.

Reference to the Nairobi Zonal Development Ordinance Guideline and the Nairobi Integrated Urban Development Master Plan (NIUPLAN) is key in identifying hotspots and locations of vulnerable populations. In addition, AQ linkage with impacts is a message which needs to be well

articulated to all stakeholders. SEI looks forward to continuing working with various partners (both old and new) to attain the desirable AQ for the city of Nairobi.

Questions and Comments

Comment 1: A participant appreciated the SEI approach and reiterated that engaging the community on the issue of air pollution is critical for sustainable problem-solving. In addition, linking policy and science is equally important. Scientists should craft their communication in a way that is accessible to citizens and politicians, too. The community and the politicians should be integrated into the policy process at the point of design and planning in any area. Health professionals should be included in policy design to guide and inform policy makers on air pollution dangers.

Presentation 3

Monitoring Research Using Low-Cost Sensors (LCS) in Different Cities Within the City

By Victor Nthusi

Associate Officer, Pollution and Health Unit

UN Environment Programme (UNEP)

Recent Advancements in Air Quality Monitoring Networks in Nairobi, Kenya

The third presentation was by Victor Nthusi, an Associate Officer, Pollution and Health Unit, at UNEP. Nthusi began by noting that any effort of controlling air pollution needs data. We need data so that we can have emission inventory, AQ modeling and monitoring, and control measures.

According to Nthusi, even though not all pollutants can be measured, we need sensors for AQM. AQM is a costly affair. But we can move from high-cost to affordable AQM stations. Despite high-cost AQ monitors being more accurate, they are expensive ($150,000–$200,000). The costs of installation and operation are also high. The affordable AQ monitors are sufficiently accurate and less costly ($100–1,000). The costs of installation and operation are relatively low.

Nthusi used several case studies to demonstrate the concepts of affordable AQM. The first case study Nairobi Network (2016 – 2018) had six sensors deployed in the area of high population density targeting schools and high-traffic sites as shown in Table 6.

Table 6: Sensors Deployed in Area of High Population Density

Site No.	Name	Type	Data Capture	Description
1	Kibera Girls Soccer Academy	Informal settlement	100%	Site located to measure typical concentrations in an area of high population density
2	Viwandani Informal Settlements	Industrial/ Informal settlement	32%	Site located to determine the impact of a significant source (industry) on air quality
3	St. Scholastica Catholic School	Traffic (Highway)	100%	Site located to determine the impact of a significant source (traffic) on air quality
4	UNEP Headquarters, Gigiri	Sub urban	100%	'Clean' site
5	All Saints Cathedral Primary School	Urban	100%	Site located to determine the impact of a significant source on air quality
6	Alliance Girls High School	Urban background	83%	Sites located to determine general background concentration levels

The second case was done at Luthuli Avenue Regeneration (2019–2020) while the third case entailed Real Time AQ Monitoring (2021–2022) in several spots in Nairobi. The details of these studies and findings can be retrieved by clicking the link http://doi.org/10.13140/RG.2.2.10240.64009

Lessons Learnt: Why a Monitoring Strategy is Important?

There are several reasons why scientists monitor AQ, as captured in Table 7.

Table 7: Why Monitoring Strategy is important

Basic Objectives	Specific Objectives
Timely public reporting	Assess short-term pollution levels Develop an AQ index (or other tools for data communication) Forecasting Activate emergency control procedures for episodic conditions
Compliance/ Planning	Determine compliance levels with standards Observe pollution trends Formulate pollution control strategies Evaluate the effectiveness of pollution control strategies Support national and international agreements and initiatives
Impact Assessment	Assess impacts on different groups of populations Assess impacts of land use, transport plans and other control strategies and regulations on ecosystems and assets Develop and validate management tools (e.g., models) Discover new contaminants Develop and test analytical instruments Assess the impact of significant sources or source categories on ecosystems and assets To establish exposure-response and/or cause-effect relationships regarding the risk to human health, animals, crops and ecosystems
Long-term Monitoring	Observe long-term pollution trends Establish general background concentration levels

Opportunity for Upscaling

A few opportunities for upscaling were highlighted. The current AQM presented opportunities for:

h) integrating networks into the global movement;

i) provoking action — by highlighting the current PM values against WHO thresholds; and

j) filling the data gap.

Presentation 4

Theme: Sharing Data on Sources of Air Pollution in Nairobi City

Air Quality impacts on Health

By Prof Augustine Afullo

Consultant

Geo Health

Background

In his presentation, Prof Afullo observed that poor AQ resulting from rapid economic development, industrialization, and the socio-demographic transition is a major challenge in many African countries. There are several air pollutants, but Prof Afullo singled out a PM and termed it as a pollutant of high interest globally. As such, there is a need for more data for a time series comparison, especially for the rapidly growing city of Nairobi.

Low-Cost Sensors (LCS) used to collect real-time AQ data provide high-resolution partial and temporal quality data. They are, however, subject to biases, calibration dependencies, and corrections ranging from the meteorology, age of the sensor, and aerosol source.

Air pollution can have varied effects on humans depending on the age of a person, the concentration of the pollutants, and exposure time. Cumulatively, it is estimated that air pollution causes the deaths of about 7 million people a year and accounts for a third of fatalities from stroke, lung cancer, and heart disease. Figure 6 summarizes the health impacts of air pollution on human systems (particularly the PM air pollutants).

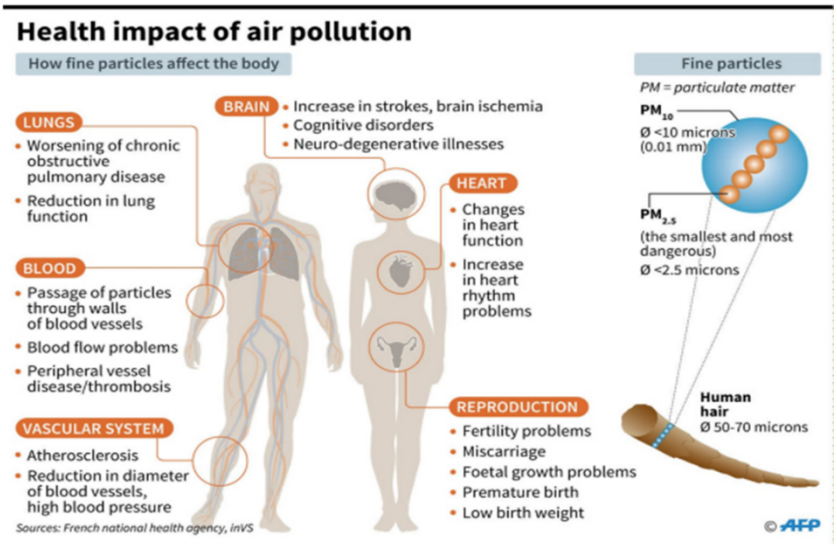


Figure 6: Health Impacts of Air Pollution on Human Systems

PM is commonly classified by size — PM10 [10 micro centimeters in diameter or less] while PM2.5 [2.5 micro centimeters in diameters or less]). The PM10 particulate matter may be from windblown dust, marine aerosol, or pollen, while the PM2.5 may be from industry, motor vehicles, home heating, and outdoor burning. The course particles may deposit on the upper region of the airway, irritate it, and cause coughing and difficulty in breathing. Fine particles may lodge deep in the lungs and could lead to aggravated asthma or harm to the cardiovascular system. Respiratory system diseases remain a big challenge in the country and were the leading cause of morbidity (at 25 percent) of all disease incidents in 2019 in Kenya. Figure 7 below summarizes the health effects of PM10 and PM2.5 on human health

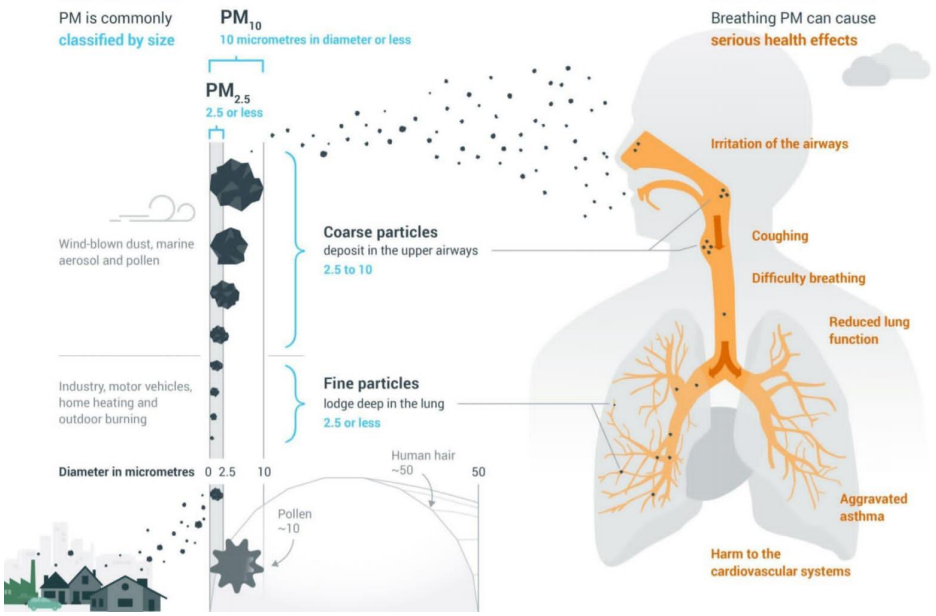


Figure 7: Particulate Matter (PM) and Health Effects

To manage the problem, sufficient data from the AQ sensors would be needed - to establish where and when the pollutants are likely to be at their most dangerous points.

Presentation 5

Low-Cost Monitoring and Community Engagement: A Regional Perspective

Gideon Lubisa

Embedded Systems and Network Support Engineer

AIRQO

This presentation set out to provide a regional perspective on the use of Africa-centric innovation low-cost sensors and the importance of community engagement. While providing a background of AirQo, the presenter noted that AirQo was founded in 2015 at Makerere University, Uganda, to close the gaps in AQ data in Uganda and across Sub-Saharan Africa.

AirQo has turned to Africa-centric innovation and low-cost monitoring infrastructure using locally developed technology. AirQo has two types of monitors: static or mobile. They are GPS enabled, powered by a battery, and come with solar backup. They have dual PM2.5 and PM10 sensors. They are designed and built to meet the challenges of the local environment — including intermittent power and internet connectivity, high PM levels, dust, and humidity.

AirQo also offers a low-cost data pipeline that entails Cloud IoT, data (pre)processing and raw data storage, local calibration (retrained monthly), calibrated data storage, and analytics modeling. Another salient feature is its effective large device network management capability by harnessing site details and metadata, understanding device uptime and overall device performance, calibration as a useable product for low-cost sensor initiatives, and creation of opportunities for a one-stop center for quality assurance.

To advance data-driven conversation for action, development partners, the public, and the government — i.e., the City County and designated government agencies, civil society organizations, academia, and the private sector — should be involved and properly engaged. Different avenues and strategies should be employed to engage diverse stakeholder groups for action. In addition, there should be collaboration synergies for policy and awareness initiatives. Data collected during these projects could be used to close the feedback loop between citizens and authorities.

