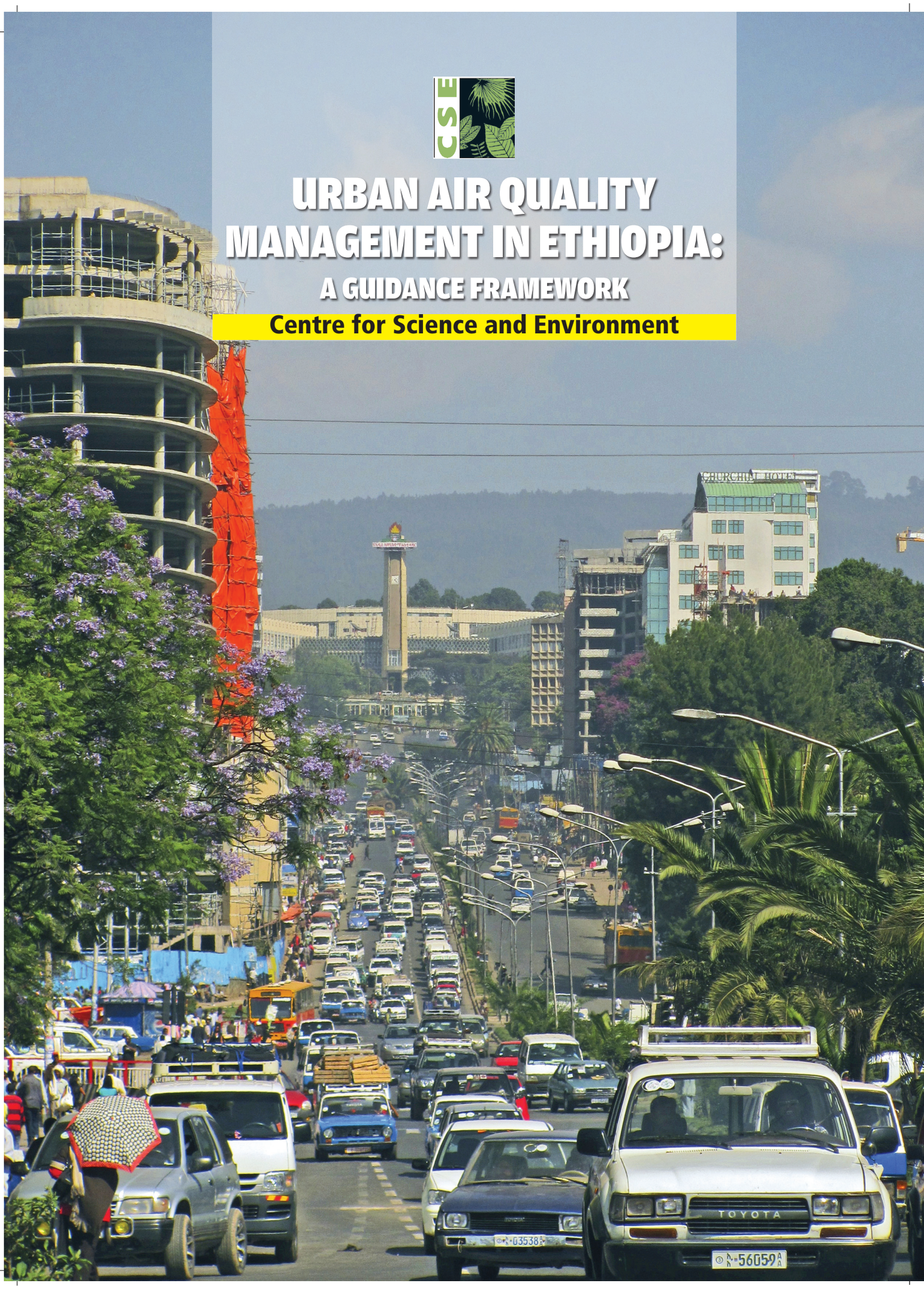

URBAN AIR QUALITY MANAGEMENT IN ETHIOPIA:

A GUIDANCE FRAMEWORK

Centre for Science and Environment

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Objectives and scope of the guidance

Air pollution is one of the leading risk factors in the developing regions of Africa. Africa is one of the fastest-urbanizing regions and more than half of its population is expected to live in polluted urban areas by 2040. According to the World Energy Outlook of the International Energy Agency of 2016, outdoor air pollution is responsible for more than 210 000 premature deaths in African region and this is only half of the total deaths caused by indoor air pollution. From public health perspective Africa like Asia is poised for an enormous epidemiological transition. Health science shows widely diverse health outcomes of air pollution that include respiratory, cardiac and metabolic effect; and effect on brain, unborn child, cancer among others. Strong early action is needed to be preventive.

The global experience shows that the game of pollution cannot be won by catching up but by leaping ahead. The developing world has to speed up the transition to minimise public health impacts of its rapid growth. But they will have to do this differently. They need leapfrog strategy that is affordable, scalable, inclusive and inventive.

Africa and Asia cannot remain conventional in their approach, method and practice – or spread action incrementally. They are running against time. If air pollution do not get worse but remain just as it is today, the number of lives lost will continue to grow as the population in developing countries grows and ages. Pollution and health risk would need to decline significantly over the next 15 years to offset health impacts from growing numbers and ageing. This brings out the magnitude of the challenge.

Learn from the global learning curve. The world is shifting the problem around. Advanced countries that have shown progress in reducing air pollution are also facing newer challenges – mix of pollutants and nature of health risks are changing setting new goals for mitigation. The poorer world is still struggling harder to contain it and reduce it.

Progress in advanced countries is a result of decades of investment, incremental change, regulatory and technical capacity building, and continuous refinement of strategies based on the lessons learned. But this will have to be scaled globally – in poorer regions of Africa as in Asia to accelerate the rate of progress.

This challenge gets more complex due to the unique pollution profile in the developing regions. On one side modern technology is constantly shifting around the health risk – as for instance, in vehicle and other combustion sectors the problem is shifting from coarser particulate matter to tinier particles and to more toxins and secondary pollutants in the air. On the other side, the traditional problems of low end technology with poor controls and high emissions continue to add to the burden of health risk. Even poor dust and waste management adds to that burden.

Developing country cities need capacity to use science and tools inventively to assess risk from all sources of pollution to inform policy and action. Instead of lagging behind in technology ladder they can use innovative fiscal solutions to achieve economy of scale for advanced technologies. They can

build institutions and strengthen public policy to control pollution from all sources and also deliver on real world performance to meet clean air target. They can protect the sustainable modes of travel – walk, cycle and bus that are already dominant. Build community and public agenda to shift people towards sustainable alternatives. This will require a change in policy mindset in developing world -- that must think in leaps and not steps.

Towards clean air action plan

This guidance framework has been developed for the Ministry of Environment and Forest and Climate Change, Ethiopia, that is the overarching apex body for management of air quality in Ethiopia.

This guidance is based on detailed analysis of the challenges in cities of Ethiopia mainly the capital city of Addis Ababa that is the primary growth centre. This guidance is expected to create a comprehensive template for integrated action to improve urban air quality. While the Ethiopian government has already initiated process to control pollution from industrial sources and mining across the country, this guidance is primarily aimed at air quality management framework for cities. The cities like Addis Ababa are densely populated and have widely dispersed sources of pollution – vehicles, small industrial sources, construction industry, open burning of waste and also solid fuel burning. All of these together contribute to pollution levels. Addis Ababa as a city has to meet clean air target to protect public health. This will require strong air quality monitoring and management framework and compliance strategy to meet the clean air target not only for each pollution source but also for the city as a whole. This management framework for the city and the larger metropolitan region will enable time bound and source wise implementation.

This guidance framework for air quality management includes the critical components -- air quality monitoring and assessment of pollution sources; guidance on standards and regulation development, legal framework for air quality management, and guidance on pollution source-wise action plan. While this guidance lists the possible action on air quality management further technical detailing will follow to projectise the implementation.

Air quality management will require action in all critical sectors including vehicles and transport, industry, and area sources in the city. This will require institutional interface and aligned action by all concerned departments and ministries for combined impact.

This guidance framework has been developed based on detailed analysis of local issues and challenges in cities of Ethiopia primarily Addis Ababa, learning curve in other developing country cities in Africa and Asia including India; global best practices and a consultation process with Ministry of Environment and Forests and Climate Change and local stakeholders in Addis Ababa and field investigation. Special effort has been made to illustrate how on several fronts developing country cities have taken action.

The New Delhi based Centre for Science and Environment is extremely grateful for this opportunity to engage to contribute to development of this guidance framework. Centre for Science and Environment expresses its appreciation and gratitude to Ministry of Environment and Forests and Climate Change for this opportunity.

Guiding principles for air quality management

Ethiopia is at the early stages of growth. The level of urbanisation and motorization has started to gather speed but comparatively are still at much lower level than several other developing countries. This is an opportunity. As most of the growth is yet to come, it is possible to develop a roadmap now that can make that growth more sustainable and ensure clean air. Its trajectory will not be weighed down by the legacy. The roadmap would need to be informed by the best practices of other countries with more matured air quality management practices. They will also have to be guided by the inventive, affordable and equitable solutions that are emerging in developing countries. This guidance framework will therefore draw lessons from the experience of both the advanced countries that have robust tools and methods of air quality planning as well as from other cities of Asia and Africa that have configured solutions to many common and unique challenges of the developing world.

Address the unique health risk transition of the developing country region: Even before the cities of Africa and Asia could fully address the traditional health risks, they have fallen into the pincer grip of modern toxic risk associated with rising pollution. The pollution situation is also very different. While pollution levels are rising, prevalence of urban poverty, poor nourishment, and underlying diseases in the population further enhance the heath risk. This demands quick transition.

Reduce integrated exposure to air pollution from all sources to protect public health: Identify and control air pollution exposure from all pollution sources to reduce public health burden. Traditionally, air pollution control measures have aimed at controlling emissions to reduce outdoor ambient concentrations to meet specified levels or standards. These standards have been established by the WHO and further customized by countries on the basis of health criteria. The standards help to set the clean air targets and guide action.

Control pollution where people are: The actual exposures to air pollution can be higher and vary for different pollutants across micro environments within a city depending on the local circumstances and time spent close to the pollution sources. This demands pollution mapping in micro environment to inform control measures. Several pollution sources contribute to human exposures in a greater proportion than they do to general ambient pollution. Exposure assessment can change the ranking of local pollution sources in micro environment. For instance, the role of road side pollution from vehicles, trash burning, and household pollution can be enhanced compared to large-scale industrial sources in the region. Exposure to vehicular pollution can be very high while traveling and residing close to the road side. Power plants with high stacks will be a significant contributor to overall ambient levels in the region.

Need regional air quality planning to reduce the effect of pollution movement: Air pollution does not follow political boundary. Its dispersion can have larger regional impacts and undermine the local efforts to control local pollution. Air quality monitoring and assessment needs to account for it. In developing country situation, monitoring air pollution in urban, rural and urban periphery can be of relevance from public health stand point. Internationally, as in India, the Global Burden of Disease has established that household air pollution can contribute as much as 25 per cent of the outdoor particulate pollution.

Adopt the principle of co-benefits to design air pollution control action for diverse benefits of public health, climate mitigation and energy security: While in any developing country city public health will remain the primary driver of air pollution control efforts, the action must also be calibrated against the indicators of green house gas reduction; and mitigation of short lived climate forcers like black carbons that not only harm public health but also trap heat. The other welfare gains include energy savings, and reduction of road safety risks.

Control measures needed to address equity, affordability, inventiveness, compliance and transparency: These are the key elements of good air quality management practices. This is particularly important in developing country where urban poverty is high and welfare gains have to ensure health risk reduction across all income strata.

Quicken steps at the early stages of growth to leapfrog to clean air target, best available technologies and demand management measures to control pollution: This will require inventive solutions including adoption of polluter pay principle to meet the cost of transition.

Adopt a legal framework for governance to enable time bound implementation of action plan to meet clean air target: This is needed to establish clear processes to bring all concerned implementing bodies and stakeholders within an integrated framework to monitor, frame and implement control measures.

Build capacity and skills for air quality management and implementation: Need critical strategy to build human resource, technical resource and skills to enable monitoring, planning and management and compliance. This will require unified action, ability to adopt scientific tools of air quality management for science based action.

CHAPTER 1: Air quality monitoring and management

SECTION 1: Status of the problem

In cities of African continent the problem of air pollution though not well assessed yet, is not expected to be as bad as that of some of the worst air pollution situations in several cities of Asia. Though the reported level of particulate matter of less than 10 micron size (PM10) in most African cities are lower than some of the worst hit cities in India, their levels are still much higher than the stringent WHO guidelines. The WHO database of 2013 shows that PM10 levels are 7.5 times the WHO guidelines in Dakar, 5 times higher in Accra, 6 times higher in Lagos, and more than 3 times higher in Johannesburg and Tunis. Even at the comparatively lower levels of pollution than those in Indian cities the African cities have a cause of concern. The Global Burden of Disease (GBD) estimates show that the most health effects occur at lower levels. There is no reason to think that the risk in these cities is less.