The following are the implications and opportunities for upscaling from AirQo initiatives:

i. Scalable network set-up: participatory network development for cities

ii. Data Access and QC: calibration as a useable product; and AirQo/UNEP BAM Data Solution (Low-cost solutions to AQ data access)

iii. Digital platforms: Platform interoperability for increased data access. Case of UNEP and AirQo platforms

iv. Engagement: Awareness models; and hands-on training for (potential) data users critical for uptake

Presentation 6

Air Quality Studies in the City of Nairobi

Prof. Michael J. Gatari

The Institute of Nuclear Science and Technology,

University of Nairobi

This presentation by Prof Michael Gatari entailed reviewing some recent studies that have been carried out on AQ in Kenya and other parts of Africa. One of the papers reviewed was titled, *"Indoor and Outdoor AQ for Sustainable Life: A Case Study of Rural and Urban Settlements in Poor Neighborhoods in Kenya".* The study was motivated by the need to improve consciousness and to understand the harmful health effects of AQ on vulnerable people, especially in poor communities. Ng'ando urban informal settlement and Leshau Pondo rural village in Kenya were selected as representative poor neighborhoods where unclean energy sources are used, including for cooking, lighting, and heating. The findings from Ng'ando and Leshau Pondo showed levels exceeding the limit suggested by the World Health Organization (WHO), with rare exceptions. Significantly higher levels of PM2.5 and black carbon were observed in indoor than outdoor samples, with a difference in the orders of magnitudes and up to 1,000 µg/m3 for PM2.5 in rural settlements. The findings demonstrated that most of the households lived in deplorable AQ conditions for more than 12 hours a day and women and children were more affected. AQ condition was much worse in rural settlements where wood and kerosene were the only available fuels for their energy needs. (Read the whole paper by following: *https://doi.org/10.1155/2021/4258816*).

Another study, discussed during this session was titled, *"Spatial Extent and Distribution of Ambient Airborne Particulate Matter (PM2.5) in Selected Land Use Sites in Nairobi, Kenya".* This study set out to assess the spatial extent and distribution of ambient airborne particulate matter (PM2.5) in NCC. Seven sites were selected for monitoring based on the land use type: High- and low-density

residential, industrial, agricultural, commercial, road transport, and forest reserve areas. Calibrated low-cost sensors and cyclone samplers were used to monitor PM2.5 concentration levels. The highest 24-hour average concentration of PM2.5 was observed in Viwandani, an industrial area (111.87 μg/m³), and the lowest concentration at Karura (21.25 μg/m³), a forested area. The results showed a daily variation in PM2.5 concentration levels with the peaks occurring in the morning and evening due to variation in anthropogenic activities and the depth of the atmospheric boundary layer. The study suggested that residents in different selected land sites were exposed to varying levels of PM2.5 pollution regularly, hence increasing the potential of causing long-term health effects.

A different study carried out by Nairobi and Lagos scholars analyzed VOCs at selections of roadside and urban background locations in both Nairobi and Lagos, and 74 VOCs were quantified. The analysis revealed that all locations were dominated by hydrocarbons typical of vehicle emissions, with the aromatic hydrocarbons benzene and toluene among the most abundant VOCs. Typical personal exposure scenarios for citizens of the cities were calculated and it was noted that they exceeded those of a resident in a city in Europe/the US.

Other published scholarly works highlighted during the session are listed below:

- 2019-Gatari et al.: Transp Res Part Transp Environ 68:99–109.

  BC assessment on Kinney et al. (2011) samples. River Road, Ronald Ngala and Tom Mboya streets, and Thika Road (into and out of Nairobi). 30±3, 30±5, 36±4, 31±11, and 34±7 respectively

- 2018-Pope et al.: Atmospheric Chem Phys 18, 15403–15418

  Low-Cost particulate Monitors. The mean daily PM2.5 concentration at the urban roadside, urban background, and rural background sites were 36.6, 24.8, and 13.0 μg m −3, respectively

- 2018-Maina et al.: Environ Monit Assess 190:251
- 2017-Mukaria et al.: J Atmos Pollut 5: 62–68
- 2018-Pope et al.: Atmospheric Chem Phys 18, 15403–15418

  Low-Cost particulate Monitors. The mean daily PM2.5 concentration at the urban roadside, urban background, and rural background sites were 36.6, 24.8, and 13.0 μg m −3, respectively

- 2018-Maina et al.: Environ Monit Assess 190:251
- 2017-Mukaria et al.: J Atmos Pollut 5: 62–68
- 2014-Gaita et al.: In Atmos Chem Phys:14.

780-24 h PM2.5 Samples in 2008-2010;

21±9.5 μg m−3 (Range 3–53) in Urban Background;

13±7.3 μg m−3 (Range 2-36) in Suburban Background).

The range of BC was 0.04–9.5 (3.9±0.8) in the former and 0.07-5.7 (1.5±1) in the latter.

●2014-Gaita et al.: In Atmos Chem Phys:14.

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●2011-Odhiambo et al.: Res J Environ Earth Sci 2(4): 178–187

●2010-Gitari et al.: Ethiop J. Environ. Stud. Manag:.3.

Presentation 7

Air Pollution Monitoring at Different Sites in The City

Dr. Kennedy Thiong'o

Deputy Director — Climate Services

Kenya Meteorological Department (KMD)

The presenter began by highlighting the following mandates of KMD: provision of timely early warning weather and climate information for the safety of life; protection of property, and safeguarding the natural environment. Further, KMD is mandated to monitor environmental pollution and Greenhouse Gases (GHGs) for AQ assessment and climate change detection and attribution over Kenya. Finally, KMD monitors tropospheric and stratospheric ozone over Kenya in fulfillment of the Montreal Protocol and Vienna Convention.

KMD has the following monitoring stations: Regional Global Atmosphere Watch **(GAW)** station at the KMD headquarters; University of Nairobi — Chiromo Campus; Jomo Kenyatta International Airport, Mobile Air Pollution Monitoring laboratory, and Mt. Kenya GAW station.

The Nairobi Regional Global Atmosphere Watch station located at the KMD headquarters measures the total column ozone, the vertical profile of ozone, ground-level ozone (since 2012), and other various weather parameters.

Total Column Ozone is a ground-based instrument that measures the amount of total ozone present in the atmospheric column. It determines the intensity ratio of Ultraviolet B (UVB) and Ultraviolet A (UVA) which are used to calculate how much ozone is present in the entire atmospheric column. Initially, it was located at the University of Nairobi Chiromo Campus from 1984 and later it was moved to KMD in 2005. On average, Nairobi has 254 DU which is within the acceptable range.

Vertical Profile of Ozone uses Ozonesondes as a measure and measurements are taken once per week. Two major types of measurements are taken — Ozonesonde Type: Model 2Z ECC Ozonesonde and Radiosonde Type: Vaisala RS-80-15.

Monitoring at the University of Nairobi Chiromo Campus commenced in 2005 and was terminated in 2012. Two types of measurement were done here: Ozone (M400E UV photometric Ozone analyzer); and carbon monoxide (M3000E CO analyzer). The Jomo Kenyatta International Airport

monitoring point commenced in 2010 and terminated in 2012. Ozone, carbon dioxide, and sulfur dioxide were measured from this station.

KMD also has a Mobile Air Monitoring Laboratory equipped with several instruments and a power backup generator. The following are the parameters within this mobile air monitoring laboratory: PM2.5, PM10, black carbon, ozone, carbon monoxide, carbon dioxide, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), nitric oxide (NO), hydrogen sulfide (H_2S), methane, and ammonia.

Other meteorological parameters measured by the Mobile Air Monitoring Laboratory include wind speed and direction, temperature, relative humidity, precipitation, and pressure. Several studies have been done using the Mobile Air Monitoring Laboratory. Table 8 shows some of the monitored sites by the mobile laboratory.

Table 8: Monitored Sites by the Mobile Laboratory

Site	Description
Athi River	Located down wind of major cement factories and to the west of Athi River
Imara Daima	Located down wind of major factories and to the south of Athi River
KMD Hqs	Head office and west of NCBD along Ngong Road
Roads in Nairobi	Nakumatt Junction, Prestige, KNH roundabout, Mbagathi Way, Valley Road, Community Area, Landhies, and Juja Road.
Olkaria Geothermal	Within Geothermal Station

Mt. Kenya GAW Station: The feasibility study for Mt Kenya GAW Station was conducted in 1976-1978 (WMO/UNEP). Thereafter, the station was set up under WMO/GAW with funds from GEF. The implementation of the Mt Kenya GAW Station began in 1993. By December 1999, measurement of meteorological parameters and ozone had commenced. The station is located at an altitude of 3,678m a.s.l; longitude 37.30 degrees East; latitude 0.06 degrees South; 660mbs atmospheric pressure average, and; 6°C temperature average. The monitor is exposed to wind from all directions. The Mt Kenya GAW Station measures rainfall amount, temperature, humidity, wind speed, wind direction, air pressure, and radiation.

Figure 8: Mt. Kenya GAW Station

Presentation 8

Air Pollution and Climate Nexus

Augustine K. Kenduiywo

Deputy Director, Climate Change

Ministry of Environment and Forestry

The presentation began with the definition of air pollution and climate change and an explanation of how climate change and air pollution management have consequences for each other.

i. Air pollution and climate change have similar sources

The presenter described air pollution as contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere, while climate change is the long-term increase in the earth's average surface temperature and the large-scale changes in global, regional, and local weather patterns that result from that increase. This is caused by a significant increase in the levels of greenhouse and industrial gases. The former includes carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), while the latter include hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

Air pollution and climate change have the same sources. The two influence each other through complex interactions in the atmosphere. Many sources of air pollutants are also sources of CO_2 (including the burning of fossil fuels and solid biomass [including forests] and agriculture emissions) and other GHGs that affect climate.

iii) Linking Air Pollution to Climate Change

Black Carbon: Increasing levels of air pollutants, e.g., black carbon, alter the energy balance between the atmosphere and the earth's surface which, in turn, can lead to temperature changes that change the chemical composition of the atmosphere. Black carbon remains in the atmosphere for a relatively short time (one week) but strongly absorbs solar radiation. Black carbon emitted from domestic burning of solid fuels, particularly indoors, and high emitting diesel engines is likely to contribute to climate change.

Ground level ozone: Poor AQ is also caused by emissions of nitrogen oxides, methane, and other volatile organic compounds that combine in the lower atmosphere to produce ozone. Ground-level

ozone is a serious pollutant, which at high levels, damages human health and vegetation, including crop yields. Ozone is a short-lived GHG contributing to climate change.

Particulate matter 2.5: When carbon-based fuels are burned, incomplete combustion causes the emission of carbon dioxide (CO_2) and other pollutants, including particulate matter (PM2.5). The PM aerosols can cool or heat the Earth's climate by reflecting or absorbing the radiation of the sun.

iv) Linking climate change to air pollution

While linking climate change to air pollution, the presenter argued that climate influences the state of the atmosphere and, in turn, has an impact on the development and flow of air pollutants. Climate change influences air pollution by altering the frequency, severity, and duration of heat waves, air stagnation events, precipitation, and other meteorology conducive to pollutant accumulation. Climate change leads to an increase in wildfires that affect AQ. Such wildfires are increased when the temperature gets warmer.

v) Climate change and air pollution management have consequences for each other

According to the presenter, climate change and air pollution management have consequences for each other and that is why climate change and air pollution are human goals and are part of the challenges of sustainability as envisioned by the Sustainable Development Goals (SDGs).