Air quality monitoring in cities of Ethiopia

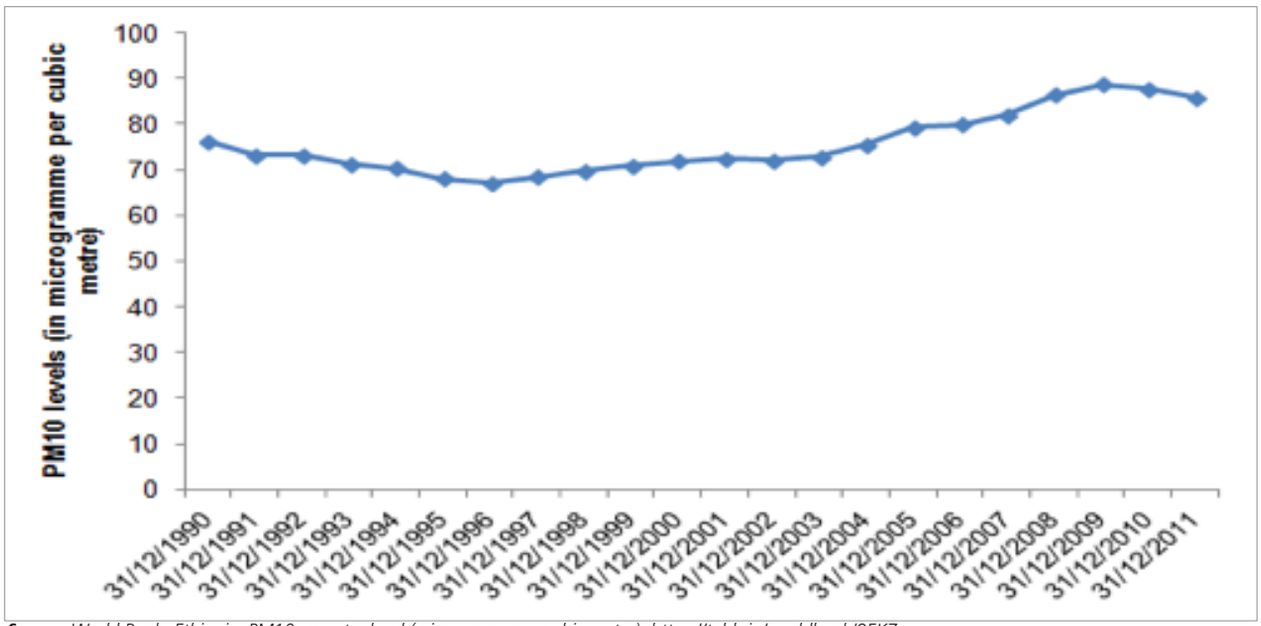
Ethiopia is among the leading nations in the region that has one real time air quality monitoring station located at the National Meteorology Agency (NMA) campus in Addis Ababa. Set up by Thermo Fischer Scientific India Private Limited, an Indian company at a cost of 5 million Birr one and a half years ago, can monitor nitrogen oxide (NOx), ozone (O3) and carbon monoxide (CO). Particulate matter is not being monitored yet. Air quality data is not publicly available. According to a NMA official, data is provided to the agencies on request. There are plans to set up air quality monitoring stations in other cities of Ethiopia as well.[1] The NMA has invited bids for procurement of continuous ambient air quality monitoring station.

Rising particulate pollution in Addis Ababa

The only available time series data on particulate matter is from the World Bank document that has PM10 data from 1991 to 2011. It shows increasing PM10 levels from 1996 till 2009 and decline in 2010 and 2011 *(see Graph 1: Rising particulate levels).* Few other available studies show monitoring of PM10, CO, NO_2 and SO_2.

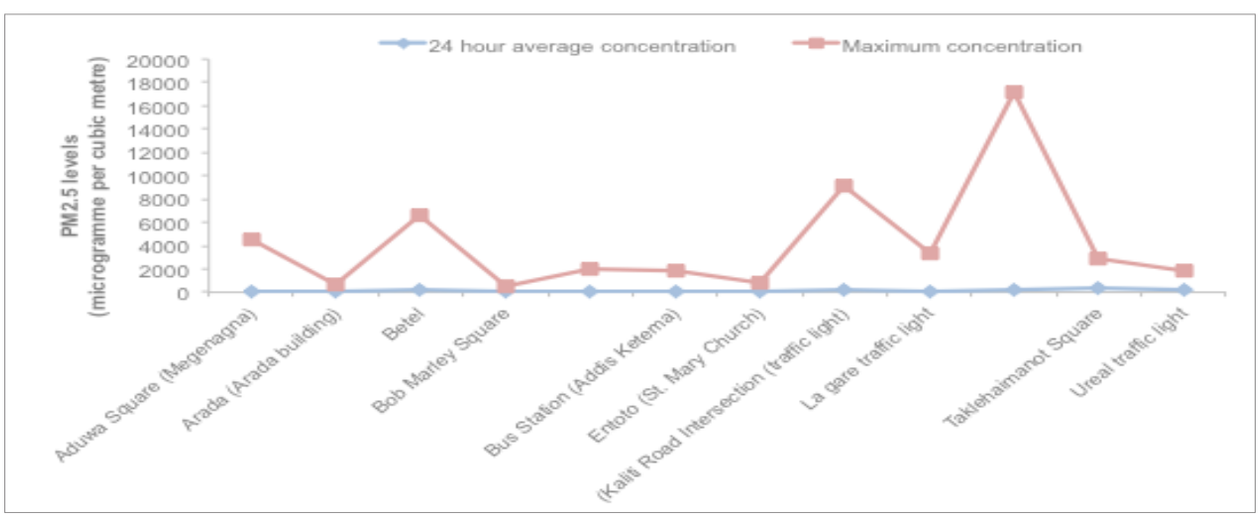
There are other evidences as well. In a pilot air pollution monitoring study carried out carried out by researchers from Desert Research Institute, Environmental Protection Authority of Ethiopia and Clark County Department of Air Quality Management in Addis Ababa during 2004 dry season found 24 hourly PM10 concentrations ranging from 35 to 97 microgramme per cubic metre across 12 sampling sites around the city.[2] In another study conducted by researchers from Addis Ababa University and US based National Risk Management Research Laboratory, aerosol samples collected from February 22, 2008 to April 15, 2008 in seven urban and peri-urban areas of Addis Ababa showed concentration of total suspended particulate matter ranging from 17 (Kaliti sub-station in June 2008) to 556 microgramme per cubic metre (NSLP site in February 2008) and PM10 ranging from 17 (COLTI site in July 2008) to 285 microgramme per cubic metre (KWWT site in March 2008). The study attributed high PM10 concentration during dry season to emissions of dust particles from paved and unpaved road and incomplete fossil fuel combustion, biomass and waste burning activities around the sampling site.[3]

Graph 1: Rising particulate levels



Source: *World Bank, Ethiopia: PM10, country level (micrograms per cubic meter), https://tablr.io/worldbank/9EKZ*

Graph 2: PM 2.5 concentration in different locations in Addis Ababa

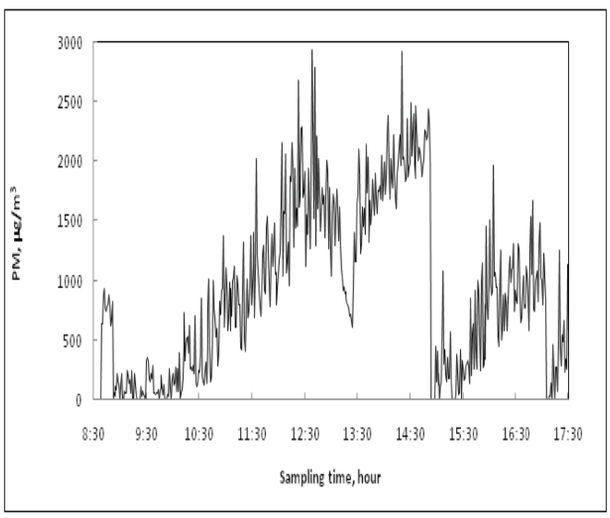


Source:*Zerihun Abate 2015, Impact of vehicle emission on air pollution in Addis Ababa, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.*

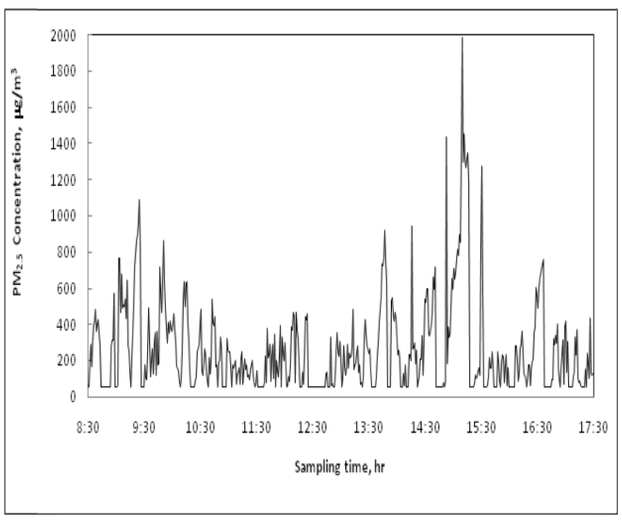
Air quality monitoring done by Zerihun Abate of Addis Ababa University of Science and Technology in different areas of Ethiopia such as Aduwa Square (Megenagna), Arada (Arada building), Betel, Bob Marley Square (Imperial Hotel), Bole Bridge, Bus Station (Addis Ketema), Entoto (St. Mary Church), Kaliti Road Intersection (Traffic light), La gare traffic light, Mexico Square, Taklehaimanot Square and Urael Traffic Light found PM2.5 concentrations to be higher than the WHO guideline. The PM2.5 levels were also found to be higher than the Ethiopian Environmental Protection Agency limit values except for areas such as Aduwa Square, Arada, Imperial Hotel and Entoto sites. The highest 24 hourly PM2.5 concentration was observed at Taklehaimanot Square *(see Graph:*

Graph 3: High PM 2.5 levels at some sites

PM2.5 levels at Teklehaimanot Square



PM2.5 levels at Bole Bridge



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Graph 2: PM2.5 concentration in differ locations in Addis Ababa and Graph 3: High PM2.5 levels in some sites). However, the levels of carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) were found to be below the guidelines. While 24 hour averages show moderately high levels the maximum peaks hit very high level. This requires further investigation.[4]

Signs of multi-pollutant crisis

While particulate matter has emerged as a concern, evidence also points towards traces of several other gaseous pollutants that add to the toxic trail. In a study by researchers from Addis Ababa University, US based Bowling Green State University, Addis Continental Institute of Public Health and Umea University 80 roadside and 24 on-road daily traffic air samples were taken during wet and dry seasons of 2007 and 2008. Nearly 15 per cent of roadside samples and all on-road samples were almost more than 50 per cent of the 8 hour WHO guideline for CO. The daily CO maxima were observed in early mornings and late afternoons. This implies vehicles are prime air pollution source.[5] A study by researchers by Addis Ababa University Natural and computational Science College Department of Physics, Addis Ababa University Natural and computational Science College, Faculty of Agriculture and Environmental Science South Africa University was also conducted to monitor traffic air pollution in Addis Ababa around bus stations. More than 18 air pollutant elements were identified indicating high pollution due to traffic air pollution.[6]

Traces of air toxins

Volatile organic compounds (VOCs) monitoring was conducted in two Ethiopian cities – Jimma and Addis Ababa found higher levels. This is part of a global multi-city study done by researchers from Ghent University in which thirty four VOCs were measured at eight different urban sites across the world -- in Ghent (Belgium), Hanoi (Vietnam), Jimma and Addis Ababa (Ethiopia)

from September 2008 to September 2010. The highest total VOC concentrations were measured in street samples with maximum values of 318 microgramme per cubic metre in Addis Ababa, 507 microgramme per cubic metre in Hanoi and 54 microgramme per cubic metre in Ghent.[7]

Public health challenge

Globally, there are enough health evidences to signal the need for urgent action to reduce the public health risks — both short and long term impacts, on children, elderly, poor and general population. For toxic effects like cancer to surface there is a long latency period therefore exposure to toxic pollution will have to be reduced today. Global burden of disease (GBD) has ranked air pollution as one of the major factors behind global deaths.

According to the GBD estimates, 176,000 deaths occur every year due to outdoor air pollution in African region. This is still less than 279,000 deaths in Europe and much less than 670,000 in India. While the health impact studies are of global nature, country or city specific studies can show different scale of the problem. Africa region needs to be preventive and precautionary to avert public health disaster.

The GBD estimates for Africa shows that ambient particulate pollution is the 13th risk factor for disease burden in Ethiopia.[8] According to the 2009 WHO report, the country has reported the highest number of air pollution deaths followed by Kenya and Uganda. In 2004 there were 72,400 and 2,500 premature deaths from indoor and outdoor air pollution respectively.[9] The African region is also reporting one of the highest death rates from non-communicable disease. Air pollution can further exacerbate this. In Sub-Saharan Africa non communicable disease (NCDs) are projected to surpass infectious diseases by 2030. NCDs are estimated to account for 34 per cent of all deaths in Ethiopia.[10] The global risk transition studies show that countries gradually shift from communicable disease burden to non-communicable burdens associated with lifestyle choices that are aggravated by exposures to pollution.

Not many health studies exist on air pollution and its impact in the country. Yet, the available ones do show high impact of outdoor air pollution. According to Worku Tefera, Lecturer, College of Health Science, Addis Ababa University, there is paucity of evidence on outdoor as well as indoor air pollution. There are relatively more studies on impacts of indoor air pollution. The few outdoor air pollution and health studies are available for Addis Ababa. Tefera added that as there is no regular air quality monitoring, lack of data hampers studies.[11] A specific medical study conducted in Addis Ababa and published in IUP Journal of Environmental Science in August 2011, found 40 per cent increase in acute respiratory infection cases.[12] Another study by University of Nottingham on 3,592 adults and children in an urban community in Jimma city found increased risk of wheeze amongst those living within 150 meter from roads. The risk of wheeze increased significantly and linearly with proximity to the road.[13]

The University of Southern California and Addis Ababa University scientists will conduct the Eastern Africa Children's Health Study which will look at the impact of air pollution on the respiratory health of 4,000 children aged 9 to 10 years in Ethiopia, Kenya, Rwanda and Uganda. This will conduct air quality study in Addis Ababa including PM2.5 in five locations. This will involve speciation of chemical composition, NOx measurement and traffic related pollution and correlation with hospital data.' He emphasised on establishing

air quality monitoring stations in urban centres as well as in industrial areas in the city and across the country and need for air pollution and health impact studies.

Community studies of air pollution have shown a number of different types of adverse health effects from exposure to ambient pollution. The expected health effects depend on the type of pollution, the level of exposure and the personal susceptibility of an individual. Already wide variety of health outcomes have been associated with air pollution: reduced lung functioning, asthma attacks, respiratory symptoms, heart ailments, stroke, cancer, hypertension, diabetes, effect on brain and foetus and premature deaths. Health impacts lead to restricted activity, increased medication use, increased hospital admissions, increased emergency room visits, and loss of productive life years.

The WHO has in its recently released Resolution on air pollution in the World Health Assembly 2015 on Health and the environment has asked for urgent action to address the health impact of air pollution in all countries *(see Box: The Resolution on air pollution passed in the World Health Assembly 2015 on Health and the environment: Addressing the health impact of air pollution).*

Particulate levels in Addis Ababa are lower than other regions. But a cause of concern

Though the overall particulate levels are comparatively lower than the other regions in the country, the levels are much above the WHO guidelines. Also the global assessments that are now available from the Global Burden of Disease estimates show that the most of the health effects occur at lower levels. Also the cities have several local pollution hotspots, and road side exposures are also high. Annual averages do not help to capture the range of this risk.

The rudimentary data from sporadic studies show high exposure. According to a source apportionment study in 2004 in Addis Ababa, the air pollution sources include light and heavy-duty vehicles, industry, home heating and cooking, as well as fugitive sources such as biogenic emissions and dust.

Resolution on air pollution passed in the World Health Assembly 2015 on 'Health and the environment: Addressing the health impact of air pollution'

This resolution has urged Member States to develop air quality monitoring systems and health registries to improve surveillance for all illnesses related to air pollution; promote clean cooking, heating and lighting technologies and fuels; and strengthen international transfer of expertise, technologies and scientific data in the field of air pollution. The key highlights on health outcomes of air pollution and relevant excerpts of this resolution are as follow:

- Air pollution is one of the main avoidable causes of disease and death globally.
- Even at relatively low levels air pollution poses risks to health, and because of the large number of people exposed it causes significant morbidity and mortality in all countries. However, although all populations are affected by air pollution, the distribution and burden of consequent ill-health are inequitable. The poor and disempowered, including slum dwellers and those living near busy roads or industrial sites, are often exposed to high levels of ambient air pollution. Women and children in households that have to use polluting fuels and technologies for basic cooking, heating and lighting bear the brunt of exposure to indoor air pollution.
- Pollutants with the strongest evidence for public health concern are fine particulate matter1 and gases (mainly carbon monoxide, ozone, nitrogen oxides, sulfur dioxide and volatile organic compounds). Fine particulate matter, which is widespread both indoors and outdoors, damages the health of more people than any other air pollutant, through the deposition of particles in smaller airways and alveoli in the lungs and their penetration into the bloodstream.
- Among the types of fine particulate matter, particular concern centres on elemental carbon and organic materials, transition metals and metal compounds; inorganic sulfates and nitrates; ammonia; sodium chloride; and mineral dust. Absorbed particles can damage inter alia lung function and the cardiovascular system, through oxidative stress, alteration of the electrical processes of the heart and systemic inflammation, leading to endothelial cell activation and dysfunction; altered blood pressure and heart rate, including heart rate variability; arrhythmia; and deregulated coagulation pathways; and ischaemia.
- Exposure to air pollution, especially fine particulate matter, is a leading risk factor for non-communicable diseases, in particular: ischaemia, myocardial infarction, stroke, chronic obstructive pulmonary disease and cancers. Of deaths due to outdoor air pollution 80% are attributed to heart disease and stroke and 20 per cent to respiratory illnesses and cancers. For household pollution, acute respiratory diseases in children and chronic obstructive pulmonary disease are the most serious consequences, followed by heart disease and stroke. Indoor and outdoor air pollution together cause about one fifth of the global mortality from stroke and ischaemic heart disease, and more than one third of deaths from chronic obstructive pulmonary disease.
- Air pollution and in particular its fine particulate component have recently been classified as a cause of lung cancer by IARC,2 which had already classified diesel combustion and the burning of coal (two main causes of household and ambient air pollution) as the source of carcinogens. Around 30 per cent of all lung cancer deaths can be attributed to the joint effects of household and ambient air pollution.
- Most sources of both ambient and household air pollution are directly influenced by the choice of energy technologies and fuels used, including the energy efficiencies of homes and transport systems. Therefore, the prevention of diseases related to air pollution depends on the implementation of specific sectoral policies that reduce air pollution at point of source (for instance, in energy and power generation, transport, urban planning, buildings, industry and agriculture).
- The use of cross-sectoral approaches to health, such as health in all policies, can help to identify the appropriate policy responses for tackling the main sources of air pollution in specific sectors, as well as related opportunities for more joint action.
- Integral to strategies to control the damaging effects of air pollution on health is the setting of clear health benchmarks, targets and reporting mechanisms for monitoring the effectiveness of air pollution control measures. WHO's air quality guidelines for both ambient2 and indoor air quality3 provide benchmarks, which are considered by most countries when setting goals for clean air.

SECTION 2: Strategy to guide air quality monitoring and management

Setting air quality standards

The obvious starting point of air quality management is to first study if an area has an air pollution problem. The ambient air quality monitoring standards are a regulatory measure to set the target for pollution reduction and achieve clean air. The air quality standards are needed to provide adequate margin of safety to protect public health; vegetation and property; establish priorities for abatement and control; provide uniform benchmark for assessing air quality at national level; provide uniform benchmark for assessing air quality at national

Elements of air quality standards

The objective of air quality standards: The goal of air quality management is to protect human health, especially the sensitive group, and ensure overall welfare of animal and plant life. Standards should be adopted as a regulatory tool that is legally enforceable. The basic premise is that standards must protect the people with an adequate margin of safety.

Standards are expressed in time averages to indicate the maximum concentration that can be allowed for each pollutant and reduce the number of exceedances over an assigned time period – annual average, daily average, hourly averages. The annual average helps to establish the trend in pollution over time. The shorter duration – daily and hourly averages are more important from public health perspective. This varies across pollutants. While some critical criteria pollutants like particulate matter, nitrogen oxide, sulphur dioxide, are regulated based on the 24 hour or daily average basis, other pollutants like carbon monoxide and ozone can have shorter duration time averages like 8 hours and one hour respectively. From health standpoint these pollutants cannot exceed limits even for short duration as this can have immediate health impacts on susceptible population. The annual average and 24-hourly average standards are fixed for sulphur dioxide (SO2), oxides of nitrogen (NOx), suspended particulate matter which are respirable or breathable (that means microscopic particles of 10 micron or 2.5 micron sizes), heavy metals such as lead (Pb) and ammonia. For ozone and carbon monoxide only short term standards, 1 and 8- hourly standards, are prescribed. Some criteria pollutants like sulphur dioxide can have shorter duration standards too. For instance, in India there is a four hour average standards for sulphur dioxde due to its impact on some sensitive crops near industrial area and power plants.

Need target date for compliance: This will decide the nature of compliance and emissions standards for different sources for attainment of the overall standards. For instance in India the 24 or 8 hourly values of different pollutants must be met 98 per cent of the time in a year and they should not exceed the standards on two consecutive days.

WHO guidelines as the reference for development of national standards: The World Health Organisation (WHO) has framed guideline values for different pollutants and also updated them from time to time. These have been developed based on the wide body of evidences from epidemiological and toxicological studies and risk assessment. The principle is that it is possible to have a threshold limit that if met can minimized health effects. While the WHO has provided for the final guidelines that are very stringent and entirely health based, it is possible for the national governments to set standards based on the intermediate standards leading to the final standards recommended by the WHO. National government can set standards based on local circumstances and technological feasibility. In adopting legally binding standards, other considerations such as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, as well as social, economic and cultural conditions must be taken into consideration (SEI, 2008).

The air quality standards should be health based and uniform across the entire population: Ambient air quality standards should not be land use based – that means weaker standards for industrial areas than for urban areas/ residential areas. Industrial areas are also densely populated and as the urbanization progressed the boundaries between residential and industrial areas become porous exposing people to high level of air pollution. India had originally started with different standards for different land use classes but changed that in 2009 to adopt uniform standards.

Source: Anon 2014, *Improving Air Quality Monitoring in Asia: A Good Practice Guidance,* Asian Development Bank, Mandaluyong City.

level and impact of control measures over time and indicate the need and extent of monitoring programme *(see Box: Elements of air quality standards).*

The air quality standards should be health based and uniform across the entire population: Ambient air quality standards should not be land use based – that means weaker standards for industrial areas than for urban areas/ residential areas. Industrial areas are also densely populated and as the urbanization progressed the boundaries between residential and industrial areas become porous exposing people to high level of air pollution. India had originally started with different standards for different land use classes but changed that in 2009 to adopt uniform standards.

Ethiopia has adopted national ambient air quality standards (NAAQS). The WHO guidelines are the reference point. It is reported that the Ethiopian Environmental Protection Authority and the United Nations Industrial Development Organisation have prepared the guideline ambient environment standards (including air quality standards) for Ethiopia under the Ecologically Sustainable Industrial Development (ESID) Project in 2003. Under this, guideline limit have been set for six air pollutants such as SO_2, NO_2, CO, O_3, PM10, PM2.5 and lead. While some air pollutants have similar values as that of WHO guidelines (for example, sulphur dioxide (10 minutes), nitrogen dioxide (1 hour) and nitrogen dioxide (annual), others are not as stringent as the WHO guidelines except the annual PM2.5 which is marginally higher than the WHO *(see Table 1: Air quality guidelines: Ethiopia and WHO).* Standards for compounds with non-carcinogenic and carcinogenic

Table 1: Air quality guidelines: Ethiopia and WHO

Pollutants	Guideline value (microgramme per cubic metre)	WHO air quality guidelines
Sulphur dioxide (10 minutes)	500	500
Sulphur dioxide (daily)	125	20
Sulphur dioxide (annual)	50	-
Nitrogen dioxide (1 hour)	200	200
Nitrogen dioxide (annual)	40	40
Carbon monoxide (15 minutes)	100000	-
Carbon monoxide (30 minutes)	60000	-
Carbon monoxide (8 hour)	10000	-
Ozone (8 hours)	120	100
Ozone (1 hour)		180
Particulate matter less than 10 microns (annual)	50	20
Particulate matter less than 10 microns (daily)	150	50
Particulate matter less than 2.5 microns (annual)	15	10
Particulate matter less than 2.5 microns (daily)	65	25
Lead (annual)	0.5	-

Source:*1. Guidelines Ambient Environment Standards for Ethiopia 2003, The Environmental Protection Agency and The United Nations Industrial Development Organization prepared under the Ecologically Sustainable Industrial Development (ESID) Project, August, Addis Ababa*

2. WHO guidelines

Upgradation of standards in developing country: Case of India

India had first notified the National Air Quality Standards in 1994 under the Air Act 1986 for the criteria pollutants including total suspended particulate matter (TSPM), sulphur dioxide (SO2), nitrogen oxide (NO2), carbon monoxide (CO) and lead. Subsequently ammonia was added in 1998. Initially, India had adopted different standards for different land use classes – industrial, residential and sensitive areas.

These standards were subsequently reviewed based on new science, data and review of international practices and notified in 2009. The process was initiated through multi stakeholder consultation. The new revision introduced several significant changes. The key changes include the recognition of the fact that standards should be uniform across land use classes and health based to protect public health.

New pollutants were brought within the ambit of regulations including PM2.5 and ozone (O3). Air toxins were included for the first time. These include benzene, benzo(a)pyerene, nickel and arsenic.

The older standards for NOx were made more stringent. While standards for NOx and SO2 have aligned with the that of WHO, the standards for PM2.5 and PM10 are still more lax reflecting the challenge of local situation.

endpoints (compounds like benzene, benzopyrene, diesel exhaust etc) have also been listed. It may be noted, that normally carcinogens like benzene, PAH, benz(o)pyrene are harmful even at trace level.

It is not clear whether these guidelines are being implemented. The MEFCC has notified the national ambient air quality standards and emission standards for different groups of industries. The country needs strategy for monitoring, enforcement and compliance. The developing world has however adapted from the WHO air quality guidelines without framework for enforcement. Legal framework for enforcement of air quality standards is therefore needed along with strong compliance framework. Likewise emissions standards for both mobile source as well as industrial sources will have to be set and mandated. The roadmap for each source will be discussed under relevant section of this report.

Several developing countries are now setting and further upgrading the air quality standards *(see Box: Upgradation of standards in developing country: Case of India). But many of them do not have the requisite framework for implementation.*

Emissions standards in Ethiopia

According to the directory of industries published by the Ministry of Trade and Industry, Ethiopia, there are over three thousand industrial establishments in the country. The industries represent eight major sectors such as tanning and production of leather goods; manufacture of textiles; extraction of mineral ores and production of metals and metal products; processing of food products including beverages, meat and meat products; manufacture of cement and cement products; preservation of wood and manufacture of wood products including furniture; production of pulp and paper and paper products; and manufacture and formulation of chemical products including pesticides. These industries however vary in process technology, size, nature of product, characteristics of waste discharged and the receiving environment.

Provisional standards have been set for industrial pollution control in Ethiopia. Limits have been set for water discharge and also for air emissions. The Ministry of Environment, Forest and Climate Change, Ethiopia has reviewed

Emissions standards for different categories of industry in Ethiopia

Type of industry	Parameter	Limit value
Tanning and leather finishing	Total particulates	50 mg/Nm^3
	Volatile organic carbons	75 g/m^2 product produced
	Total hydrogen sulphide, sulphides and mercaptans (as S)	5 ppm v/v
	Ammonia	40 ppm v/v
	Acid vapours (as HCl)	30 mg/Nm^3
Manufacture and finishing of textiles	Particulate matter	50 mg/Nm^3
	Volatile organic carbons (as C) (excluding formaldehyde)	50 mg/Nm^3
	Formaldehyde	20 mg/Nm^3
	Isocyanates (as NCO)	0.1 mg/Nm^3
Production and processing of iron and steel	Particulate matter	50 mg/Nm^3
	Hydrogen fluoride (as HF)	5 mg/Nm^3
	Mercury (as Hg)	0.05 mg/Nm^3
	Lead (as Pb)	0.5 mg/Nm^3
	Zinc (as Zn)	10 mg/Nm^3
	Chromium (as total Cr)	0.5 mg/Nm^3
	Nickel (as Ni)	0.5 mg/Nm^3
	Cadmium (as Cd)	0.05 mg/Nm^3
	NO_x (as NO_2)	1000 mg/Nm^3
	SO_x (as SO_2)	800 mg/Nm^3
	Dioxins as International Toxicity Equivalent(I-TEQ)	1 ng/Nm^3
Metal working, plating and finishing	Particulate matter	10 mg/Nm^3
	Hydrogen fluoride (as HF)	5 mg/Nm^3
	Mercury (as Hg)	0.05 mg/Nm^3
	Lead (as Pb)	0.5 mg/Nm^3
	Zinc (as Zn)	10 mg/Nm^3
	Chromium (as total Cr)	0.5 mg/Nm^3
	Nickel (as Ni)	0.5 mg/Nm^3
	Cadmium (as Cd)	0.05 mg/Nm^3
	NO_x (as NO_2)	300 mg/Nm^3
	SO_x (as SO_2)	300 mg/Nm^3
	Dioxins as International Toxicity Equivalent (I-TEQ)	1 ng/Nm^3
Base metal and iron ore mining	Particulate matter	50 mg/l
	Silica	15 mg/l
	SO_2 (mg/Nm^3)	1000 mg/l
	Nickel (as Ni)	5 mg/l
	Iron (as Fe)	10 mg/l
	Copper (as Cu)	20 mg/l
	Sulphuric acid (as H_2SO_4)	50 mg/l
	Nitric acid (as HNO_3)	50 mg/l
	Ammonia (as NH_3)	300 mg/l
	Arsine	5 mg/l
	Dioxins as International Toxicity Equivalent (I-TEQ)	1 ng/Nm^3
Malting, brewing, distilling, production of wines and other alcoholic liquors	Total Particulates (at a mass flow of 0.5 kg/h or above)	100 mg/Nm^3
	Hydrogen chloride (as HCl) (at a mass flow of 0.3 kg/h or more)	30 mg/Nm^3
Manufacture of dairy products	Total particulates (at a mass flow of 0.5 kg/h or above)	100 mg/Nm^3
	Hydrogen chloride (as HCl), at a mass flow of 0.3 kg/h or more	30 mg/Nm^3
Fruit and vegetable processing	Total Particulates (at a mass flow of 0.5 kg/h or above)	100 mg/Nm^3
	Hydrogen chloride (as HCl) (at a mass flow of 0.3 kg/h or more)	30 mg/Nm^3
Manufacture of sugar	Total particulates (at a mass flow of 0.5 kg/h or above)	100 mg/Nm^3
	Hydrogen chloride (as HCl) (at a mass flow of 0.3 kg/h or more)	30 mg/Nm^3
Slaughtering meat processing and rendering		
a. Slaughtering and meat processing plants	Total particulates (at a mass flow of 0.5 kg/h or above)	100 mg/Nm^3
	Hydrogen chloride (as HCl) (at a mass flow of 0.3 kg/h or more)	30 mg/Nm^3
b. Rendering plants	Total particulates	100 mg/Nm^3
	Ammonia	50 ppm v/v
	Amines	5 ppm v/v
	Hydrogen sulphide, and mercaptans	5 ppm v/v
Manufacture of fertilizers		
a. Phosphate fertilizer plant		
Fertilizer Plant	Total Particulates	100 mg/Nm^3
	Fluorides (as HF)	10 mg/Nm^3
Sulphuric Acid Plant	Sulphur Dioxide (as SO_2)	2 kg/t acid
	Sulphur Trioxide (as SO_3)	0.15 kg/t acid
Phosphoric acid plant	Total Particulates	100 mg/Nm^3
	Fluorides (as HF)	10 mg/Nm^3
b. Nitrogenous fertilizers		
Ammonia production	Nitrous oxides (as NO_2)	1.3 kg per tonne of NH_3 produced