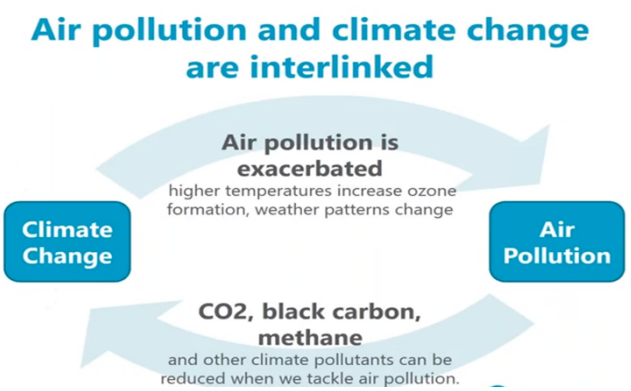


Figure 9: The Nexus between Air Pollution and Climate Change

vi) Kenya's policy to address climate change

Kenya is highly vulnerable to climate variability and change due to its economy being highly dependent on natural resources. This threatens its long-term vision of being "a newly-industrializing, middle-income country providing a high quality of life to all its citizens in a clean and secure environment by 2030". Efforts of moving toward the attainment of the Vision 2030 have been

hampered by climate change and extreme weather events such as floods and droughts, causing great socio-economic losses. This necessitated the crafting of the National Climate Change Response Strategy in 2010 (NCCRS, 2010).

The primary focus of NCCRS was to ensure adaptation and mitigation measures are integrated into all government planning, budgeting, and development objectives. The NCCRS process ushered in an era of policy and legislative efforts to address climate change in Kenya: NCCAP (2013-2017, 2018-2022) NAP (2015-2030); NCCFP [2016] and CCA 2016

Climate Change Act, 2016: In 2016, an Act of Parliament to provide for a regulatory framework for enhanced response to climate change was enacted. It aimed to provide mechanisms and measures to achieve low carbon climate development. The Act got assent on 6 May 2016 and commencement on 27 May 2016. This Act recognizes the complementary roles of national and county governments. Further, the Act establishes three key institutions (CCC, CCD, and CCF).

National Climate Change Action Plan (NCCAP, 2018-2022): The development of NCCAP was a **r**equirement of the Climate Change Act of 2016. The plan provides the main climate change planning and mainstreaming tool. NCCAP seeks to:

i. align climate change actions with the government's development agenda, including the Big Four;
ii. help in achieving the Sustainable Development Goals (SDGs);
iii. encourage participation of the private sector, civil society, youth, marginalized and majority groups — including women, people with disabilities, and indigenous people;
iv. serve as the implementation plan for Kenya's Nationally Determined Contribution (NDC) and Kenya's National Adaptation Plan 2015-2030 (NAP) for 2018-2022; and
v. provide a framework for mainstreaming climate change into sector functions at the national and county level.

Conclusion

In his conclusion, the presenter observed that air pollution and climate change influence each other through complex interactions in the atmosphere. Combining local air pollution and global climate

change mitigation policies provides a win-win situation whereby medium-term efforts to control air pollution will support long-term strategies that aim to curb climate change.

Presentation 9

Health impacts

Dr James Mwitari

Principal Investigator, Clean Air Africa

Kenya Medical Research Institute (KEMRI)

Clean Air Africa (CAA) is a partnership between public health experts from the UK, Kenya Uganda, Tanzania, Rwanda, and Cameroon. This partnership aims to provide policy-relevant evidence to address: (i) lack of access to clean household energy; and (ii) associated air pollution affecting 3 billion of the world's population. In addition, CAA is clean fuel/technology agnostic but has been primarily focusing on population transition from cooking with polluting fuels to bottled gas/LPG given national clean domestic energy targets in partner countries and the LPG scalability potential.

CAA is supporting national clean household energy programs by identifying community and institutional barriers to attaining large-scale, equitable, and sustainable transition to clean energy and innovations/interventions to overcome these barriers, while demonstrating achievable health, gender, and environmental impacts.

Despite the adverse health effect of the polluting fuels used in many households around the world, it is estimated that approximately 3 billion people, globally, rely on polluting fuels for households. Household pollution remains a significant cause of morbidity and mortality in many countries, Kenya included. It is estimated that there were about 22,109 premature deaths and 1 million Disability-Adjusted-life-Years (DALYs) annually, as of 2020. This translates to 8 percent of the total deaths and 6 percent of the disease burdens in Kenya. Although 76 percent of Kenyans use biomass, Kenya SDG targets clean cooking with LPG by the year 2028.

Impact of Air Pollution on Health

The presenter used case studies to explain and demonstrate the adverse impact of air pollution on Kenyans.

The following are the case studies that were used:

1) *Child Incidence in Kenya:* A study conducted in Nyeri found a statistically significant association between household air pollution and acute respiratory infections (RR=1.57, 95% CI,1.19-2.07); the mean PM10 levels were higher than the standard set by the British Health Panel and

European Commission. Besides exposure to indoor air pollution, stunting and time spent in the cooking place were risk factors for acute respiratory infections (www.iosrjournals.org).

2) *Child Mortality in Myanmar:* A Myanmar study on the use of biomass revealed that the risks of infant (aRR 2.02; 95% CI, 1.01–4.05; p-value = 0.048) and under-five mortality (aRR 2.16; 95% CI 1.07–4.36; p-value = 0.031) was significant as a result of exposure to pollutants.
3) *Low birth weight in Nigeria:* In a Nigerian study, mothers exposed to biomass fuel gave birth to infants who were on average 113g lighter (95% CI −196 to −29) than those using liquefied petroleum gas (Plos Global Public Health).
4) *Diabetes type 2 in several countries:* Current cumulative evidence appears to suggest that diabetes type 2 increases with increasing exposure duration and concentration of air pollutants. Current cumulative evidence appears to suggest that T2DM-related biomarkers increase with increasing exposure duration and concentration of air pollutants. The chemical constituents of the air pollutant mixture may affect T2DM to varying degrees. Effects include increased inflammation, oxidative stress, and endoplasmic reticulum stress. (Endocrinology and metabolism 10.1177/2042018819897046)
5) *Cardiovascular disease in the U.S., data from 90 cities:* Cardiopulmonary mortality increased in the short term by 0.31 percent (±0.09 SE), for each 10-$\mu g/m^3$ increase in PM_{10} (measured over 24 hours). AHA journal
6) *Global eye diseases:* Twenty-eight review papers and 83 research papers, including both human and animal studies, were analyzed, and conjunctivitis was the ophthalmologic disorder most associated with air pollution. (PubMed and Medline databases)
7) *Cognitive disorder in Taiwan:* A Taiwan study revealed that a high level of particulate matter ($PM_{2.5}$), low ozone (O_3), high carbon monoxide (CO), high sulfur dioxide (SO_2), high nitric oxide (NO), high nitrogen dioxide (NO_2), and high nitrogen oxide (NO_x) were significantly associated with low total MMSE scores i.e., low mental ability. (Int J Environ Res Public Health)

Impactful Solutions from CAA Evidence

Case 1: Langas Case: At Langas, one of the trained CHVs visited a home where a lady was cooking with a jiko in a small homestead with her family. She and her children were experiencing symptoms of carbon monoxide poisoning. The CHV explained the health issues using the job aids.

The lady started cooking outside and has now switched to LPG (after doing the cost calculations from the training). This is an example of the importance of training and messaging.

Case 2: Pay-as-you-go (PAYG) LPG: This study used novel smart meter data collected between January 2018 and 2020, spanning the COVID-19 lockdown, from 426 PAYG LPG customers living in an informal settlement in Nairobi, Kenya to evaluate stove usage (e.g. cooking events/day, cooking event length). LPG use was sustained despite a COVID-19 lockdown, illustrating how PAYG smart meter technology may help foster clean cooking access. Up to 95 percent of study households continued using PAYG LPG during the COVID-19 lockdown, with consumption increasing from 0.97 to 1.22 kg/capita/month. Daily cooking event frequency also increased by 60 percent (1.07 to 1.72 events/day, https://doi.org/10.1016/j.apenergy.2021.116769).

Case 3: Adoption of innovative energy efficiency pots to enhance sustained use of clean cooking with gas in resource-poor households in Kenya (2020-2021): The objectives of the study were to test the energy efficiency and other impacts of using the two pots in real-life community cooking circumstances within the urban informal settlement communities of Nairobi. Specifically, the study set out to determine:

(i) quantified impacts on the amount of LPG used (to document any energy savings);

(ii) household perceptions of other pot attributes (time and cost savings) that might encourage household investment in purchasing the pots; and

(iii) the influence of the pot on cooking and fuel use practice compared with the use of traditional Kenyan cooking pots (known as *sufurias*).

In general, the study highlighted the potential role of energy-efficient pots as a solution to sustained /exclusive clean cooking with LPG in resource-poor settings. Universal appreciation of the benefits of the pots for cooking, fuel and time saving, and prestige were reported by the cooks with all cooks reporting advantages over their traditional locally-available *sufurias*.

Case 4: Air Pollution and Schools in Nairobi's Informal Settlements: The study aimed at exploring the potential health, safety, and economic benefits of LPG for cooking in Nairobi schools, Kenya (https://amref.ac.ke/air-pollution-and-schools-in-nairobis-informal-settlements/). PM2.5 levels in the kitchens greatly exceed WHO guidance for the key health damaging pollutant — fine particulate

matter (to be safe for health, PM2.5 exposure levels should be lower than the WHO interim target of 1 (35 μg/m3).

Below are the full references and links to other cases highlighted during the presentation:

1. Shupler, M., et al. (2021). Beyond household socioeconomic status: multilevel modelling of supply-side determinants of LPG consumption among 5,500 households in sub-Saharan Africa. [https://doi.org/10.21203/rs.3.rs-154082/v1]
2. Shupler, et al. (2022). Widening inequities in clean cooking fuel use and food security: compounding effects of COVID-19 restrictions and VAT on LPG in a Kenyan informal urban settlement. Environmental Research Letters, 17(5), 055012. https://iopscience.iop.org/article/10.1088/1748-9326/ac6761/meta
3. Shupler, M., et al (2022). Gendered time, financial & nutritional benefits from access to pay-as-you-go LPG for cooking in an informal settlement in Nairobi, Kenya. medRxiv. https://doi.org/10.1101/2022.06.02.22275930
4. Puzzolo, E., et al. (2019). Clean energy access for the prevention of non-communicable disease in Africa: the NIHR CLEAN-Air (Africa) Global Health Research Group. Environmental Epidemiology, 3, 319. Doi: 10.1097/01.EE9.0000609492.94114.c9

Presentation 10

Community Perspective on Air Quality

Henry Ochieng

Kenya Alliance of Resident Associations (KARA)

The Kenya Alliance of Resident Associations (KARA) is the apex body representing the voice and proactive action of resident associations on service delivery issues as well as their rights, roles, and responsibilities. KARA was formed in the year 2000 as an umbrella organization wholly mandated to coordinate resident associations in Kenya to tackle the service delivery challenges they face in a structurally unified voice. KARA brings together resident associations under one umbrella to strengthen their voice and facilitate their participation in service delivery agenda, thereby enhancing social accountability both at the county and national levels.

Further, KARA promotes structured citizens' actions aimed at realizing responsiveness, accountability, and transparency in service delivery. Focus areas include:

i) good governance and representation of resident associations;

ii) urban development and management;

iii) security, safety, and disaster management; and

iv) environment, water, and sanitation.

KARA is involved in civic awareness and education, evidence-based advocacy, capacity building, mediation and arbitration, research and knowledge management, and networking, learning, and sharing.

Sources of Air Pollution

Most neighborhoods, especially in urban areas, are faced with the serious challenges of having to contend with poor AQ. Sources of pollution are from both within the household (e.g., from the use of biomass and kerosene for cooking and heating) and the surrounding environment. Estates built near or within industrial areas face the greatest challenges regarding air pollution.