	Sulphur oxides (as SO_2)	0.1 kg per tonne of NH_3 produced
	Carbon dioxide (as CO_2)	500 kg per tonne of NH_3 produced
	Carbon monoxide (as CO)	0.03 kg per tonne of NH_3 produced
Fertilizer plant	Total particulates	100 mg/Nm^3
	Ammonia	50 mg/Nm^3
	Amines	5 mg/Nm^3
Pulp and paper	Total particulates	150 mg/Nm^3
	Hydrogen sulphide (as H_2S)	15 mg/Nm^3
	Sulphur dioxide (as SO_2)	800 mg/Nm^3
	Total sulphur	
	Sulphite mills	2 kg/ton ADP*
	Kraft and other mills	1.5 kg/ton ADP*
	Chlorine	20 mg/Nm^3
	Nitrous oxide (as NO_2)	
	Natural gas	100 mg/Nm^3
	Liquid fuels	150 mg/Nm^3
	Solid fuels	300 mg/Nm^3
	Volatile organic carbon compounds	20 mg/Nm^3
	Smoke	2 units of Ringlemann shade
Cement manufacturing	Total particulates	150 mg/Nm^3
	Sulphur dioxide (as SO_2)	1000 mg/Nm^3
	Nitrous oxide (as NO_2)	2000 mg/Nm^3
Petrochemical manufacturing	Total particulates	50 mg/Nm^3
	Nitrous oxides (as NO_2)	500 mg/Nm^3
	Sulphur dioxide (as SO_2)	800 mg/Nm^3
	Hydrogen chloride (as HCl)	20 mg/Nm^3
	Benzene	5 mg/Nm^3 0.1 ppb at plant fence
	1,2-Dichloroethane	5 mg/Nm^3 1 ppb at plant fence
	Vinyl chloride	5 mg/Nm^3 0.4 ppb at plant fence
	Chlorine	20 mg/Nm^3
	Ammonia (as NH_3)	15 mg/Nm^3
Pesticide manufacturing	Total particulates	10 mg/Nm^3
	Volatile organic carbon compounds	50 mg/Nm^3
	Hydrogen chloride (as HCl)	20 mg/Nm^3
	Chlorine (or chloride)	5 mg/Nm^3
Pesticide formulation	Total Particulates	10 mg/Nm^3
	Volatile organic carbon compounds	50 mg/Nm^3
	Hydrogen chloride (as HCl)	20 mg/Nm^3
	Chlorine (or chloride)	5 mg/Nm^3
Pharmaceutical manufacturing	Total particulates	50 mg/Nm^3
	Active ingredients	0.2 mg/Nm^3
	Organic compounds (Listed in Annex 1, p.36)	
	Class I	20 mg/Nm^3
	Class II	100 mg/Nm^3
	Class III	300 mg/Nm^3
Printing and surface coating	Solvent use or consumption less than 15 tonnes per annum	
	Class I	50 mg/Nm^3
	Class II	200 mg/Nm^3
	Class III	300 mg/Nm^3
	Solvent use or consumption greater than 15 tonnes per annum	
	Class I	20 mg/Nm^3
	Class II	100 mg/Nm^3
	Class III	300 mg/Nm^3

Note:
1. In case of printing and surface coating industries, the emissions from surface coating operations come from evaporation of organic solvents in the coatings consisting primarily VOCs.
2. In case of continuous monitoring for emissions to the atmosphere, the following is to be refereed:
   a) No 24 hour mean value shall exceed the emission limit value.
   b) 97% of all 30 minute mean values taken continuously over an annual period shall not exceed 1.2 times the emission limit value.
   c) No 30 minute mean value shall exceed twice the emission limit value.
   d) For Total Organic Carbon (as C) concentration limits, no hourly average value shall exceed 1.5 times the emission limit value.
3. During non-continuous monitoring:
   e) For flow, no hourly or daily mean value, calculated on the basis of appropriate spot readings, shall exceed the relevant limit value.
   f) Mass flow threshold refers to a rate of discharge expressed in units of kg/h, above which concentration the emission limit value applies. Mass flow threshold rates shall be determined on the basis of a single 30 minute measurement (ie. the concentration determined as a 30 minute average shall be multiplied by an appropriate measurement of flow and the result shall be expressed in units of kg/h).
   g) Mass flow limits shall be calculated on the basis of the concentration, determined as an average over the specified period, multiplied by an appropriate measurement of flow. No value, so determined, shall exceed the mass flow limit value.
   h) For all Total Organic Carbon (as C) concentration limits, the average of all readings in one monitoring exercise shall not exceed the emission limit value and no hourly average value shall exceed 1.5 times the emission limit. At least three readings shall be obtained in each monitoring exercise.
4. For all other parameters, no 30 minute mean value shall exceed the emission limit value.
   The concentration and volume flow limits for emissions to the atmosphere shall be achieved without the introduction of dilution air and shall be based on gas volumes under standard conditions of :-
5. In the case of non-combustion gases, a temperature of 273^0K, and a pressure of 101.3 KPa without any correction for oxygen or water content.
6. In the case of combustion gases, a temperature 273^0K, and a pressure 101.3 KPa of dry gas with 3% oxygen for liquid and gas fuels, 6% oxygen for solid fuels, and 10% oxygen for thermal oxidisers.

Source: *Ministry of Environment and Forests and Climate Change, Ethiopia*

standards in force in other countries including Bangladesh, Pakistan, India, Jamaica, China, Thailand, Uganda, Nigeria, Zambia, and Kenya. Information was obtained from development agencies such as The World Bank, UNEP, United Nations Industrial Development Organization (UNIDO), and from other information sources such as the European Union and the USEPA. The standards have been adopted where they were deemed relevant for Ethiopian conditions, or they were modified and adapted on the basis of practical experience. (Box: Emissions standards for different categories of industry in Ethiopia). Ethiopia is developing draft emission standards for vehicles and fuels.

Need legal framework for enforcement and compliance

A clear compliance mechanism for air quality standards is necessary. As of now there is no legal framework to back up air pollution control and compliance in Ethiopia. Article 44 of the Constitution of Ethiopia deals with Right to the protection of environment and states, 'Everyone has the right to a clean and healthy environment.' Article 51 (3) authorises the Federal government establish and implement national standards and basic policy criteria for public health, education, science and technology…….'

It is possible to act under this provision. However, backed by this constitutional provision a legislation like Clean Air Act may be enacted to create the legal mandate for monitoring, control and compliance for source-wise emissions standards and also compliance with urban or regional air quality targets.

The legislation must meet the explicit link between air pollution control and monitoring and health risk reduction. Mandate legal framework for monitoring, setting of air quality targets for cities, implementation strategy for all pollution sources to be implemented in a time bound manner and make provision for penalty and incentive in case of non-compliance.

This legal framework is weak or non-existent in most developing countries. But this is an important step that needs to be taken at the early stages of air quality management. India for instance has enacted the Air Act (Prevention and Control) in 1986 at the national level that mandates air quality standards, emissions standards for industry and power plants, and provides for penalty and closure in case of non-compliance. India is further reviewing this legislation for future reforms. This also establishes the role of the national and state governments in the federal structure. While the overall standards setting and supervision role rests with the central government the actual implementation is with the state government. The crucial lesson from the Indian experience is that while Air Act provides for regulation of all pollution sources, in practice one key source of pollution – vehicles – are not effectively regulated under this Act, administered by the Indian Ministry of Environment and Forests. Vehicular pollution – emissions standards for vehicles and fuel quality, in India is regulated under a different legislation which is called Central Motor Vehicles Act which s administered by the Ministry of Road Transport and Highways. This has created dichotomy in the system and impeded integrated decision making and action. This should be avoided.

As Ethiopia develops its legal framework for air quality management it is important to ensure from the earliest times that all pollution sources are regulated under the same legislation administered by one nodal agency. Even if some pollution sources are administered by other ministries a nodal task force should be formed to ensure integrated action to meet clean air standards.

It is important to create a strong compliance strategy for cities. International experience shows that while framework for implementation of emissions standards for different pollution sources are implemented, there is virtually no mechanism for setting a compliance strategy for cities or region to meet national ambient air quality standards. There are very few instances where cities are made accountable for meeting the national ambient air quality standards in a time bound manner. Such framework has emerged in the US and Beijing in China. Europe has also framed a broad framework. (Box: Global practices: effective legal frameworks for health driven air pollution control).

Roadmap for air quality monitoring in Ethiopia

Once standards are set it is important to set up the air quality monitoring grid to generate air quality data on a routine basis. This will help to establish the level of compliance with the air quality standards and also inform control strategies. Advanced countries of the US, Europe and Japan have the most evolved and matured systems. The monitoring systems are still evolving in developing countries that are at different stages of development. Advanced systems are more resource intensive and need strong and robust infrastructure and technical capacity for quality control of data.

Ethiopia has just begun air quality monitoring one and half years back with setting up of a real time monitoring station in the NMA Campus in Addis Ababa. Three gaseous pollutants excluding particulate matter are being monitored. The data is not published but is supposed to be available on demand. Maintenance challenges exist. There are plans to expand network. The second Growth and Transformation Plan of Ethiopia, which is a 5 year Plan lays emphasis on air quality issue and has air quality as one of the components.

Ethiopia needs to adopt the key elements of air quality monitoring and management. These include air quality monitoring strategy (monitoring network design, leapfrog to realtime monitoring and adopt good monitoring protocol, select pollutants and meteorological factors for monitoring, quality control and assurance for credible data, data reporting and pubic information system and pollution forecasting); pollution source assessment strategy Emissions inventory, source apportionment and modeling tools); exposure management; implementation of Clean air action plan in time bound manner and setting up of institutional process for air quality management.

Air quality monitoring is important for baseline data, status and trend evaluation, to determine environment exposure and cleansing potential of environment. Baseline data helps to assess level of contamination and possible effects in future. Status and trend evaluation helps to understand whether pollution control strategies are reducing pollution levels or additional control is required to meet air quality standards. With environment exposure level, define inter-relationship of sources of pollution, atmospheric parameter and measurable manifestations to evaluate nature and magnitude of existing problem. Environment has cleansing potential. It is important to understand natural cleansing process through dilution, dispersion, wind movement, dry deposition, precipitation and chemical transformation of pollutants generated.

Air quality monitoring should be done in areas where problem exists or may increase such as industrial areas, urban areas, traffic intersections etc. Ideally, three monitoring stations are chosen one each in residential (or commercial), sensitive and industrial area. Distribution of monitoring depends on distribution

Global practices: Effective legal frameworks for health-driven air pollution control

Several countries have adopted legal framework for effective compliance with the goals of clean air and reduced health risks.

US: The Clean Air Act in the US is the key piece of legislation which requires EPA to set national ambient air quality standards in order to protect public health and periodic review. The EPA has to demonstrate attainment of these standards —with an adequate margin of safety. This is done through the states, who have to submit a State Implementation Plan (SIP) showing how they will meet, and by when, the standards for which they exceed the AAQS. The states must identify the major emission sources and then lay out a specific plan on how and when they will show attainment for a specific pollutant. The Act also requires the major sources of air pollution to meet stricter emissions control in non-attainment areas.

The EPA has to approve the SIPs. When the EPA approves the plan the rules specified therein are federally enforceable. If the State does not submit an adequate plan, they can be subject to sanctions—withholding federal funds for example—or have the EPA produce a Federal Implementation Plan (FIP).

Every major regulation has a cost-benefit analysis but this is not required by the law but rather is an administrative requirement. Every 5 years EPA reviews all the health information for the criteria air pollutants and based on the review considers whether the existing air quality standard for that pollutant is adequate to protect public health with an adequate margin of safety. If it is not adequate EPA is required to revise the standard. That standard then drives the entire process – states must take actions to comply with it as quickly as reasonably possible and faces penalties if they don't do so. Where EPA has direct responsibility such as for automobile emission standards or power plant standards, the protection of health is the primary driver but other factors such as the state of technology and cost of implementation are also considered. For instance, the estimated benefits of Tier 2 emissions standards for light-duty, heavy-duty and non-road vehicles rules are expected to be USD 175 billion, which more than justifies the investments of USD 11 billion that are expected to be required in order for attainment of these emission standards.

The EPA and California Air Resources Board (CARB) also have a separate Toxic Air Contaminant (TAC) program. These are controlled directly from the soiurce. Legislation is required to address this issue and there is a lengthy list of toxics including benzene and diesel particulates that have gone through a detailed risk assessment/risk management process. The risk assessment is overseen by the California Office of Environmental Health Hazard Assessment (OEHHA), which provides scientific advice to the California EPA (drawing on the work of a Scientific Advisory Board composed of national health experts). The OEHHA process informs CARB if a program to manage risks from specific pollutants is necessary. For example, it took nearly 10 years to complete the risk assessment for diesel particulate.