There are several challenges associated with air pollution, including:

i. A low awareness level of the effect of poor AQ on health and the environment;

ii. lack of readily available and comprehensible data to paint the real picture of the negative impact of poor AQ;

iii. weak enforcement of laws regarding AQ — residents provide information on sources of pollution but in most cases, no concrete action is taken;

iv. investment in prevention and addressing AQ challenges is not given adequate priority by the government and other actors; and

v. there is a lack of proper coordination between various government agencies responsible for the enforcement of AQ laws/regulations.

Solutions

i. An active and structured engagement with organized community groups such as resident associations in AQ initiatives —– research, policy processes, and dissemination. The presenter defined a community as a group of people living in the same place or having a particular characteristic in common, who share the same interest or passion. These are people trying to bring about change. Sometimes, a community constitutes people brought together by geographic boundaries.

ii. Simplify data and information on AQ and make it readily accessible to communities — use of technology can enhance collaboration and sharing of information among various stakeholders.

iii. An integrated digital platform can be created to facilitate sharing of information, reporting of cases of air pollution, and providing feedback on action taken against those violating laws.

iv. Create an AQ fund to specifically support initiatives aimed at mainstreaming the AQ agenda and prioritization in decision-making.

v. Regular AQ status alerts to increase sensitivity and preventive activities.

vi. Invest in an efficient public transport system to reduce the number of cars on the roads.

vii. Invest in non-motorized transport infrastructure to reduce the use of cars.

viii. Embrace modern waste management approaches such as circular economy to eliminate practices such as the burning of waste.

ix. Better coordination among government agencies and effective enforcement of the law.

Presentation 11

Air pollution impacts on vulnerable groups in Nairobi

Dennis Ngugi

Muungano wa Wanavijiji

Mukuru

This presentation on air pollution impacts on vulnerable groups was based on Mukuru, one of the largest informal settlements in Nairobi. Mukuru has three settlements, mainly — Mukuru Kwa Njenga, Reuben, and Viwandani — covering 300 acres of land with a population of 400,000 people. Mukuru is surrounded by about 800 factories and one dumping site. According to Ngugi, garbage from other parts of Nairobi is deposited at the Diamond dumping site in Mukuru.

Challenges

Mukuru faces several challenges — including an unregulated dumping site, emissions from the burning of waste at the dumping site, indoor pollution from unclean cooking energy (firewood and charcoal), encroachment of public spaces like the playing field, and the lack of basic amenities and electricity (meaning that many families use candles and paraffin lamps for lighting – which cause eye irritations and lung issues).

According to presenter, research was done by KEMRI and Stockholm University among children from Mukuru and Buruburu, requiring them to run for a specified distance and then blow air into a balloon. The research showed that the children from Mukuru could not fill up air balloons. It was concluded that most of them could be suffering from some lung issues.

Community outreach programs

Muungano wa Wanavijiji has come up with various initiatives to create awareness and behavior change on AQ issues through art, music, and sports. These community-driven interventions are crafted in a language that is comprehensible to the community.

Figure 10:A Youth from Mukuru Conducting Awareness Campaigns.

DAY 3

Theme: Shared understanding of sources and impacted communities

Presentation 1

Regional Perspective on Air Quality Policy Landscape

Gerry Opondo

Executive Director

Environmental Compliance Institute (ECI)

Gerry Opondo's discussion revolved around: i) the policy landscape in the East African Community (EAC) — both direct and indirect AQ policies, laws regulations, and standards; ii) the EACAQ interventions; and iii) policy/legislative design and implementation gaps and challenges.

The presenter considered direct AQ policies, laws regulations, and standards from Ethiopia, Kenya, Rwanda, Tanzania, and Uganda and indirect AQ policies, laws regulations, and standards from Burundi, South Sudan, and Zanzibar.

The policy and legislative interventions include the Treaty Establishing the EAC; EAC Protocol on Environment and Natural Resources; EAC Climate Change Policy, 2011; EAS 750:2010, AQ — Emissions to the air by cement factories — Guidelines; EAS 751:2010, AQ — Specification; EAS 752:2010 — Tolerance limits of emissions discharged to the air by factories; EAS 158:2012 — Automotive Gasoline (Premium Motor Spirit) Specification; EAS 177:2012 — Automotive Gas Oil (Automotive Diesel) Specification, and; EAS1047:2022 — Air Quality — Vehicular Exhaust Emission Limits.

Challenges

The policy/legislative design gaps and challenges include the absence of appropriate data to inform policy/legislative design and implementation strategies; lack of appropriate policies/laws and/or shortcomings in existing policies and laws; the lack of consensus on the most appropriate policy approaches for AQ regulation; and fragmented national policies and laws leading to overlap and conflict in roles.

The implementation gaps and challenges highlighted during this discussion included weak coordination between the concerned agencies; inadequate resources (funds, technology, skilled personnel, etc.); ineffective law enforcement and monitoring and resistance to regulation/push-back from regulated entities; and inadequate mechanism for coordinated management of trans-boundary issues of air pollution.

Presentation 2

Health and monitoring

African Population and Health Research Center (APHRC)

Presenter: Kanyiva Muindi

Designation: Air Quality Researcher

This presentation was about ambient AQ in Nairobi slums and its impact on the health of the residents. Slums are home to about 60% of the City's population, yet these residents face exclusion (in the context of weak environmental protection policies). Sometimes the residents' actions expose them to higher pollution, thus increasing the burden of disease.

The presenter used case studies to describe the ambient AQ in Nairobi slums and its impact on the health of the residents. One such study set out to achieve three objectives — assessing the levels of ambient $PM_{2.5}$ in two of Nairobi's slums; assessing perceptions around AQ and health risk; and assessing the impact on morbidity and mortality in children below five years. The study's setting was Korogocho and Viwanndani slums in Nairobi.

It was concluded that the risk of morbidity and mortality was significantly higher among children from highly polluted areas compared to those from less polluted areas. Figure 11 shows the risk of PM2.5 level of exposure in child morbidity and the risk of PM2.5 level of exposure in child mortality.

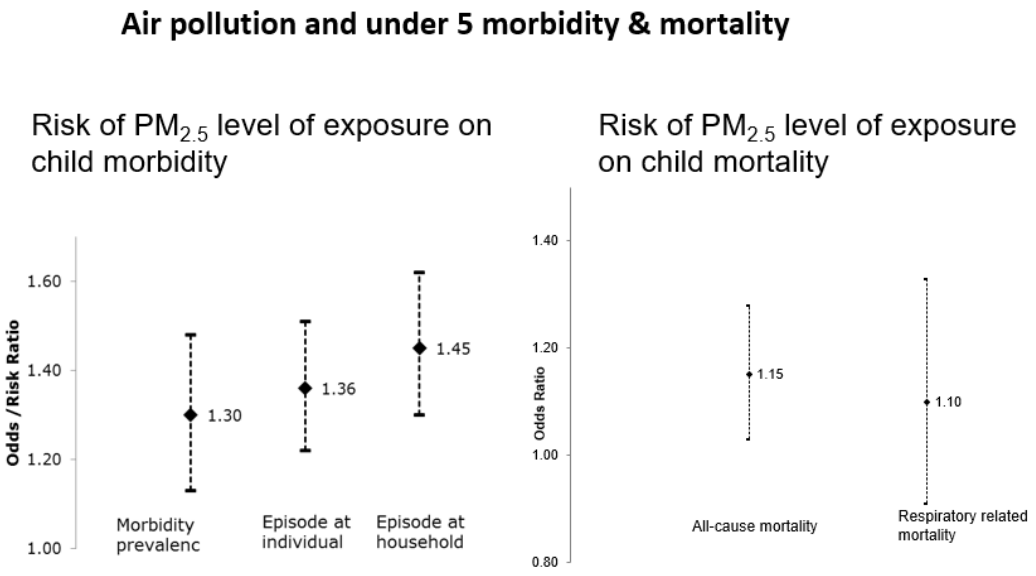


Figure 11: Air pollution and under 5 morbidity and mortality

The study recommended urgent health impact assessments, the need for a publicly accessible central repository of AQ data, and increased efforts on community awareness of AQ and health.

Presentation 3

Gender-Community/Women's Perspective

Fridah Githuku

Executive Director

GROOTS Kenya

The presenter began by providing a brief background of GROOTS Kenya. GROOTS Kenya is a civil society organization that brings together over 3,700 grassroots women-led CBOs in 21 counties of Kenya. Its mission is to facilitate the effective engagement of grassroots women and their communities in development spaces and decision-making in local, national, and global spaces.

Clean Cooking Energy initiative

One of the major projects of GROOTS has been the clean cooking energy initiative. Household pollution sources (unclean cooking energy) are a major contributor to air pollution in Nairobi City and many other parts of the County. According to WHO, approximately 3.8 million deaths are recorded every year as a result of households' exposure. Some of the accelerators of energy pollutants are poverty; cultural beliefs; low literacy and knowledge; and low access to resources for those in the low-income categories.

According to the Kenya Population Housing Census (KPHC), 2019 (Volume 1V, 2.1.4 Housing Conditions and Amenities), firewood was the most commonly used type of cooking fuel as reported by 55.1 percent of households followed by LPG at 23.9 percent.

Gender and Social Contexts

To understand gender and its role in AQ, it is important to give it some social context. Generally, communities have bestowed certain gender roles to women that perpetuate inequalities. In addition, women bear the responsibility to source household cooking energy and have less financial capacity (resources) compared to men.

Often, in many homes, women engage in unpaid care work. Such unpaid work limits them from participating in leadership and public policy formulation. The fact that decision-making, and equally, their choices are limited at the household level compounds the problem.

Women are the most vulnerable to impacts of air pollution including climate change and are more pre-exposed to indoor air. The AQ and pollution problems are exacerbated by a lack of sufficient knowledge among community members. Many communities are highly unaware of air pollution and the pollutants beyond indoor pollutants.

To address air pollution – women, men, and youth need to be targeted as change makers. The clean cooking initiative, therefore, seeks to:

1. Increase awareness of the health and environmental impacts of unclean cooking technologies and fuels.
2. Influence policies, and public budgets towards increased adoption of clean energy.
3. Influence community/public behaviors and fuels.
4. Promote women's ability to participate in the market economy.

There are three key areas of focus in addressing the air pollution issues among communities: Building agency, voice, and addressing resources gaps.

1. Building Agency

Building individual and collective knowledge, awareness, and consciousness to create a critical mass of grassroots women and men who were developed to become clean cooking champions is important in reaching a critical mass of the population.

2. Voice

This refers to giving the community a voice in the policy process through:

- Collaboration with other stakeholders like county governments, partners like SNV-Netherlands, Clean Cook Stoves Association (CCAK), etc.
- Contribution to community needs assessments.
- Participation in County Energy Plan solution development.
- Solution validation and prioritization.
- Resource mobilization for the development and implementation of the county energy plan.
- Undertaking a county-wide household baseline survey targeting 200 households through key informant interviews and focus group discussions.

3. Resources

Provision of resources includes:

- Business skills and market linkages through training artisans to produce clean cooking stoves; and grassroots women on how to connect producers and consumers as distributors.
- Provision of affordable financial credit through Groots Savings and Credit Cooperative (SACCO) societies, to provide community resilience funds as an incentive fund for any innovation about climate change adaptation and renewable energy.

Presentation 4

AQ impacts on children in underprivileged communities

Josephine Mbandi

Embedded Systems Engineer & Co-Founder

Afristem Connections

This presentation AQ impacts on children in underprivileged communities was based on a case of 12 schools in three Counties by AfriSTEM Connection.

Background to the Project

There is an increase in **technology** awareness in Africa. However, the confinement of **innovation hubs** in urban centers means that young innovators in **rural settings** and most pre-urban settings do not have awareness of these emerging technologies. To close the STEM skills gap and increase equity sustainably, AfriSTEM Connection, in collaboration with its partners, developed a training toolkit and carried out a pilot AQ monitoring study to investigate the AQ information available in schools located in underserved communities within Kenya.

The project set out:

1. To build a STEM community that has sustainable air pollution understanding and awareness through education and training.
2. To equip and harness emerging technologies to support local solutions and interventions, thus forming a strong and expanded air pollution resource base in the near future.

What was used: A prototype training kit used in schools for AQ training on the measurement of air parameters and air pollution. A sensor training kit using an SDS011 particulate matter sensor and a questionnaire for feedback were also used.

Impacts

Lessons learned by trainees from the outreach towards sustainable AQ management:

i. Small input by all makes a difference in a community.
ii. Importance of Science, Technology, Engineering, and Mathematics (STEM) subjects.
iii. Clean air is essential for all.

iv. Technology can be experienced inexpensively.

v. Learners can find local solutions to their challenges.

vi. Adaptation and resilience are important for continuous changes in the environment.

vii. Clubs and group activities create continuity of AQ learning.

Lessons learned toward AQ management

The input towards resilience and adaptation to changes in AQ was largely successful. Of the **810** seedlings planted in the first phase, **37 percent** survived. The lesson tailored over the tagline that ***"trees are the lungs of the world"*** encouraged the young science enthusiasts to adopt a tree and take care of it. Of the 12 schools trained, six have environment clubs. To continue the work and community-based outreaches, the schools are in the process of forming clubs with science teachers as their patrons.

Of the 14 schools visited, two have improved their kitchens. In addition, the science teachers formed a WhatsApp group to share experiences and grow in their knowledge and practical lessons on AQ.

In conclusion, the presenter observed that, in meeting clean air priorities in schools, AfriSTEM Connections was contributing towards communities, and also learning how to better evolve actions for climate adaptation and resilience.

Group Work

Shared Understanding of Sources and Impacts

Groups Areas of Discussion

1. Major streams driving emissions from the sector
2. Most impacted communities (gender and equity dimensions)
3. Localities/neighborhoods of interest
4. Current legal framework
5. Current implementation levels of the legal framework
6. Ease transformation
7. Potential for integration with climate change work

Groups Sectors

1. Waste
2. Transport
3. Industries
4. Street food vendors
5. Construction and demolitions

Table 9 presents a summary of the outcomes of the deliberations from the groups' plenary sessions and discussions.

Table 9: Responses from the Group Discussions

Areas of Discussion	1. Major streams driving emissions from the sector	2.Most impacted communities (gender and equity dimensions)	3.Localities, neighborhoods of interest	4.Current legal framework	5.Current implementation levels of the legal framework	6.Ease of transformation	7.Potential for integration with climate change work
Waste	-Municipal waste plastics, papers, organic -Bio medical waste -Waste tires	- Low- & mid-income areas - Both male female and children affected	- Informal settlements - Low and middle-income areas - -Social amenities, e.g. schools - health centers and markets	- Constitution of Kenya, 2010 - EMCA,1999 & subsidiarity legislation e, g NEMA - Sustainable Waste Management Act, 2022 - Nairobi City County Solid Waste Management Act - Public health Act Cap 242(NMS) - Nairobi City County Air Quality Act - Climate Change Act 2016 CCD - Nairobi Climate Action Plan	- Ongoing	- Long term, progressive needs; and - political good will.	- The nexus between AQ and climate change is clear - Key prerequisites are a common platform for common understanding and defining roles, responsibilities and coordination procedures
Transport	- Infrastructure - Fossil fuel quality - Vehicles emissions - Factory materials transport - Low technology in vehicles, rail and marine - Maintenance compliance levels - Repair and services - Use of coal and heavy fuels in rail and marine	- Operators of vehicles and machinery - Users – passengers, posho mills - Street vendors, - Street families - Pedestrians - Communities living around airports, shipping ports, busy highways, bus parks, - Traffic police and marshals - Children going to school	- Communities living around airports, ports, busy highways, - Street families - Joggers / pedestrians	- Constitution - NTSA - Traffic Act (at different implementation levels)	- Different implementation levels depending on state agency - Lengthy court process - Conflicting laws - Weak enforcement	- Low awareness - Capacity building - Economic interest - Enforcement challenge - Silo mentality - Political goodwill - Lack of equipment - Synergy	- Collect emission data - Detailed greenhouse gas inventory

	- Emissions - Carbon footprint aviation - Congestion in road transport						
Industries	- Inputs raw materials - Energy - Technology	- People near the industries - Dependent on type of product being produced	- Kitengela - Athi River - Baba Dogo - Mavoko - Mukuru - Syokimau - Dandora	- Constitution - EMCA - (Environmental Act) - NEMA - Energy Act of 2019 - Water Act, 2016 - County legislation - Oshal Act	- Monitoring and enforcement - Effectiveness - Issuing of emission licenses	- Industry open to change - Adopting and incentivizing the adoption of new technology	- Public participation is a collaborative approach
Street Vendors	- Emission from Lighting devices candle, kerosene lamp - Dust - Combustion from -biomass - Emission from food - Smoking emissions	- Street vendors - Street families - Idlers - Government county workers - Security guards - Public vehicles crew - Low-income earners - Traffic police - Both men and women - Children and people living with disability	- All informal settlements —Mukuru, Kibra, Mathare, Huruma, etc. - Industrial zones-Viwandani, Baba Dogo, South C, Kariobangi - Bus parks, railway stations, Country Bus Station, bus stations - Middle-income estates - Construction sites - Major markets along the market streets — Gikomba, Githurai, Muthurwa, Burma, Kenyatta Market,	- CAP 242 Public Health Act - CAP 254 Food, Drugs And Chemical Substances Act - Nairobi County Nuisance Act - National Environment Coordination Act, 1989 - Meat Control Act, Cap 356 - Nairobi County Air Quality Act - Occupational Health and Safety Act 2007 - Tobacco Control Act - Nairobi City County Food Policy 2021-2030 - Nairobi City Food Safety and Fortification Act of 2021 - Street Food Vending Regulation of 2021 - Nairobi City County Inspectorate Act - Nairobi City County Pop up Market and Street Vending Act, 2019	- No response	- Enablers for transformation - Use of clean fuel - Zone of streets for vending - Use of mobile kitchen-technology - Complications-livelihoods, political interest, status of employment, affordability of better technology	- Clean cooking interventions contribute to reduced emissions, saving of trees, and water catchment.

Construction and Demolitions	- Transport - Equipment and machinery - Construction materials - Construction activities, e, g excavation - Burning of waste	- Male construction workers - Low-income earners - Food vendors – women - Children – neighboring households. - Dumping sites for construction wastes	- Neighboring communities - Transportation routes - Source of raw materials	- Physical Planning Act - EMCA 1999 - Building code - NCA Act - Occupational Safety and Health Act - Public Health Act Cap 242 - AQ Regulations - Nairobi County Air Quality Act, 2021	- High level of non-compliance - Lack of enforcement capacity by lead agencies - Inadequate stakeholder involvement - Lack of awareness - overlapping roles	- Need increased public awareness and engagement. - Require political goodwill	- Opportunity for industry stakeholders' engagement - Climate-friendly building materials/green technology in construction, e.g., renewable energy sources - Green building standards are listed in the climate action plan. - Climate change awareness to all stakeholders in the construction sector.

THEME: Integrating of Gender, Health and Climate Dimensions in Air Quality Work

Presentation 5

Urban Health Initiative: A Model Process for Catalyzing Change

Thiga Mwaura

Project Officer, Air Quality and Health

World Health Organization (WHO)

A Model Process for Catalyzing Change

According to the presenter, the Urban Health Initiative **(UHI)** goes beyond improving access to healthcare and promoting healthy behaviors and focuses on how to build cities that enable and encourage good health.

Guiding questions for this initiative:

i. How can the health evidence be used to support the implementation of sustainable policies that reduce air pollution from key sectors?
ii. How can realistic interventions and scenarios be implemented, given the political nature of the governance in a country and a city?
iii. What is the role of the health sector in promoting healthy and livable cities through sector policy change?

Aim: The overall aim of the project is to promote policies that reduce deaths and diseases associated with air and climate pollutants, and to enhance health co-benefits from interventions and measures to tackle air and climate pollution across relevant economic sectors.

Pathways to Health

AQ, climate mitigation, physical activity, noise reduction, interpersonal violence, social interaction and exchange, and food security and nutrition were identified as pathways to health.

Background

Scientists have continually warned about the increasing levels of pollution around the globe. For instance, a team of researchers led by Prof Gavin Shaddick at the University of Exeter has shown that, despite global efforts to improve AQ, half of the world's population is exposed to increasing air pollution. The study[2], carried out with the WHO, suggests that air pollution constitutes a major, and in many areas increasing, threat to public health (Shaddick, G. et al., 2020).

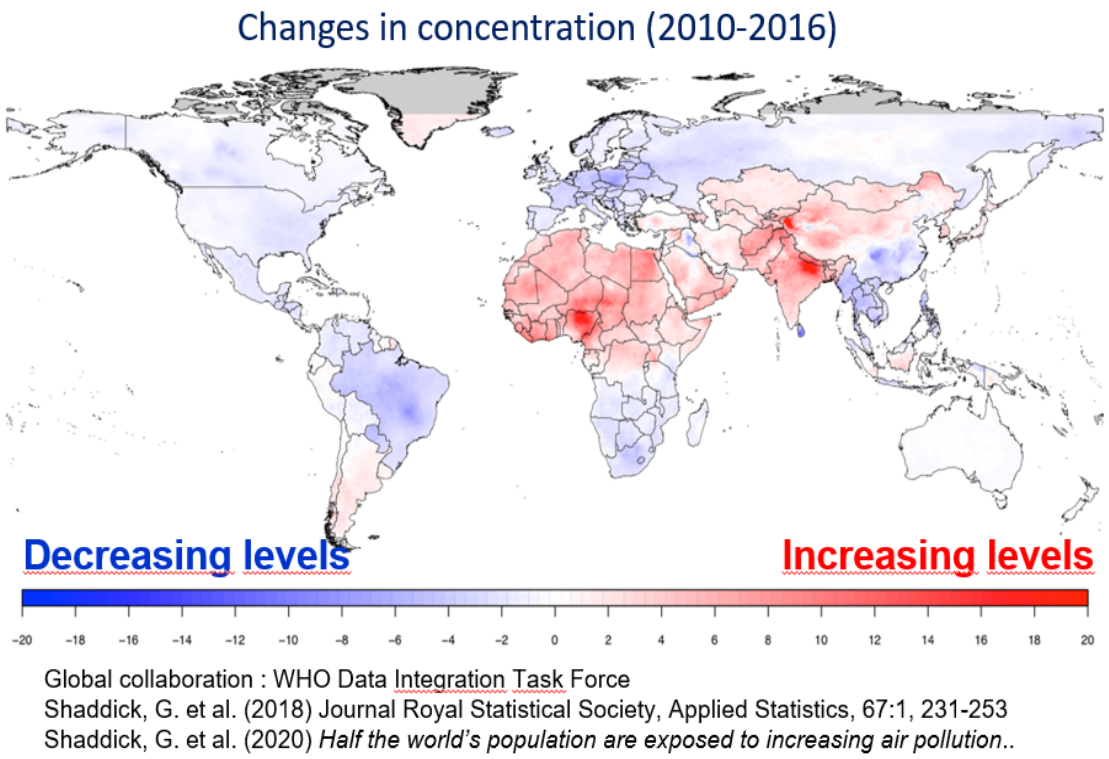


Figure 12: Levels and Trends in Air Pollution

The Role of the Health Sector

The health sector is a respected voice on the issue of pollution in cities and it can catalyze policy change through three main pillars:

i. **Health evidence:** Developing and using the health evidence on air pollution and health-related issues.

ii. **Health competency:** Strengthening health competencies to identify and address the effects of AQ and the multiple benefits we can win by addressing it.

iii. **Health communications:** Improving understanding, raising awareness, and mobilizing action.