Moreover, for air toxics the EPA sets 'maximum achievable control technology (MACT) standards' that are based on emissions levels of air toxics already achieved by the better-controlled and lower-emitting sources in an industry.

There also is a strong and ongoing engagement with scientific institutions and universities to keep abreast of the state of knowledge on relevant areas of air pollution and health. For example, many of the health studies are contracted by CARB to the University of California system. The CARB also is guided by a Research Screening Committee consisting of outside experts.

Europe: The European Commission has set health-based target for air quality. The Thematic Strategy on Air Pollution aims by 2020 to cut the annual number of premature deaths from air pollution related disease by almost 40 per cent from the 2000 level. While covering all major pollutants it pays special attention to fine particulates and ground level ozone. It would also set a cap on concentration on most polluted areas. Emissions ceiling will be brought into line with the objectives. Europe also sets standards for each toxic air pollutant individually, based on its particular health risks.

China: China has also drafted Clean Air Act that makes public health its stated objective. It states that its objective is "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population". It provides for environmental health effect research and preparation of environmental health assessments for each of the hazardous air pollutants. Recent efforts are going on to adopt clean air act to make compliance stronger.

What to monitor?

- **Criteria for SO_2 measurements:** Domestic emissions from fossil fuel burning, industrial emissions and diesel vehicles.
- **Criteria for NO_2 measurements:** High NO_2 levels are expected at locations where NO, ozone and hydrocarbons levels are high — areas with high population and traffic.
- **Criteria for particulate measurements:** Combustion sources (industry and vehicles etc) and dust sources (construction and road).
- **Criteria for CO measurements:** Traffic intersections, highways, commercial areas with high traffic density.
- **Criteria for ozone measurements:** Ozone is secondary pollutant and is formed in atmosphere by reactions of other pollutants such as NO, HC. ozone precursors react to form ozone such that peak levels

of pollution sources, land-use and population in a city. Distribution of stations can also be carried out by dividing the entire area in a grid and locating stations at intersections of a grid or within a grid. Identification of sensitive areas is crucial in air quality monitoring. In India, the Central Pollution Control Board has set criteria for defining sensitive areas for monitoring and regulations. These include 10 kms around the periphery of health centres, 10 kms around the periphery of biosphere reserves, national parks, 5 kms around archeological monuments, areas with crops/horticulture sensitive to air pollution and 5 kms around centers of tourism or centres of religious, historical, scenic or other attractions.

Adopt real time monitoring of the key criteria pollutants and selected air toxins

Well designed monitoring network that can well represent the air pollution situation in the city or the region. Among the criteria pollutants the focus can be on PM10, PM2.5, nitrogen oxides, carbon monoxide and ozone. If there are industry and power plants or incidence of coal burning sulphur dioxide can be included. Air quality monitoring is critical to track the trends, risk assessment and the changing profile of pollutant mix in the air. For instance, globally, urban monitoring of sulphur dioxide inside cities has been curtailed largely because of change in energy use and shift from coal. However, the need for this monitoring can be evaluated in Addis Ababa. Also as very old vehicles especially gasoline vehicles dominate the vehicle fleet carbon monoxide monitoring is needed.

There are several technical guidelines on air quality monitoring network and protocol that can be taken as the reference to establish the monitoring network. These include guidelines on protocol of the WHO; air quality planning and standards of the USEPA; European Union Directive among others. These details can be shared at a later stage.

Cities in developing world are dominated by manual monitoring in which quality control and reliable operation is a challenge. Manual monitoring often fails to meet the minimum requirement of number of days to be monitored

What and how to monitor?

More advanced programmes include air toxin programme. The US has very elaborate programme.

India monitors on a limited scale lead, toxic trace metals, ammonia and polycyclic aromatic hydrocarbons, benzene etc in metro-cities. The sampling duration and frequency include annual averages to indicate trend over time and short time averaged – 24 hour average for most pollutant and 1 hr and 8 hours for a few like ozone, CO are needed to protect public health. In case of Ethiopia, the measurement methods will have to be defined.

in a year. For instance, in India to arrive at an annual average at least 104 measurements in a year are necessary. The measurements must be taken twice a week, 24-hourly, at uniform intervals. Sometime data has to be rejected as cities fail to meet the basic criteria. Moreover there are serious challenges related to calibration and quality control of data.

It is advisable that cities that are establishing new monitoring systems should try to garner resources to establish automatic real time monitoring.

Assess and adopt monitoring approaches

There are a number of approaches to designing a network and selecting sites. Exposure assessment often needs to target both source-oriented monitoring sites (often synonymous with worst-case or hot-spot environments) and background locations optimized for quantifying general population exposure. Depending on the pollutants being assessed, data from a wide variety of location types may therefore be necessary to build up a reasonably complete picture of ambient exposure patterns.[14]

Network design: factors to consider in site location:
- Major sources or emissions of pollutants in the area
- Target receptors and environments
- Weather and topography
- Model simulations of dispersion patterns in the area
- Existing air quality information (such as from screening studies)
- Data on demography, health and land use

The network design is largely defined according to the stated goals. There are no universal rules for network design. A large number of criteria would govern the decisions such as where most people live, the pollutants they are exposed to, the kind of exposure they face in heir micro environment and the need for daily alert system.

While international guidelines provide the basic criteria for the minimum required number of monitoring stations but there is no universal rule of minimum number of monitoring sites because it may be insufficient for areas with complex terrain or mixed emissions distribution. This is to ensure that the measurements taken are adequate and representative of the air quality conditions of the area. Sizing also involves tradeoffs on the resources available, distribution of pollutant sources, local meteorological conditions and topography that affect the dispersion of pollutants. In most guidelines, while values and categories vary, the minimum number of monitoring stations is decided according to population and pollution levels. Guidelines recommend more monitoring stations in areas with higher levels of pollution. The minimum number of stations is also dependent on the type of pollutant monitored.[15]

Reasons for having more monitoring sites include complicated terrain, different types of sources distributed in the urban area, spectrum of emitted pollutants, among others. Developing Asian cities do not necessarily have to follow the same approach and may develop a monitoring system which would provide sufficient information within their available resources.[16]

It is observed that the monitoring coverage of cities from developing countries only achieved the bare minimum, while the coverage for developed countries

Table 2: Prescribed number of PM 10 sampling points recommended by EU according to pollution levels and population agglomeration

Population of agglomeration or zone (thousands)	Number of PM10 monitoring stations needed if the pollution level is high	Number of PM10 monitoring stations needed if the pollution level is low
0-249	2	1
250-499	3	2
500-749	3	2
750-999	4	2
1 000-1 499	6	3
1 500-1 999	7	3
2 000-2 749	8	4
2 750-3 749	10	4
3 750-4 749	11	6
4 750-5 999	13	6
≥ 6 000	15	7

Source: *11.6.2008, Official Journal of the European Union, DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 on ambient air quality and cleaner air for Europe*
http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0050&from=en#ntr1-L_2008152EN.01002101-E0001

are more than double the prescribed number. For example, Dhaka in Bangladesh has only three monitoring stations for a population of 14 million whereas Chiba in Japan has 19 monitoring stations to cover a population of 96,000.[17]

In a developing country like India, the minimum requirement is three monitoring stations. The location is dependent upon the wind rose diagram that gives predominant wind directions and speed. One station must be at upstream of predominant wind direction and other two must at downstream pre dominant wind direction. More than three stations can also be established depending upon the area of coverage.[18] Criteria for setting air quality monitoring stations requires that cities having population between 100,000 to 10,00,000 need at least three stations per city, the mega cities (cities with more than 10 million people) need at least nine stations per city, the state Capital cities need at least six stations per city and the industrial areas/ cities need at least six stations per city.

The Indian protocol for monitoring mandates certain basic requirements. The site should be away from major pollution sources. Distance depends upon the source, its height and its emissions like the monitoring station should be at least 25 meter away from domestic chimneys, etc. The instrument must be located in such a place where free flow of air is available and it should not be located in a confined place. The ambient monitoring should be done at 3-10 metre height. India has provision for downtown pedestrian exposure stations in congested urban areas. While the average daily travel on the street should exceed 10,000 vehicles, pedestrian monitoring is to be done at three meter height from streets.

According to CAI Asia, cities with relatively flat terrain and no heavy industrial areas, can have minimal air quality monitoring sites. However, for cities with complicated terrain and many heavy industrial areas, the need more air quality monitoring sites. Additional assessments or modeling with basic emissions inventory is recommended to determine whether the recommended minimum number of monitoring sites is adequate.[19] *(see Table 2: Prescribed number of*

Table 3: US Criteria of PM 10 minimum monitoring requirements

Population category	High concentration[2]	Medium concentration[3]	Low concentration[4, 5]
>1,000,000	6-10	4-8	2-4
500,000-1,000,000	4-8	2-4	1-2
250,000-500,000	3-4	1-2	0-1
100,000-250,000	1-2	0-1	0

Notes: *1 Selection of urban areas and actual numbers of stations per area jointly determined by EPA and the State agency.*
2 High concentration areas are those for which ambient PM10 data show ambient concentrations exceeding the PM 10 NAAQS by 20 percent or more.
3 Medium concentration areas are those for which ambient PM10 data show ambient concentrations exceeding 80 percent of the PM 10 NAAQS.
4 Low concentration areas are those for which ambient PM10 data show ambient concentrations less than 80 percent of the PM 10 NAAQS.
5 These minimum monitoring requirements apply in the absence of a design value.

Source: *40 CFR Part 58, Appendix D to Part 58 - Network Design Criteria for Ambient Air Quality Monitoring, USEPA, https://www.law.cornell.edu/cfr/text/40/part-58/appendix-D*

PM10 sampling points recommended by EU according to pollution levels and population agglomeration, Table 3: US Criteria of PM 10 Minimum Monitoring Requirements and Table 3: Recommended Minimum Number of Stations, Population-Wise in India).

Weather or meteorological information is needed as weather has great influence on air quality. It is important to generate meteorological data on temperature,

Table 4: Recommended minimum number of stations, population-wise in India

Pollutant	Population of evaluation area	Minimum number of AAQ monitoring station
SPM (Hi-Vol)	< 100 000	4
	100 000 - 1 00 000	4 + 0.6 per 100 000 population
	1 00 000 - 5 000 000	7.5 + 0.25 per 100 000 population
	>5 000 000	12 + 0.16 per 100 000 population
SO_2 (Bubbler)	<100 000	3
	100 000 - 1 000 000	2.5 + 0.5 per 100 000 population
	1 000 000 - 10 000 000	6 + 0.15 per 100 000 population
	>10 000 000	20
NO_2 (Bubbler)	<100 000	4
	1 000 000 - 1 000 000	4 + 0.6 per 100 000 population
	>1 000 000	10
CO	<100 000	1
	100 000 - 5 000 000	1 + 0.15. per 100 000 population
	>5 000 000	6 + 0.05 per 100 000 population
Oxidants	-do-	-do-

Source: *Guidelines for Ambient Air Quality Monitoring 2003, Central Pollution Control Board, Delhi*

Table 5: Pollutants and monitoring methods in India

Pollutants	Time weighted average	Industrial, residential, rural and other areas	Ecologically sensitive area (notified by central government)	Methods of measurement
Sulphur dioxide (SO_2), µg/m³	Annual *	50	20	Improved West and Gaeke Method
	24 hours **	80	80	Ultraviolet Fluorescence
Nitrogen dioxide (NO_2), µg/m³	Annual *	40	30	Jacob & Hochheiser modified ($NaOH\text{-}NaAsO_2$) method
	24 hours **	80	80	Gas Phase Chemiluminescence
Particulate matter (size less than 10 µm) or PM10, µg/m³	Annual *	60	60	Gravimetric
	24 hours **	100	100	TEOM
				Beta attenuation
Particulate matter (size less than 2.5 µm) or PM2.5, µg/m³	Annual *	40	40	Gravimetric
	24 hours **	60	60	TEOM
				Beta attenuation
Ozone (O_3) µg/m³	8 hours	100	100	UV Photometric
	1 hour **	180	180	Chemiluminescence
				Chemical Method
Lead (Pb) µg/m³	Annual *	0.5	0.5	AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper
	24 hours **	1	1	ED-XRF using Teflon filter
Carbon Monoxide (CO) µg/m³	8 hours **	2	2	Non dispersive Infrared (NDIR) Spectroscopy
	1 hour **	4	4	
Ammonia (NH_3), µg/m³	Annual *	100	100	Chemiluminescence
	24 hours **	400	400	Indophenol blue method
Benzene (C_6H_6), µg/m³	Annual *	5	5	Gas chromatography (GC) based continuous analyser
				Adsorption and desorption followed by GC analysis
Benzo(a)Pyrene (BaP) particulate phase only, ng/m³	Annual *	1	1	Solvent extraction followed by HPLC/GC analysis
Arsenic (As), ng/m³	Annual *	6	6	AAS/ICP Method after sampling on EPM 2000 or equivalent paper
Nickel (Ni), ng/m³	Annual *	20	20	AAS/ICP Method after sampling on EPM 2000 or equivalent paper

Source: *Minstry of Environment and Forest and Climate Change, india*

relative humidity, wind speed and direction. Wind direction plays an important role. The monitoring stations should be located in areas that are downwind from the sources. Mixing height data should be collected. Seasonal information is also required.

Need quality control of air quality monitoring for credible and reliable data

Quality control for credible and reliable data is of utmost importance. This would include quality assurance programme for comparability of data from various agencies; quality assurance in laboratory – periodic calibrations, duplicate checks, split samples, spiked samples and the keeping of adequate and neat records; on-site system surveys, independent performance audits, interlaboratory comparisons and periodic evaluation of internal quality assurance data etc; data handling and presentation; calibration and auditing of equipments and training, infrastructure, skill building, power supply etc.

There is need for detailed protocol for quality assurance. System and instrument audit for operation and performance will be critical. Experience in developing country cities show gamut of challenges – lack of certification of monitoring instruments, lack of standardized methods for calibration, high error levels, poor

comparability and repeatability of results, high variability in results are not checked, little control over monitoring environment conditions, lack of spare parts and stand by equipment, and even erratic power supply. All these will have to be addressed and prevented while developing the protocol for monitoring.

The standards operation practice will have to be defined. This will have to pay attention to data quality, measurement methods, site selection, instrumentation, network design and location of monitoring, data validation, and capacity building. Adequate size and scope of air quality monitoring system based on population and area size. Several countries have published detailed guidelines to decide number of monitoring stations. For instance, India has published Guidelines for Ambient Air Quality Monitoring in 2003.[20]

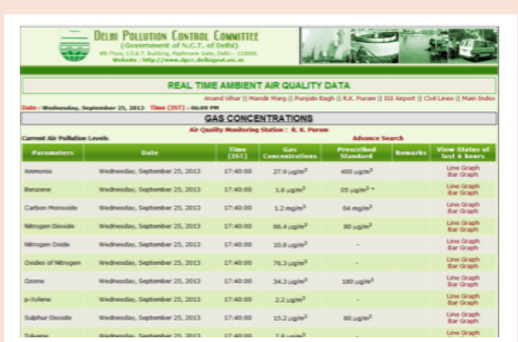
Manual versus automatic monitoring

Automatic analyzers can be used to monitor all gases and particulate matter of all size fractions. These are sophisticated analyzers with good quality control and assurance. Instant online real time data generation and dissemination takes place. This also helps in air quality index and early warning system and forecasting and modelling. In case of manual monitoring PM10 and PM2.5 and most gases in particulate matter can be monitored. In gravimetric method, sample processing is done by chemical analysers and for gases, wet analysers are used. However, challenges pertaining to quality assurance and quality control remain in manual monitoring such as delayed reporting and no instant relay of data etc.

Other challenges and trade-offs include too complex systems or failure prone systems can compromise performance of monitoring networks; resource constraint, availability of skilled personnel; trade-off between equipment cost, complexity, reliability, and performance; advanced system can give refined data but is skill intensive, expensive, need good maintenance and reliable service; manual monitoring has quality issues and also limits application; and do limited number but high quality monitoring.

Real time monitoring in Delhi

Delhi relays real time air quality data. This is user friendly. One can access the station wise continuous real time hourly update or 24 hour average data. Back data is also available. But However, there are maintenance issues. The next step is need of an air quality public information system to make it relevant to public health.



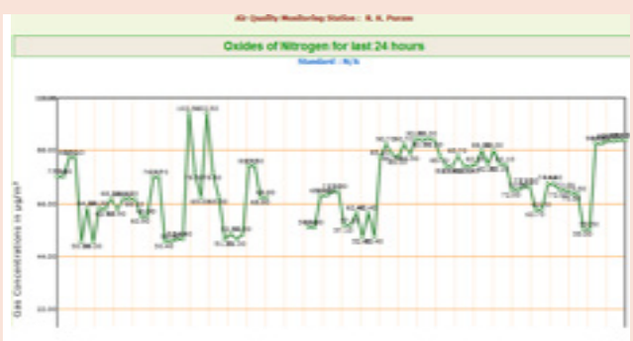


Table 6: Air quality index systems in different countries

INDIA (proposed) PM2.5		USEPA, PM2.5		Ontario, Canada*		China		EU	
AQI	$PM_{2.5}$ 24-hr µgm/m^3	AQI	$PM_{2.5}$ (24-hr avg.) (µgm/m^3)	AQI	$PM_{2.5}$ 3-hr µgm/m^3	AQI	$PM_{2.5}$ 24-hr (µgm/m^3)	AQI	$PM_{2.5}$ (24-hr avg.) (µgm/m^3)
Excellent (0–50)	0-30	Good (0–50)	0-15	Low (1-3)	0-22	Excellent (0–50)	0-35	Very low (0-25)	0-10
Acceptable (51–100)	31-60	Moderate (51–100)	16-40	Moderate (4-6)	23-45	Good (51–100)	36-75	Low (25-50)	11-20
Moderate (101–150)	61-90	Unhealthy for sensitive groups	41-65	High (7-10)	46-90	Lightly polluted (101–150)	76-115	Medium (50-75)	21-30
Poor (151–200)	91-120	Unhealthy (151–200)	66-150	Very high (10+)	>90	Moderately polluted (151–200)	116-150	High (75-100)	31-60
Very poor (201–300)	121-250	Very unhealthy (201-300)	151-250	N/A	N/A	Heavily polluted (201-300)	151-250	Very high >100	>60
Severe (301-500)	>250	Hazardous (301-500)	251-500	N/A	N/A	Severely polluted (>300)	>250	N/A	N/A

Source: *Central Pollution Control Board, India, Air Qulaity Index Final Report 2015*

Link air quality monitoring with routine public information system

Air quality reporting will require an air quality index (AQI) system, a globally established tool to classify the air quality in different categories based on the severity of the problem. The AQI is used to inform people along with health advisories. Along with the AQI health advisories are important and should be framed to indicate expected health outcome at certain level of pollution mainly among the susceptible population and healthy population. Public information system through media, bill boards and other media should be designed for maximum outreach.

Across the world, governments take action based on the quality of air in their cities on a particular day. This allows for health advisories to the most vulnerable—those who are suffering from respiratory and cardiovascular ailments and asthma—so that they can reduce their exposure. Governments also take emergency action to reduce emissions on high-pollution days. Emergency pollution control measures are taken to bring down the peak pollution levels.

During episodic pollution events, on-line air quality monitoring can be used in warning and alert systems, which use mass media to inform people of the current air quality and, if necessary, to give instructions aimed at reducing excess pollution and minimising exposure. Monitoring ambient air quality also provides important input data for epidemiological studies, which are crucial in establishing associations between health outcomes and concentrations of ambient air pollution.[21]

It is therefore important to adopt public information system on daily air quality data based on the AQI and issue health advisory. The best practice countries include the US, Mexico, Hong Kong and Beijing, China *(see Table 4: Air quality index systems in different countries). India has begun to implement this system from last year (see Box: India: National Air Quality Index (NAQI) system).* Hong

India: National air quality index (NAQI) system

India's National Air Quality Index (NAQI) developed by the Central Pollution Control Board was launched by the Union Ministry of Environment and Forests in October 2014. With reference to the national ambient air quality standards (NAAQS), NAQI has classified air pollution concentration as good, that is 50 per cent below the standards, and satisfactory that meets the standards. The higher categories of moderately polluted, poor, very poor and severe are defined according to the degree of exceedance from the standards *(see Table 1: National Air Quality Index and Table 2: Health advisory).*

The NAQI also lists the health risks associated with different levels of concentration. For instance, a 'severe' classification means, '(the levels) may cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity'. In other words, this quality of air is severely bad for human health. While the NAQI has broad health advisories it does not detail what urgent measures need to be taken for people to avoid exposure and what needs to be done to improve levels, something that is done across the world. When pollution levels are severe, aside from other measures, people are advised not to do heavy outdoor exercise and to remain indoors as much as possible.

Table: National air quality index

AQI category (range)	PM10 24-hr (µg/m^3)	PM2.5 24-hr (µg/m^3)	NO_2 24-hr (µg/m^3)	O3 8-hr (µg/m^3)	CO 8-hr (µg/m^3)	SO_2 24-hr (µg/m^3)	NH_3 24-hr (µg/m^3)	Pb 24-hr (µg/m^3)
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5-1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

Note: Breakpoints for AQI Scale 0-500 (units: µg/m^3 unless mentioned otherwise)

Table: Health advisory

AQI	Associated health impacts
Good (0–50))	Minimal impact
Satisfactory (51–100)	May cause minor breathing discomfort to sensitive people
Moderately polluted (101–200)	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease
Very poor (301–400)	May cause respiratory illness on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases
Severe (401-500)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity

Source: *Ministry of Environment, Forest and Climate Change, Government of India*

Unique health-based air quality Index in Hong Kong

Hong Kong adopted an Air Quality and Health Index (AQHI) system that utilized health risks derived from local hospital admissions data for air pollution-related illnesses. They use data in illness. The indexes are grouped into five health risk categories with health advice for general public. This informs people of the short-term health risk of air pollution. This is a unique experiment in Asia where the air pollution index is linked with hospital data on illness.

Kong's Air Quality and Health Index (IAQHI) is a unique experiment in Asia where the AQI is linked with hospital data on illness *(see Box: Unique health based air quality Index in Hong Kong)*. There are good practices in the African continent as well. Ethiopia can also learn from Senegal, which is the first country in the African region to monitor air quality and implement the AQI system.

Build capability for pollution forecast

The AQI will additionally require pollution forecasting capacity so that advance warning can be issued to people. This will also require systems for monitoring of meteorological information.

Cities will need to implement emergency measures when daily pollution levels hit very poor and severe levels. Data on pollution is available from different parts of the c ity on a real-time basis. Indian cities do not have a forecasting system to issue advance warning. In such cases there is a time lag and the only way to inform people is during the day or the day after. Another approach would be to issue warning if there are two days of severe pollution. This is not a satisfactory solution but there is no alternative as in the current situation people have no information about the dangers of 'poor' and 'severe' levels of pollution and no emergency steps are taken to deal with the pollution.

Pollution emergency measures

Air pollution index and health alert also merit emergency action during smog episodes. Many countries take action based on the level of pollution. For example in Beijing if the air quality consistently remains at the worst category according

Senegal: Air quality monitoring and air quality index

The Ministry of Environment and Sustainable Development, Senegal set up its air quality monitoring centre in Dakar in 2009. Data is generated and collected every 15 minutes. Out of two servers, one runs with the software for communicating between stations and the central laboratory and is used for daily export of automatic validated data and monthly export of quality controlled data. The second server is called AirQUIS, developed by the Norwegian Institute for Air Research (NILU) and used for hourly automatic import for calculating the AQI and for performing different statistical analysis with data and also for modelling and quality control. The AirQUIS system consists of different modules - monitoring modules, emission inventory modules, map data, background data – all stored in the oracle database. It also consists of user interface with graphics, GIS and Internet connection. The internet connection is used for disseminating information to the public.

The AQI is calculated every day from real-time data monitored by the stations using the AirQUIS system. Five pollutants (O3, PM10, CO, SO2 and NO2) are used to calculate the AQI. The AQI between 0 and 50 indicates good air quality is depicted by the green colour. Between 51 and 100 comes the moderate air quality indicated by yellow colour. Sensitive people like children, older people or those suffering from asthma and other lung and heart diseases might face some health problems during this time. The next category between 101 and 200 is considered unhealthy and is shown by orange colour. This impacts the sensitive as well as the health people. The AQI beyond 200 is considered as unhealthy shown by red colour. During this time, emergency measures are needed to be taken to improve air quality.

There was an air pollution episode during February 27 to March 1, 2015. Dakar and other parts of the county were covered by dust that hampered visibility. The daily average PM10 concentration exceeded three times the Senegalese limit value and 20 times the WHO limit value. The highest PM2.5 concentration (232 microgramme per cubic metre) was measured on February 27th. It exceeded the WHO limit value by 9 times. An alert was sent that episode of poor air quality started on February 26 due to high PM concentration and is still going on. Children, elderly and people with asthma and other chronic lung diseases were advised to remain vigilant and contact a physician if needed. This message was put up on the website and also communicated through the media and radio.

A recent example is from the pollution episode that started on January 26, 2016. An alert message was sent to the press and hospital (pnemology services) stating that the air quality for today is very unhealthy (red index), desert particulate concentration started increasing since yesterday and this situation could last for the next 72 hours.

Pollutant	Averaging time	Maximum Limit Value	
		WHO	Senegal
Sulphur Dioxide (SO_2)	1 hour 24 hours Year	500 (10 min) 125 50	- 125 50
Nitrogen Dioxide (NO_2)	1 hour Year	200 40-50	200 40
Ozone (O_3)	1 hour 8 hours	150-200 120	- 120
Carbon Monoxide (CO)	1 hour 8 hours	30 000 10 000	- 30 000 (24h)
Particles <10 µm (PM10)	24 hours Year	50 * 20 *	260 80
Lead (Pb)	Year	0.5-1,0	2

*) EU limit values

Air Quality Index (AQI) values…	Levels of Health Concern	Colors
When the AQI is in this range…	… air quality conditions are:	… as symbolized by this color:
0 – 50	Good	Green
51 - 100	Moderate	yellow
101 - 200	Unhealthy	Orange
> 200	Very Unhealthy	Red

Source: *Aminata Mbow Diokhane 2015, Centre for Air Quality Management in Dakar (CGQA), Paper presented at Conclave of Champion Cities, Centre for Science and Environment, New Delhi, April 9, mimeo.*

to their air quality index for three consecutive days pollution emergency action is kicked in to arrest and lower the peaking of pollution. Several countries have this system *(see Box: Pollution emergency measures in cities)*.

Pollution emergency measures in cities

Several countries have framed pollution emergency measures that are implemented when AQI indicates severe pollution levels for a couple of consecutive days. Institutional mechanism has been put in place in which departments have been identified that would be responsible for implementing these measures.

Beijing: Pollution emergency measures on red alert days

Red alerts will be issued when heavy pollution (air quality index of 200+) is expected to last more than three days in a row. Orange and red alerts will be issued 24 hours in advance so that all precautionary measures are taken. These include:

- Kindergartens, primary and middle schools will close;
- About 80 per cent of government-owned cars have to be taken off the roads;
- Private cars will be allowed on alternate days according to odd and even numbers plates;
- Freight vehicles and those transporting material for construction sites will be barred;
- Polluting factories have to cut emissions or shut down when the orange warning signal is issued;
- Construction sites will have to halt excavation and demolition operations;
- Ban on barbeques and fireworks on heavily polluted days.
- **Existing public transport service is enhanced with additional buses put on the roads to meet the public demand.**

US cities: Rule 701 of air pollution emergency contingency actions (for PM and ozone)

- Industrial units reduce combined emissions by at least 20 per cent of normal weekday operations.
- For vehicles, it asks to reduce fleet vehicle miles;
- Promotes ridesharing and telecommuting.
- Liquid or solid fossil fuels cannot be burned in electric power generating systems unless a force majeure natural gas curtailment is in effect.
- It also recommends all non-emergency driving be discontinued.

Paris:

- In March 2015, the air quality index rose in Paris. To control the problem, they made public transport free and removed almost 50 per cent of vehicles off the road.
- The alternate number plate system was implemented once again to keep cars having number plates ending in odd and even digits off the roads on alternate days.
- Lorries were asked to drive on 20 km/hour speed to reduce emissions of micro particulate matter and police was deployed to fine motorists breaching the partial driving ban.
- Reduced private vehicles on the road.
- Made public transport free over the weekend to get its public to use buses and trains and share bikes.
- The city also adopted alternate vehicles system—allowing cars with either odd or even number plates to ply on alternate days.
- Paris also does not allow diesel cars on smoggy days.