[2] Shaddick, G., Thomas, M.L., Mudu, P. et al. (2020) Half the world's population are exposed to increasing air pollution. *npj Clim Atmos Sci 3, 23.* doi: 10.1038/s41612-020-0124-2

According to the presenter, communication and outreach to mobilize and sustain support is a critical aspect of the UHI model process. Urban transformation through the UHI model takes the following path which constitutes six steps as shown in Figure 14.

Figure 13: Path of Urban Transformation - Urban Health Initiative

Notably, health and economic arguments move public opinion and provide urban leaders with the incentive to act and ensure changes in air pollution and related policies are monitored and tracked. Therefore, it is important to engage urban leaders and champions to communicate the costs of inaction, including through communication campaigns (e.g., in Ghana — citywide #BreatheLife Accra), media training, community outreach, workshops, and social marketing — intensifying demand for action, providing health and economic arguments to spur policy-makers to act, and engaging healthcare workers to advise patients, workers, and communities on the need for interventions.

Bringing Health to the Policy-Making Table

Pilot projects in Accra and Kathmandu

Responding to World Health Assembly resolution WHA68.8 (2015), which requests WHO to build health sector capacity to work with other sectors, support countries to identify effective interventions, track progress, and update evidence related to the health impacts of air pollution, WHO led the development of the Urban Health Initiative (UHI).

Led by WHO, UHI worked with international, national, and local government partners and launched the pilot project in Accra and Kathmandu to change the trajectory of health impacts from air

pollution. The main partners included MoHP Nepal, Ghana Health Service, Kathmandu Valley municipalities, Accra Metropolitan Assembly, CCAC, Government of Norway, ICIMOD, UN-Habitat, Kathmandu University, University of Ghana Legon, ICLEI Local Governments for Sustainability, SEI, and Ghana EPA.

The project followed the six steps of the path of urban transformation described:

1. *Mapping the Current Situation, Policies, and Decision-Making Process:* This entailed assessing policies that impact urban health, identifying expected health impacts and gaps in the collection of data to support policy action, mapping all relevant stakeholders, and considering the socio-economic realities of impacted communities.

   Experts mapped four main sectors with policies impacting AQ in Accra, Ghana: Transport (including walking & cycling); energy (especially household energy); solid waste management (open burning), and; urban and spatial planning (green spaces).
2. *Building capacity to engage effectively across sectors:* Ghanaian experts were trained on how to effectively use the tools for health and economic impact assessments of AQ across sectors as part of the UHI pilot project in Accra, 2018. Further, capacity-building materials were developed for health practitioners, clinicians, and public health workers to strengthen professional capacities to address air pollution and health, 2022.
3. *Adapting and applying health and economic tools in the local context:* Global tools were adapted and applied to understand the impacts of air pollution on health in Accra. Tools for assessing the health and economic impacts of policies such as WHO's AirQ+, HEAT, and One Health were adapted and used locally. Tools for front-line healthcare workers were adapted to help them advise patients and communities.
4. *Developing and testing alternative scenarios:* During this phase, tests for alternative scenarios based on policy options locally to estimate the potential health and economic impacts were carried out, preferred policy scenarios and interventions were identified, health impacts, co-benefits, and the costs of inaction and interventions were measured, cost-effectiveness and cost-benefit analyses of and developing city-level action plans, strategies and roadmaps were conducted.

A series of assessment reports were produced examining household energy, transport, solid waste management, health-economic impacts of air pollution, and potential policy scenarios with multiple benefits.

5. *Communication and outreach to mobilize and sustain support:* A communications task group was developed and strategies to engage community leaders, students, media, and other stakeholders and mobilize their support for action were done. In addition, community health workers, school health education coordinators, and environmental health workers' training and sensitization materials were developed and piloted.
6. *Urban leaders actions — monitoring and refining policy:* A monitoring framework/tracking mechanism was developed to measure policy change impacts and the results from city initiatives to address health-determining policies and associated health outcomes. Considerations were made for legislation, regulation, enforcement, and investments made building on policies implemented following recommendations.

This report set out to estimate the impact of air pollution on health in Accra, Ghana. The levels of air pollution were affected by seasonal variation. In particular, during the dry season (November-March), there were high peaks due to desert dust. Nevertheless, throughout the year, anthropogenic sources of air pollution were responsible for keeping average values high and for serious health impacts.

Data on air pollution were gathered from different sources, including official monitoring stations and satellites. For the health risk assessment, two values were collected and considered: For the city of Accra: PM10 average equal to 81.1 μg/m3 (converted into PM2.5 49.47 μg/m3 mean concentration value), from residential monitoring stations in 2014–2015 and for the whole Greater Accra region: PM2.5 average equal to 36.02 μg/m3, from satellite data from 2014 and 2015.

Economic Consequences are Quite Important for Policies

On average, uninsured individuals paid $1,090 per hospitalization depending on their health condition. But even for those who were insured, co-payments were required. Taking into consideration that about 51 percent of individuals in our sample work in the informal market, and have an average annual income of $612–857, a single hospitalization could represent a complete loss of income.

For those with chronic diseases related to air pollution (e.g., cancers or severe cardiovascular and respiratory diseases), average medical costs were estimated at $ 2,146 per hospitalization. With an average of four hospitalizations per year, these medical costs corresponded to 67 percent of their annual net income. WHO defines a total health expenditure of 10 percent or more of household consumption or income as a catastrophic expense.

Presentation 6

What are the Experiences of Communities in Dealing with Air Pollution and its Impacts?

Jennifer Mutinda

GROOTS Kenya

This presentation was about communities' experiences in dealing with air pollution and its impacts, contexts of air pollution among such communities, what GROOTS Kenya has done to address air pollution, and the way forward.

Experience

Grassroots women prefer firewood to any other fuel for cooking because it is easily available. Discussions on air pollution are rare in many communities as they seem less pressing compared to water and electricity needs. However, women in many rural communities continue to suffer from the adverse effects of pollution not only when visiting urban areas, but also from within their own houses.

Context

Air pollution affects women disproportionately. This is because of the roles communities have bestowed to women that expose them to air pollution, for example cooking (where 55 percent of the households use firewood). The traditional stoves used for cooking in many homes expose many of the grassroots women to the adverse effects of pollution.

GROOTS' response to the Air Pollution issue

GROOTS Kenya has implemented a lot of initiatives aimed at solving the air pollution issue, particularly among rural communities. In 2017, GROOTS conducted research on the impacts of indoor air pollution on health in Kitui and the findings showed that many women had been affected by indoor air pollution, compared to men. The diseases and complications identified were respiratory-related — for example, runny nose, chest problems, and difficulty in breathing among children. Breathing difficulties were mostly reported during the rainy and cold seasons as they warm themselves in poorly-ventilated houses.

Consequently, GROOTS mapped 40 clean cooking champions from 40 wards, to advocate for clean cooking with improved cooking stoves which use less firewood and produce less smoke. They have developed and supported market champions and artisans who make and sell clean cooking stoves and briquettes. In 2018, GROOTS partnered with the County Government of Kitui, through public participation, and contracted some of the champions to construct clean cooking stoves for the needy households in Kitui. They also collaborated with the Ministry of Environment to grow trees to recover wood lost and clean air for breathing. Further, they participated in the development of the Kitui County Energy Master Plan (2018-2021), ensuring that the second generation CIDP captured and budgeted clean cooking and allocated resources for capacity-building.

Progress

According to the presenter, several positive things have been recorded following the interventions of GROOTS in several parts of the county.

1. There has been a high uptake of clean cooking stoves by households and institutions.
2. Further, some counties, e.g., Kitui, have agreed to integrate the clean cooking initiatives into their fiscal planning, budget, and the County Integrated Development Plan (CIDP).
3. Increased capacity building for clean cooking stoves artisans, has also opened business opportunities for women.
4. There has been increased acceptance of solar energy and installation has gone up by about 70 percent in households in Kitui County.
5. There has been increased adoption of solar-driven generators in horticultural farming. The County Government of Kitui also has plans to upscale this model of clean energy to agriculture.

Presenter 7

Integrating gender and equity dimensions

Elizabeth Moss

Environmental Rights and Justice Associate

WRI

Why Gender and Social Equity?

Moss observed that air pollution data tend to gloss over the disproportionate impact of poor AQ on vulnerable populations. Therefore, a focus on solutions is an opportunity for empowerment.

Nairobi is one of many local areas where the disproportionate impact of poor AQ on certain populations, locations, and occupations is not well defined, especially the exposure and impacts associated with specific sources of pollution outside the home. This includes not just impacts on women, but also children, the elderly, and low-income populations.

There is a need to look beyond health impacts and also assess how air pollution might impact the ability of women to work outside the home because of care responsibilities, and how the impacts and ability of low-income communities to address air pollution are often compounded by dilapidated housing, limited access to infrastructure, congested settlements, or differential treatment by city officials.

In addition, there is a data gap reality — that is, while there is high-level global or aggregated data about the risk to these vulnerable populations, there is very limited local, actionable data, especially about disparities associated with specific sources of pollution outside of household or indoor air pollution.

This gap and lack of focus have created the "lamppost effect" where Hazardous air pollutants (HAPs), and their impacts on women, are what are studied with the most attention. Women move about the city too and need to have both economic and political opportunities. They should have a voice in decision-making around air pollution.

Along those lines, CAC's specific objectives include looking at disproportionate impacts on women and vulnerable populations, including the broader socio-political drivers and intersectional impacts like income, age, occupation, and geography/neighborhood. CAC also plans to focus on catalyzing

women as clean air leaders and identifying solutions that support their economic empowerment and role in decision-making.

Empowering Women as Clean Air Catalysts

The presenter called for the prioritization of pollutant sources that disproportionately impact the health, welfare, and economic opportunity of women and underserved populations

Program Strategy

The program strategy would, as such, entail reducing the number of women and vulnerable people exposed to air pollution by identifying and addressing gendered disproportionate impacts — including how gender norms, institutional practices, and power relate to differences in exposure and vulnerabilities.

Advancing women's economic empowerment and gender equality by cultivating women's clean air leadership and empowering women and girls and other marginalized community members as change agents and decision-makers is critical.

Gender/Social Equity Strategy

Another way of looking at this strategy is through a series of guiding questions that CAC can answer, including:

1. Who are the most at-risk populations disaggregated by sex, age, income/socio-economic status, and occupation from specific source emissions?
2. How are they disproportionately exposed and impacted and where?
3. What are the social, economic, cultural, and political factors driving exposure and impacts?
4. What data do we have and where are there gaps?
5. What are the high-impact opportunities/solutions we should consider that:
    - Reduce emissions and exposure?
    - Don't perpetuate or exacerbate socio-economic and cultural harm? and
    - Advance gender equality and women's empowerment?

Gender and Social Equity

Marginalized or Vulnerable Populations

It is important to define these terms to essentially clarify what we mean by vulnerable populations and to highlight that it can mean a high level of exposure, or marginalization because of a lack of political power to change their circumstances.

Marginalized or vulnerable populations are either currently or historically underserved or underrepresented with a higher risk of disproportionate impact from air pollution. They can include women, children, the elderly, or socioeconomically disadvantaged people.

Marginalized or vulnerable populations can also include place-based exposures through their residence, employment, or activity patterns, but without the resources or power to change their exposure.

Gender and Social Equity Definitions

Social equity refers to the specific and local economically or socially determined disparities faced by vulnerable populations as a result of higher exposure and/or elevated risk or harm from exposure to sources of air pollution.

These disparities include risk or harm to health (burden of disease), but also socio-economic wellbeing or opportunity, or livelihood impacts. They can vary by population, location, or occupation.

DISPARITIES

The disproportionate impact is influenced by three dimensions:

i) **Degree of exposure**, including frequency and intensity of exposure, and proximity to specific sources.

ii) **Susceptibility to harm** associated with biological factors such as sex and age, underlying health conditions, competing risk, and socio-demographic factors (such as education, income, and occupation) and socio-economic factors (such as housing

characteristics, limited or untimely access to infrastructure, or historical political discrimination), and other traits or behaviors that predispose them to risk.

iii) **The ability to adapt to or mitigate impacts,** including factors impacting their access to services as well as broader policy or institutional norms and historical and current political conditions.

Gender and Social Equity

Work to Date

This is a broad overview of how CAC implemented this vision in the other pilot projects.

Gender and Social Equity are integrated throughout CAC's main activities as listed below:

i) **Science** — Shaped selection of priority sources and communities, gender and social inclusion-sensitive data collection, personal exposure monitoring, etc.

ii) **Engagement —** Stakeholder mapping, involvement of gender experts and women organizations in all workshops, journalist training, etc.

iii) **Solution Analysis** — Gender analysis, selection of interventions with the potential to reduce negative health impacts for women and/or to create empowerment opportunities, etc.

Gender differences in exposure in Jakarta showed that apart from the obvious higher exposures to household cooking fuel, women have significant exposure to other sources too. This is especially so for low socioeconomic status women.

In Indore, the team conducted a gender analysis to unpack how women were impacted by air pollution from the transport sector. The analysis done by a consultant also provided targeted recommendations to the CAC around data collection and women empowerment-focused solutions such as making sure to engage women organizations already working on safe and clean transport issues to cultivate opportunities for women's leadership, entrepreneurship, and employment as part of the emerging electric vehicle (e-vehicle) industry.

Finally, the team and the global partner conducted interviews, surveys, and focus group discussions with a wide range of stakeholders — including community members, civil society, government officials, and private sector representatives in Indore — around their attitudes toward air pollution.

By disaggregating the data by sex, income, and geography, they were able to gain useful insights into public knowledge of air pollution and sources as well as where people get their information from.

Key Questions for Nairobi

i) What data and information gaps about disparities in exposure and impacts beyond HAP can the CAC fill?

ii) How can we engage women and other underserved people? Where do they get their information about air pollution and who do they trust?

iii) How can we ensure women and other vulnerable populations are empowered and involved in solutions?

iv) What does gender-responsive AQ management look like in Nairobi?

Presentation 8

Integrating health dimensions

Dawit Siraw and Sumi Mehta

Virtual strategies

The overall goal of Virtual Strategies is to see governments adopt promising interventions at scale as rapidly as possible. So far, Virtual Strategies has a presence across 73 countries. They partner with governments and civil society to design solutions to their most pressing health problems.

Engaging the Public Health Sector in Clean Air Action

Virtual Strategies engages the public health sector in Clean Air Action using several approaches, including:

1) Identifying important gaps, perceptions, and misinformation about air pollution health impacts, sources, and solutions.
2) Strengthening public health data systems and data use to inform policies and investments, including active support to increase the capacity to collect and use routinely collected data to inform and measure progress on clean air action.
3) Mainstreaming AQ into ongoing public health efforts to address child survival and non-communicable diseases.

Air Pollution-Related Illness and Death are not Equally Distributed (Globally)

According to WHO, data for regional groupings shows more than 2 million deaths in Southeast Asia and the Western Pacific Regions, 1 million in Africa, 500,000 in the Eastern Mediterranean and Europe Regions, and more than 300,000 in the Americas; the leading causes of these deaths are chronic respiratory illness and cardiovascular diseases. Air pollution causes more than 27,500 deaths in Kenya, where more than 693 deaths are in Nairobi each year.

Integrating Health into Catalyst Activities

The following are strategies that Clean Air Catalysts could use to integrate health into catalyst activities:

i) Prepare local health-sector mapping.

ii) Engage with health-sector-specific stakeholders and policy stakeholders through training, convenings, and applied research.

iii) Advise on source awareness to ensure it has health observations.

iv) Conduct health impact readiness assessment.

v) Participate in relevant scientific meetings and workshops.

vi) Ensure data-driven integration of health into source awareness and root cause analysis modules.

vii) Strengthen local health sector advocacy for clean air.

According to the presenters, health sector engagement involves more than clinicians. Table 11 shows other stakeholders involved:

Table 10: Stakeholders and their Role in Clean Air Action

Stakeholder Group	**Role in Clean Air Action**
Government health officials	Technical assessment, health policy development and implementation, health sector training
Medical doctors	Technical assessment, clinical advice, cleaner air advocacy, awareness raising
Nurses	Technical assessment, clinical advice, cleaner air advocacy, awareness raising
ASHAs and Midwives	Clinical advice, awareness raising
Academia	Technical assessment, cleaner air advocacy
(Medical) Students	Technical assessment, cleaner air advocacy, awareness raising
NGOs (climate, air pollution)	Technical assessment, cleaner air advocacy, awareness raising

Tools Needed for Effective Clean Air Advocacy

Effective clean air advocacy requires some specific tools, including:

i) key messages for patients, public, media;

ii) resources on local AQ and health burden;

iii) priority clean air actions for local governments; and

iv) air pollution and health workshops and educational materials.

Presentation 9

Pathways for Integrated Clean Air and Climate Action Planning

Michael Doust

WRI

Director, Urban Efficiency and Climate

One-Atmosphere Solutions

What are one-atmosphere solutions? These are solutions that simultaneously reduce short-lived climate pollutant and greenhouse gas emissions, and air pollutant emissions from key urban sectoral activities informed by science and stakeholder input.

They are clean air solutions that are integrated with existing climate mitigation and adaptation actions, policies, and investments to maximize the climate co-benefits of improving AQ at the subnational and city level.

Why one-atmosphere solutions? Climate change and air pollution share common sources emitting primary air pollutants, short-lived climate pollutants, and greenhouse gases.

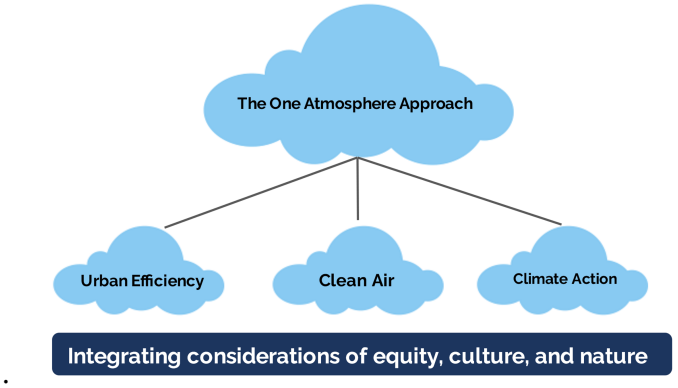


Figure 14: The One Atmosphere Approach

Activities causing climate and air pollutants lead to impacts on human health in the form of premature loss of life, onset and exacerbation of chronic and respiratory illnesses, and other diseases.

Addressing climate change and air pollution can reduce impacts on those most vulnerable to climate and air pollutant exposure. Measures taken to reduce air pollution can slow down climate change and measures taken to slow down climate change can similarly result in cleaner air for all.

Program Strategy

Climate

The strategy requires the prioritization of pollutant sources that contribute to short-lived climate pollutants and greenhouse gas emissions. Figure 16 highlights some of the highly potent short-lived climate pollutants (SLCP) and also sources and impacts.

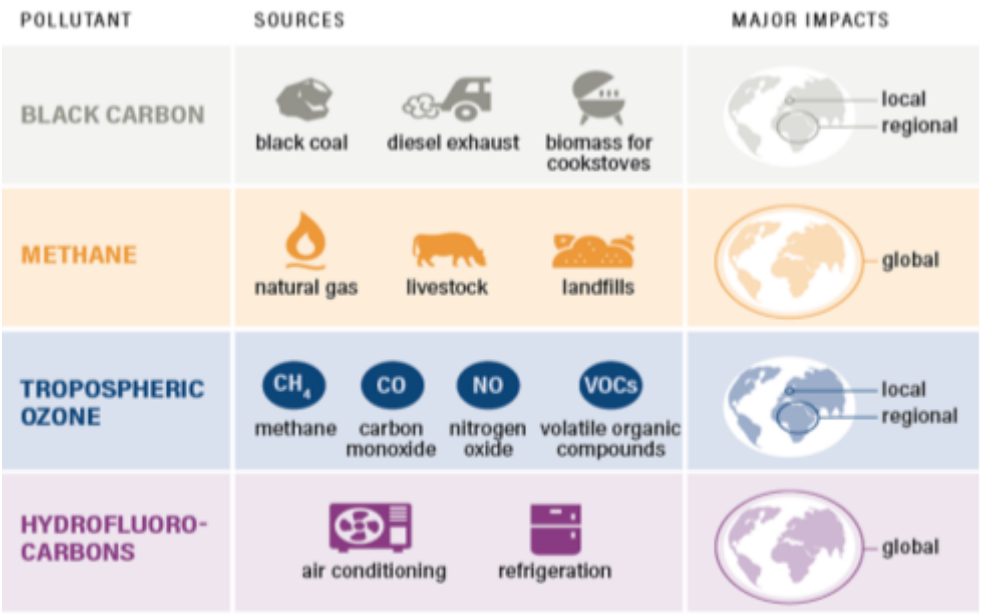


*Figure SEQ Figure * ARABIC 15: Highly Potent Short-Lived Climate Pollutants*

The program's strategy entails the following steps:

i) Communicating the "double win" of addressing air pollution and climate change simultaneously.

ii) Building on provisions to maximize climate co-benefits of the AQ interventions during the project and afterward.

iii) Integrating insights from sector-wise GHG and SLCP datasets into one-atmosphere solutions at the intersection of clean air and climate action planning.

According to Doust, reducing SLCP emissions also leads to healthy lives, as demonstrated in Figure 17. Further, it is important to note that we need to reduce GHGs and SLCPs to meet the Paris Agreement's 1.5 C target.