London

- On March 17, 2015, the first high air pollution warning was issued asking all vulnerable children and adult groups with lung and heart problems to avoid outdoor activities.
- Government gave some tips to reduce pollution, which included car-pooling and switching off engines while not in use.
- The former Mayor Boris Johnson launched an air quality campaign—Breathe Better Together. It started to raise awareness about air quality through posters and advertisements on radio while promoting walking and cycling.

Delhi

In January 2016, New Delhi, capital of India, has for the first time experimented with emergency action in which half of Delhi's cars were removed from the road for a fortnight based on the odd and even number in their number plates. This had helped to slow down the peaking of the pollution levels.

Rational for air quality monitoring

Air quality assessment: what is the air quality in the city?

- Air quality monitoring
- Application of modelling tools
- Assessing and monitoring emissions

↓

Exposure assessment: what is the level of population exposure?

- Where are different population groups located?
- What are the concentrations at these locations?
- What are the targewt populations, including sensitive groups?

↓

Health impact assessment: what health effects are caused?

- How many cases are associated with the exposure?
- How severe are the effects?

↓

Air quality management: what action is needed?

- Which sources, pollutants and areas should be targeted for reducting emissions?
- Whatnstrategies will be most cost-effective?

Source: *WHO*

Utilise air quality monitoring for urban and industrial zone planning

There are urban planning objectives that are ingrained in setting up of air quality monitoring. Once the background level of key pollutants are known the agencies can decide where to set up industries, how much a selected area can withstand the emissions without causing damages, means what is the carrying capacity and dilution capability of the local meteorological condition. Town planning also involves the local environmental conditions.

Build institutional process to set up the air quality monitoring system

This will require adequate capacity building – technical and financial – to operate and maintain the network. Sufficient resources including human and financial resources are available for sustaining operation of air quality monitoring systems. Conventional regulatory monitoring is expensive. If financial support can be augmented certain priorities can be established to design the network. It is not possible or desirable to make a dense grid of monitors in developing cities. Monitoring will have to be strategic.

Approaches to monitoring technique

Choosing the simplest technique of monitoring is a good practice. Inappropriate, too complex or equipment prone to failure can result in poor network performance, compromise data quality and utility and can be wasteful. Resource constraints and the availability of skilled personnel are limiting factors. There is a clear trade-off between equipment cost, complexity,

reliability and performance. More advanced systems can provide increasingly refined data and greater temporal resolution of measurement but may be more skill-intensive, require operation support, be more expensive to operate and maintain and less reliable in service.[22]

Cost considerations along with adequate institutional capacity

Resource availability must be addressed very early in the process of designing a network. This is the key determinant in network design that influences numbers of sites, pollutants to be monitored and instrumentation to be selected. A wide range of commitments and costs is likely to be incurred in any air monitoring programme. Before committing resources, plan a survey, assess resource availability, chose the most appropriate equipment and sites for monitoring. Any equipment must be purchased based on its long-term operational or financial sustainability. This will require in-house capability for repair and maintenance or hiring of services, together with routine operation. The thumb rule is that for equipment operation need budget typically amounting to approximately 10 per cent of the initial capital expenditure per year.

Need resources for quality assurance and control to ensure that its measurements comply fully with programme data quality objectives and are fit for the purpose. Typically, a budget of 20–50 per cent of the total annual operating costs may be appropriate for quality assurance and control, depending on the complexity of the programme and the stringency of its data quality objectives. In practice, the number and distribution of air quality monitoring stations required in any network, the samplers required in a survey, also depend on the area to be covered, the spatial variability of the pollutants being measured and how the data are to be used. The number of sites required depends on: the intended use of the data; area to be covered; spatial variability of pollutants; availability of resources and instruments deployed.[23]

Estimated costs of setting up air quality monitoring station in India indicates that often it is capital intensive and requires regular provisions for adequate operation and maintenance (O&M) cost. As per the estimates available in India about Rs. 4 to 5 lakh (Birr 125,229.18) is required for setting up a manual station and Rs. 3.5 lakh (Birr 109,575.53) per annum for the O&M. In case of a real time monitoring station, the cost could be Rs. 1.1 crore to Rs. 1.5 crore (Birr 3,443,802.36) for the station and Rs. 8 lakh (Birr 250,458.35) for O&M per annum. The O&M cost, which include data checking, validation and transfer to state level pollution control boards and committees are estimated to be 12 to 18 per cent of the capital cost of the real time stations. While the online stations are in selected cities, overall, country wide network in India is limited, India has close to 5,000 cities and towns but monitoring is being done in 247 cities. Only 16 cities have online monitoring systems to generate real time data.

Alternative monitoring strategy

Conventional air quality monitoring is based on the assumption that air quality standards exist and that systems are needed to evaluate compliance with these. Source apportionment tells us what are the sources of air pollution and the burden attributable to these. It is an important tool to characterize and at some level evaluate the impacts or benefits of tackling specific sources. Governments set standards, operate and collect the monitoring data for policy making. While the poor world will expand such capacities, this will be time consuming and expensive. Cities of Africa and Asia also need to explore other affordable strategies

that can be rolled out simultaneously and quickly that can help to generate a lot of indicative baseline data to build awareness and inform policy action.

Innovation has an important role to play in this. Science has enabled development of a range of monitoring approaches that can be quickly deployed for more effective assessment. With new monitoring technologies, digital data management, remote sensing, and modeling, expert bodies can carry out exposure assessment and apportionment. At a macro scale (satellite remote sensing) and micro scale (google maps) data collection has opened up new perspectives and new tools to further democratize data in regions where infrastructure is limited or non-existent. It is possible to carry out exposure mapping across micro environment. Opportunity for community engagement.

Of these approaches the sensor based air pollution monitoring technologies that are comparatively much cheaper than the conventional monitors can be widely used to generate indicative data in developing region. These are being widely used to build public awareness to make them aware of what they are inhaling. The advanced countries that have already invested hugely in conventional high cost monitoring system have little need to explore their use and compare with regulatory monitoring. But experiment have started in the US and more so in California to assess their wider utility. This is an opportunity to assess their application in developing country cities that are more resource constrained.

Integrate new tools for exposure monitoring and exposure management to reduce public health risk: Take integrated approach to exposure management. Reduce pollution where people are and target the more harmful particulates. New evidence on particulate matter from some sources is more harmful than others etc. Should we move from air quality standards to exposure limits? How would this affect the approach to air quality monitoring and health assessment? How can policy consider the differential toxicity of particulate matter from various sources? What would air quality policy look like if we could?

Democratise air quality information for public awareness to build public support for policy action: Low cost sensors, internet connectivity, and mobile devices are taking air quality data and democratizing it, shaping public behavior and public awareness. This is changing the balance of power over information and responsibility for air quality management and control. Is it more appropriate in the developing world to rely on citizens to monitor air quality that is complementary to regulatory monitoring? What tools are available? Can governments adopt the alternative methods?

According to USEPA low-cost, portable air quality sensors could be the next generation of air monitoring, however, this nascent technology is not without risk. Regulatory monitoring system does not use the low cost systems but they are useful to generate indicative air quality information. The regulatory system use air monitoring data adhering to the prescribed procedures followed to ensure and assess quality and consistent measurements nationally. However, USEPA has begun exploring air quality data from low-cost portable air quality sensors but recognizes that there is a tremendous risk for EPA if the quality of the data that is generated and reported by these sensors is unknown. USEPA opines that while regulatory use of these air sensors will likely be limited at best, that is not to say that collecting air monitoring data from sensors is not useful.

The regulatory air quality data verification is a complex process. And the question is if any of the lower cost sensors can be used to meet regulatory requirements

for data collections. But air quality monitors suitable for regulatory-quality data collections must meet very exacting standards of performance. No lower cost sensors currently meet these strict data quality and performance requirements. But EPA is investing in understanding citizen science opportunities and providing tools to citizens to assist them in their efforts.

Most of the lower cost particulate matter sensors use light scattering as the primary aerosol detection method. A wide variety of factors can influence light scattering and the resulting sensor response. These include the size of the aerosol as well as its composition. Direct collocation of a light scattering device with a true gravimetric (mass) measurement is one approach EPA researchers and others have employed to establish a calibrated response from low cost sensors *(see Table 5: Evaluation of various low cost technologies in USA).*

Table 7: Evaluation of various low cost technologies in USA

The R2 value if equal to 1 indicates that a technology is perfectly correlated with regulatory monitoring technique and zero value indicates no correlation. Surprisingly some techniques are close to the regulatory technique results

	Manufacturer (Model)	Type	Pollutant(s)	Approximate Cost	Time Resolution	Sensor *vs* FRM/FEM Method[1]
	**Dylos** (DC1100)	Optical	$PM_{(0.5-2.5)}$	~$300	1 min	R^2 ~ 0.65 to 0.85
	**Shinyei** (PM Evaluation Kit)	Optical	$PM_{2.5}$	~$1,000	1 min	R^2 ~ 0.80 to 0.90
	**RTI** (MicroPEM)	Optical	$PM_{2.5}$	~$2,000	10 sec	R^2 ~ 0.65 to 0.90
	**HabitatMap** (AirBeam)	Optical	$PM_{2.5}$	~$200	1 min	R^2 ~ 0.65 to 0.70
	**Met One** (Neighborhood Monitor)	Optical	$PM_{2.5}$	~$1,900	15 min	R^2 ~ 0.53 to 0.67
	**Speck**	Optical	$PM_{2.5}$	~$200	1 min	R^2 ~ 0
	**Naneos** (Partector)	Electrical	PM (LDSA: Lung-Deposited Surface Area)	~$7,000	1 min	$PM_{1.0}$: R^2 ~ 0.1 $PM_{2.5}$: R^2 ~ 0.2
	**AethLabs** (microAeth)	Optical	BC (Black Carbon)	~$6,500	1-300 sec	R^2 ~ 0.79 to 0.94
	**Air Quality Egg** (Version 1)	Optical, Metal oxide	PM, CO, NO_2 and O_3	~$200	1 min	PM: R^2 ~ 0 CO: R^2 ~ 0 NO_2: R^2 ~ 0.40 O_3: R^2 ~ 0.85
	**Perkin Elmer** (ELM)	Optical, Metal oxide	PM, NO, NO_2 and O_3	~$5,200	1 min	PM: R^2 ~ 0 NO: n/a NO_2: R^2 ~ 0 O_3: R^2 ~ 0.89 to 0.96
	**2B Technologies** (PO_3M)	UV absorption (FEM Method)	O_3	~$4,500	10 sec	R^2 ~ 1.00
	**Aeroqual** (S-500)	Metal oxide	O_3	~$500	1 min	R^2 ~ 0.85
	**Smart Citizen Kit**	Metal oxide	CO, NO_2	~$200	1 min	CO: R^2 ~ 0.50 to 0.85 NO_2: R^2 ~ 0
	**AQMesh** (v.3.0)	Electrochem	CO, NO, NO_2, SO_2, and O_3	~$10,000	1-15 min	CO: R^2 ~ 0.75 to 0.90 NO: R^2 ~ 0.75 to 0.90 NO_2: R^2 ~ 0 SO_2: R^2 ~ 0 O_3: R^2 ~ 0.25 to 0.55
	**AQMesh** (v.4.0)	Electrochem	CO, NO, NO_2 and O_3	~$10,000	1-15 min	CO: R^2 ~ 0.42 to 0.80 NO: R^2 ~ 0.0 to 0.44 NO_2: R^2 ~ 0.0 to 0.46 O_3: R^2 ~ 0.46 to 0.83
	**UNI-TEC** (SENS-IT)	Metal oxide	CO, NO_2 and O_3	~$2,200	1 min	CO: R^2 ~ 0.33 to 0.43 NO_2: R^2 ~ 0.60 to 0.65 O_3: R^2 ~ 0.72 to 0.83

[1]The correlation coefficient (R^2) is a statistical parameter indicating how well the performance of each sensor compares to that of a Federal Reference or Federal Equivalent Method (FRM and FEM, respectively) instrument. An R^2 approaching the value of 1 reflects a near perfect agreement, whereas a value of 0 indicates a complete lack of correlation. All R^2 values reported in this table are based either on a 5-min or 1-hr average data. Laboratory evaluations are still pending to confirm field results. An ad-hoc rating system will be developed to summarize the overall performance of these sensors once both field and laboratory data become available.

Source: South Coast Air Quality Management District

EPA scientists develop and evaluate Federal Reference Methods and Federal Equivalency Methods for accurately and reliably measuring six primary air pollutants in outdoor air. These methods are used by states and other organizations to assess implementation actions needed to attain National Ambient Air Quality Standards (NAAQS). As air quality management problems become more complex, there is a need for enhanced air quality and exposure monitoring capabilities. Next generation air measuring research includes the use of air sensors and apps, mobile monitoring devices, passive fenceline monitoring and the use of satellites to monitor air quality.

UNEP on low cost air quality monitoring system: Technology and Innovation Branch of Division of Early Warning and Assessment at the United Nations Environment Programme (UNEP) has begun to develop a blueprint of low cost sensor kit that can enable developing countries to monitor air quality and estimate the health effects, especially in vulnerable human populations and ecosystems in Africa region.

The UNEP has embarked on a series of partnership with national governments, research institutions and UN and international partners, including World Health Organization (WHO), UN Habitat, World Bank and World Meteorological Organization. They are part of the Global Platform on Air Quality and Health, to develop a framework, information and tools for the monitoring and evaluation of air quality and related health impacts. As part of this, UNEP is designing an affordable national air quality monitoring network based on UNEP Air Quality Units for measuring particulates, key pollutants such as sulphur dioxide, nitrous oxide and ozone (USD 1500/unit), location and temperature, plus calibration units that have an additional set of sensors including for humidity. The overall cost for a typical national network would range from USD 100,000–200,000. This would be in contrast to the current cost of a single typical high-precision instrumented station of USD 250,000.

The Division of Early Warning Assessment (DEWA) of UNEP thus contracted the development of an affordable, mobile air quality monitoring unit, costing < USD 1500 that can function well in highly polluted climates, as a first step in helping countries, especially in the developing world, to collect reliable air quality data. A network of 50 of the new monitoring units that DEWA envisages will cost USD 75,000 — much less than the cost of the single high quality monitoring station currently available in the market. Data from such a network can be used to generate a map of air quality in a region. Finally, the units can be programmed to 'talk' to each other, and calibrate each other, when aligned in the same microenvironment, thus improving the accuracy of the data.