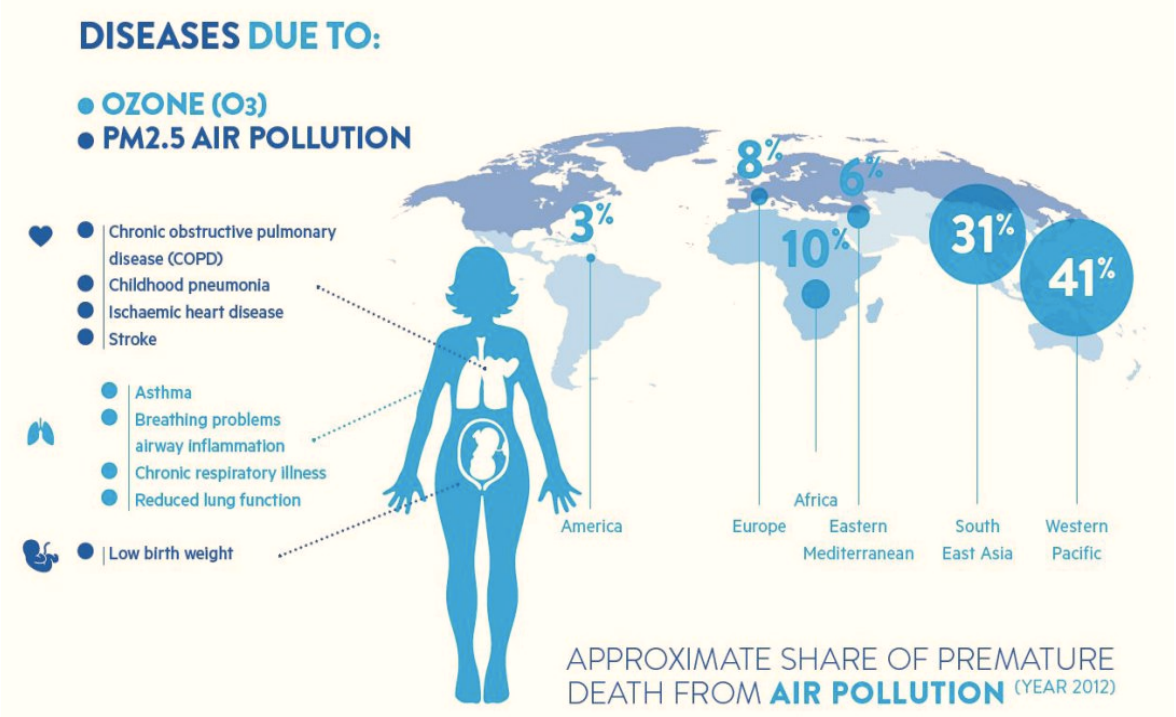


Figure 16: Reducing SLCP Emissions Leads to Healthy Lives

Black Carbon

Black carbon particles contain known toxic constituents such as carcinogens and are co-emitted with other toxic pollutants. Actions to reduce black carbon emissions must complement PM reduction strategies.

By 2040, Nairobi's transportation sector alone (with the absence of mitigating measures), will lead to an increase in black carbon emissions by over four times the estimated volume in 2020. To set specific, measurable, attainable, realistic, and time-based black carbon emission reduction targets for focus sectors, key data gaps need to be addressed.

Methane

Methane is second to CO_2, a greenhouse gas, in its proportional contribution to global warming. Reducing anthropogenic methane emissions by 45 percent by 2030 will lead Kenya to meet its Nationally Determined Contributions well ahead of time, thus reducing average surface warming in Kenya by 0.02^0C — an average cost-benefit ratio of 1:6 for the entire African continent.

There are challenges in targeted reductions posed by a lack of granular data on source contributions.

CAC Pathway to One-Atmosphere Solutions

Doust concluded the presentation by outlining the elements of the CAC pathway to One-Atmosphere Solutions, which is set within the context of sectoral engagement and coalition building:

i) Monitoring black carbon emissions and exploring the addition of methane to emissions inventory.
ii) Setting emission reduction targets for black carbon from clean air solutions in the project impact plan.
iii) Identifying existing decarbonization, mitigation, and adaptation actions.
iv) Quantifying potential climate co-benefits of action.
v) Developing climate scenarios.

Figure 18 demonstrates how the pathway to One Atmosphere Solutions is conceptualized.

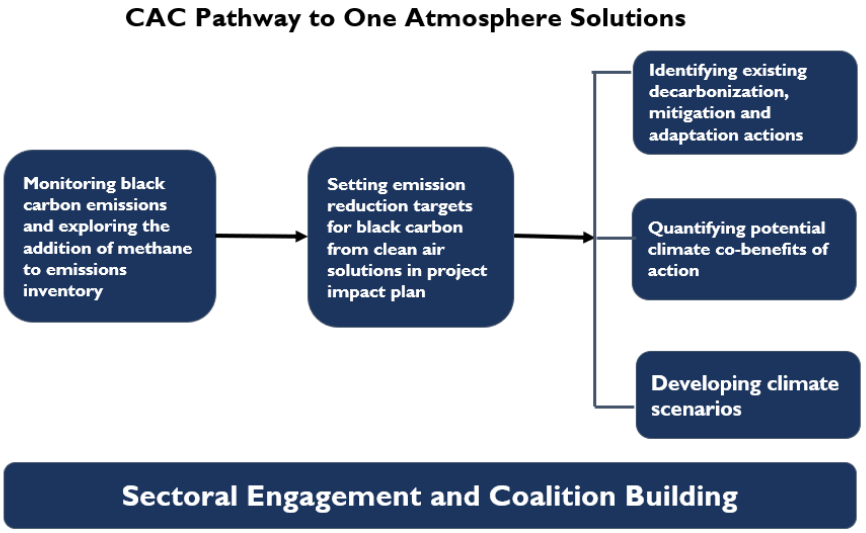


Figure 17: Pathway to One Atmosphere Solutions.

Appendices

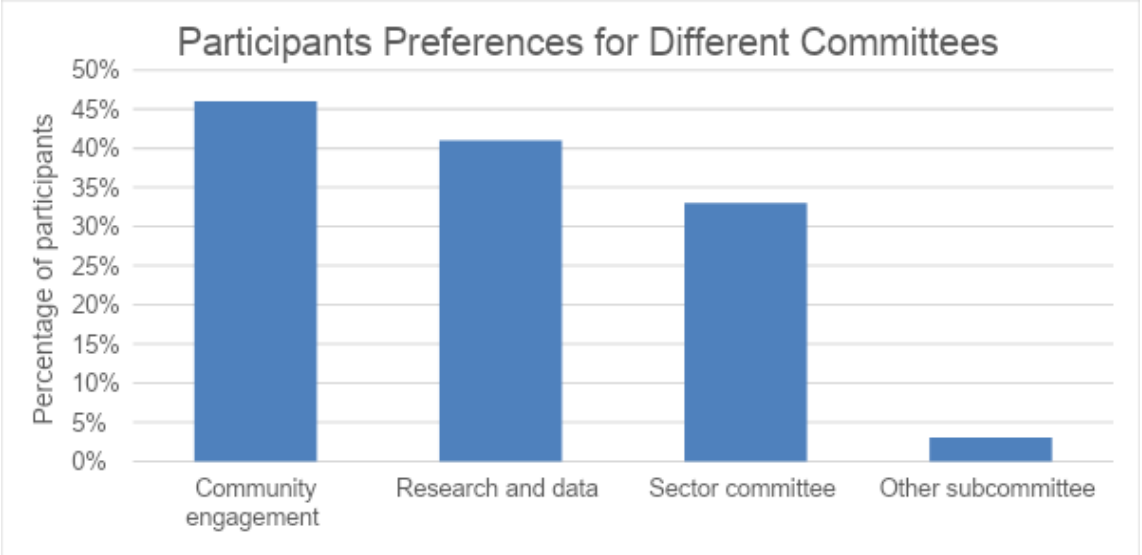
Appendix 1: Clean Air Catalyst Multi-Stakeholder Workshop Working Group survey

1. **Do you agree that we need a working group?**
   Stakeholders voted yes (100%)

2. **Who wants to be a member?**
   All the stakeholders present showed interest in being part of the working groups

3. **What other sub-committee is needed in the working group?**
   i) Transport
   ii) Occupational health
   iii) Political
   iv) Climate change
   v) Communication and awareness
   vi) Evaluation team
   vii) Data analysis and presentation
   viii) Assessment of AQ monitoring, evaluation and data authentication

4. **What subcommittee would you want to be in?**



5. **Which other organization do you think should be in the working groups? (Organization not represented here currently)**
   i) National Transport and Safety Authority (NTSA)
   ii) Airtel
   iii) Kenya Bureau of Standards (KEBS)
   iv) Matatu Owners' Association (MOA)

v) Clean Cooking Association of Kenya
vi) UNEP
vii) Kenya Industrial Research
viii) National Police Service
ix) Strathmore University
x) Ministry of public service, gender, youth and social protection
xi) Institute of climate change adaptation,
xii) university of Nairobi
xiii) Safaricom
xiv) KCB

6. Write a sentence about one of the roles of the working group

i) Guiding on the AQ project implementation
ii) Developing and implementing monitoring, reporting, and dissemination of AQ data with communities
iii) Coming up with a strategy to reduce air pollution
iv) Providing a platform to share best-fit practices on AQ achievement through research and innovation
v) Consolidating and sharing research and data from different institutions and proposing areas for further studies
vi) Developing terms of reference
vii) Policy direction on the implementation of the CAC project
viii) Disseminating research findings

Table 11: Outcomes of Deliberation by committees of the working group

	Mode of communication	Meeting schedule	Terms of reference
Community Engagement	Mailing list Email WhatsApp group (done)	Monthly meeting to be communicated by the chair. To establish reporting tool for sub-activity	Main Objective: To develop community engagement and involvement Strategy 1. Conduct situation analysis (baseline, community needs assessment, stakeholder analysis) 2. Create community awareness on AQ e.g., community dialogues, Community action day) 3. Design and implement strategies for advocacy and social mobilization on AQ 4. Design and implement communication Strategy 5. Design and implement Social Behavior Change and Communication strategy e.g., School Health 6. Design and disseminate of key messages on aspects of AQ (IEC) 7. Ensure gender mainstreaming in all aspects of AQ 8. Mapping of the sources of air pollution 9. Ensure community involvement from planning, designing, implementing, disseminating at all levels of AQ Projects 10. Build capacity of different populations on AQ, financial literacy, alternative livelihood 11. Community led dissemination of AQ initiatives Terms of reference 1. Community led dissemination of AQ initiatives 2. Resource mobilization for scaling up activities in community engagement

			3. Microfinancing initiatives 4. Organize cross learning sessions 5. Develop, train, implement community innovative solutions on AQ (community artisans) 6. Ensure knowledge management (documentation, success stories) 7. Support the county to adopt high impact technologies for improving health 8. Dissemination of policies household air pollution module 14 9. Promotion of circular economy in waste management in the community 10. Participate in AQ Conferences 11. Provide advisory role to all sub-committee 12. Identify community champions 13. Mapping of open spaces for greening including schools
Research and Data	-Group Email -Group WhatsApp -Externally – through working group reports -Minutes of the working group committee	Conduct monthly meetings to prepare CAC reports and review the Workplan for the policy progress	1. Prepare a work plan for the Policy working group 2. Policy reviews on existing laws and gaps 3. Prepare policy brief for government direction 4. Received reports from other working groups to inform policy direction 5. Take lead to conduct capacity building on policy needs as identified 6. Prepare and conduct Monitoring and Evaluation 7. Any other task as may be required on AQ management
Sector Subcommittees	Group WhatsApp	Meetings to be quarterly and when necessary	1. Coordinating the various sectors in AQ related activities 2. Reporting to working group secretariat 3. Develop terms of reference for sub committees

PRESENTATIONS

Presentations link