The UNEP air quality unit is comprised of an Optical Particle Counter PM1, 2.5 and 10 (OPCN2) sampling every 2 seconds, two gas sensors - SOx and NOx (Alpha Sense), a Global Positioning System (GPS) and temperature and humidity sensor, a Texas Beagle Bone data controller. Additional sensors, such as for ozone, and volatile organic compounds (VOCs) can be added according to local needs and conditions. The unit is powered off 12 volts and can be used as a fixed station or mobile unit. The units are GSM enabled and designed to operate as nodes in a network to allow inter-calibration. Due to its rugged design, the UNEP unit can be deployed across different terrains in a country. It can be linked in real-time to meteorological stations, county and national offices via wireless and telecommunication networks or run off-line.

UNEP will publish the blueprint for its air quality monitoring unit as a global public good. This will enable governments and organisations to purchase, assemble or fabricate the units themselves, thereby opening up opportunities for innovation and enterprise development. The data from the network of air quality units will be augmented by relevant satellite data flows and social and health surveys, via the Global Platform on Air Quality and Health, and in the first instance delivered to citizens and communities through mobile and on-line applications in UNEP Live (http://uneplive.unep.org/theme/index/2#.VeBh_vmLEXg) The data from the UNEP air quality units will help provide improved statistics on air quality exposure of vulnerable populations in urban environments and underpin cross-sectoral policy-making decisions in transport, energy and urban planning. The data can also be integrated into UNEP's National Reporting System, as part of ongoing efforts to improve "SDG readiness".

According to a UNEP representative, UNEP's low cost air quality monitor costing USD 1,500 can monitor PM10, PM2.5, temperature and humidity. UNEP had initiated work with the low cost monitor in Nairobi and plan to set up an air quality monitoring network. Ten such monitors were to be set up in May in Nairobi. UNEP has partnered with NASA. Measurements are uploaded. UNEP is also setting up these low cost monitors along with NASA weather instruments in schools in the city. All data will be made open source and put up on UNEP Live. UNEP aims to use the University of Nairobi air quality monitoring reference stations to validate their data.

Assessment of pollution sources

The basic instrument for urban air quality planning includes emissions inventory, source apportionment and air quality modeling. These are needed to assess exposure and health effects and estimate relative contribution of different sources to the pollution load. This needs to be updated regularly to account for the new sources being added and impact of mitigation measures. On the basis of model of how emissions are dispersed, experts conduct dispersion modeling to calculate the expected ambient concentration at particular receptor sites where ambient concentrations are measured. With the help of chemical analysis of particles chemically distinct source types are characterized as a part of source apportionment. Detailed chemical analysis of particles in the atmosphere to match their characteristics at given receptor and source location also called receptor modeling. Receptor modeling is a top down approach in contrast to bottom up approach which uses emissions inventory data, activity patterns, and dispersion modeling to predict concentration at the receptor site.

Air quality modeling approaches predict specific pollutant concentrations at various places and impact of different interventions on those concentrations. This is done by combining information on pollution sources with meteorological data in the form of mathematical equations. All these help to assess the contribution of to the total air quality, the rate at which these pollutants are being emitted and forecasting trends in air pollution concentration. These provide the basis for policy action, for setting policy targets and monitoring of goal attainment.

Some of the barriers to initiate these studies are lack of quality data on emissions for different pollution sources, poor record of baseline emissions sources, emissions factors and overall inadequate technical capacity to design and execute the studies.

Investment in monitoring, assessing and controlling pollution helps to avoid outcomes to health and ecosystems that are usually more expensive than preventive action. Therefore, the monitoring programmes need to be cost-effective, have stable financial, material and personnel resources and be adjusted to local needs and conditions.

In addition to emissions inventory and source apportionment studies exposure assessment and apportionment should also be carried out to map micro environment across the city to refine the action strategies.

Clean air action plan

While the basic salient features of good air quality management are being put in place simultaneously it is possible to start the action on ground to avoid further delay. At this stage detail assessment of pollution sources and their relative contribution to air pollution has not been carried out in Addis Ababa. But there is strong enough learning curve based on global evidences on health impact and also a gamut of mitigation strategies for different pollution sources that can inform policies.

National air quality planning framework is needed to establish the legal basis for action at the national level and at the local and regional level to set air quality targets and meet them in a time bound manner. National legislation will create the mandate for setting and enforcement for air quality standards, source-wise emissions standards, and regulatory framework for compliance and implementation. States and cities will need clean air action plan and implementation strategy to meet clean air target in a time bound manner.

Over the last few years significant steps have been taken in different cities of Asia to put in place a process to develop clean air action plan to guide implementation at the local level. For instance, Beijing has adopted a five year plan to reduce pollution by 25 per cent by 2017. In several Indian cities including Delhi a process has started to develop clean air action plan. This has cataysed source-wise action.

The subsequent section will detail out the possible approaches for controlling air pollution from different pollution sources to meet the urban air quality objectives – vehicles, industry and power plant and area sources. The guiding principles for air quality management in Ethiopia should include reduced integrated exposure to air pollution from all sources to protect public; integrate both ambient concentration management as well as exposure management to protect public health; integrate local air quality control with regional air quality planning to reduce the effect of pollution movement; adopt the principle of co-benefits to design air pollution control action to give diverse benefits of public health, climate mitigation and energy security; control measures need to address equity, affordability, inventiveness, compliance and transparency; address the unique health risk transition of the developing country region; quicken steps at the early stages of growth to leapfrog to cleaner benchmark for air quality, best available technologies and demand management measures to control pollution; adopt a legal framework that will enable effective and time bound implementation of action plan for each pollution source to meet clean air target; capacity and skill building and data protocol for air quality management and governance and implementation are needed and develop action plan and implementation strategy.

CHAPTER 2: Pollution from vehicles: Technology and fuel quality roadmap

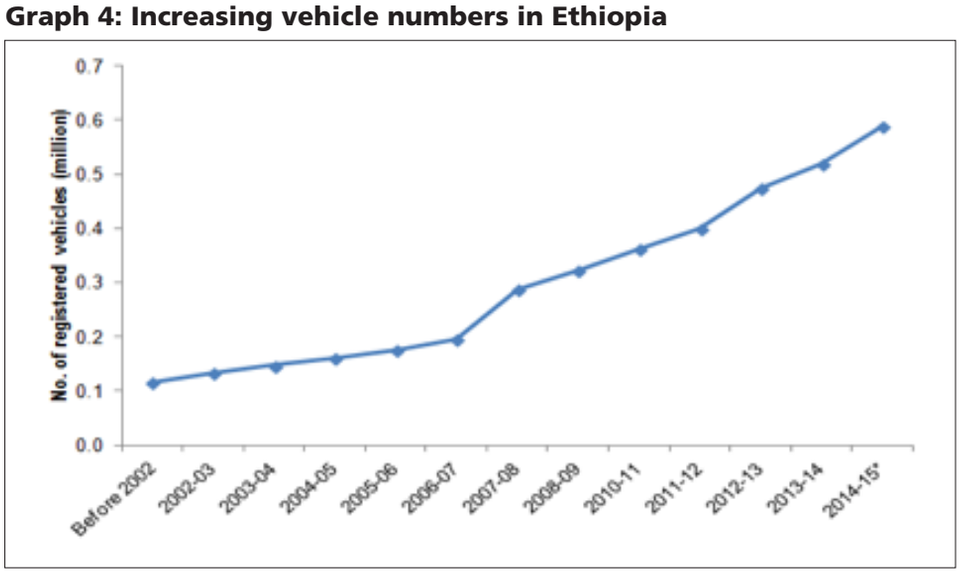
SECTION 1: Status of the problem

Cities have many sources of outdoor air pollution and all require mitigation action for total air quality improvement. But vehicles pose a special challenge as these emit extremely toxic emissions within peoples' breathing zone and are responsible for some of the highest exposure in our cities due to their close proximity. Pollution concentration in our breathe is three to four times higher than the ambient air concentration. People residing 500 metres from roads are the most exposed to vehicular fumes, found the study of Health Effects Institute of the US. For instance, when this criteria was applied to Delhi in India it was found that about 55 to 60 per cent of Delhi's population lives within that zone; so it runs a serious risk of exposure. Air quality monitoring and studies conducted by Centre for Science and Environment has also shown that the particulate levels that people are exposed to while traveling on the roads or while walking can be 2-4 times higher than the ambient concentration.

Rapid increase in vehicles numbers in Ethiopia

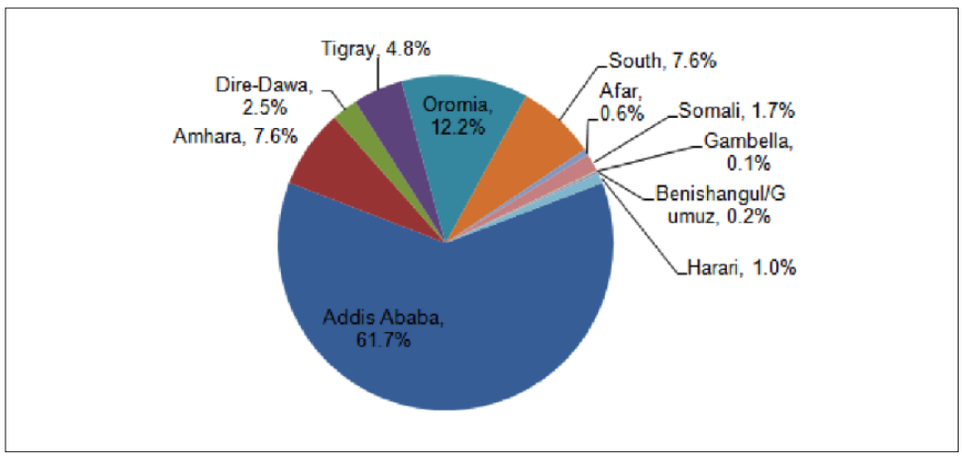
Though the overall vehicle number is low in Ethiopia it has increased exponentially. According to the Addis Ababa Transport Authority, the country has 0.59 million registered vehicles. Since 2002, there has been an increase of 406 per cent in vehicle registration in Ethiopia. Nearly 185 vehicles are being registered daily. During 2013-14 and 2014-15, there has been a 13 per cent increase in vehicle numbers. The vehicle density is 4.68 per 1,000 people. Personal vehicles, cars and two-wheelers together constitute 20.5 per cent of the registered fleet. While there are 14.2 per cent cars, 6.3 per cent two-wheelers, 3.1 per cent buses and mini-buses respectively and 8.3 per cent three-wheelers, other vehicles constitute 16.8 per cent. However, the vehicle registration data does not indicate the vehicle category for 48.2 per cent of the

Graph 4: Increasing vehicle numbers in Ethiopia



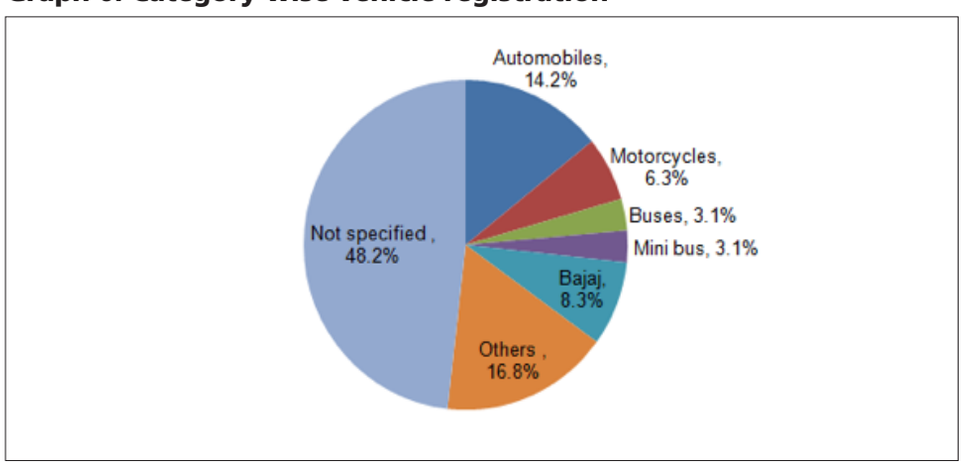
Note: ** 2014-15 data is till June 2015*
Source: *CSE based on data provided by Addis Ababa Transport Authority*

Graph 5: Vehicle registration in various administrative zones



Source: *CSE estimation based on data provided by Addis Ababa Transport Authority*

Graph 6: Category-wise vehicle registration



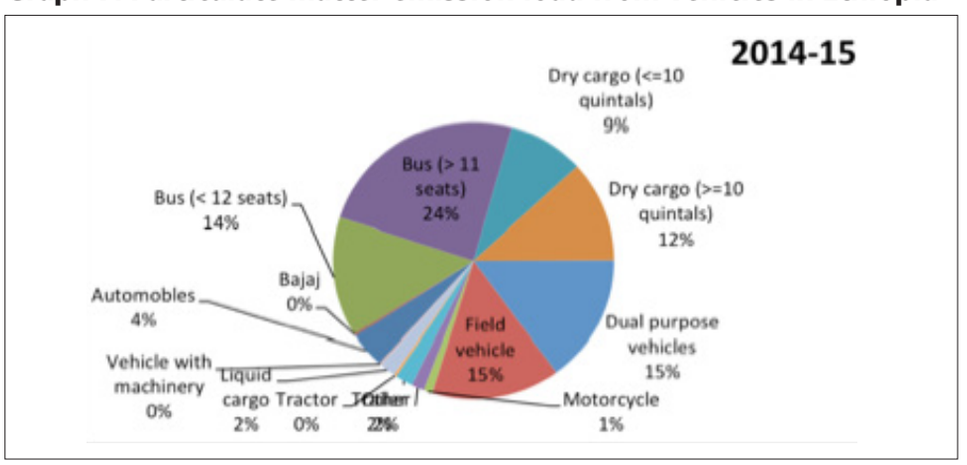
Source: *CSE estimation based on data provided by Addis Ababa Transport Authority*

remaining registered vehicle fleet *(see Graph 4: Increasing vehicle numbers in Ethiopia and Graph 5: Vehicle registration in various administrative zones).*

The data from Addis Ababa Transport Authority shows that car numbers are more than two-wheelers in Ethiopia unlike India. There are 83,512 cars and 37,152 motorcycles in the country *(see Graph 6: Category wise vehicle registration). Majority of these vehicles are in Addis Ababa alone. The capital city constitutes 62 per cent of the total registered vehicle fleet in Ethiopia (see Graph 2: Vehicle registration in various administrative zones).* Addis Ababa has 49,674 cars and 7,442 motorcycles constituting 21.3 per cent and 3.2 per cent of the registered vehicular fleet respectively. In terms of fuel type, the country has 47.5 per cent of diesel vehicles and 45.3 per cent petrol vehicles. There are however very few electric vehicles (four), 3 in Addis Ababa and 1 in Tigray.

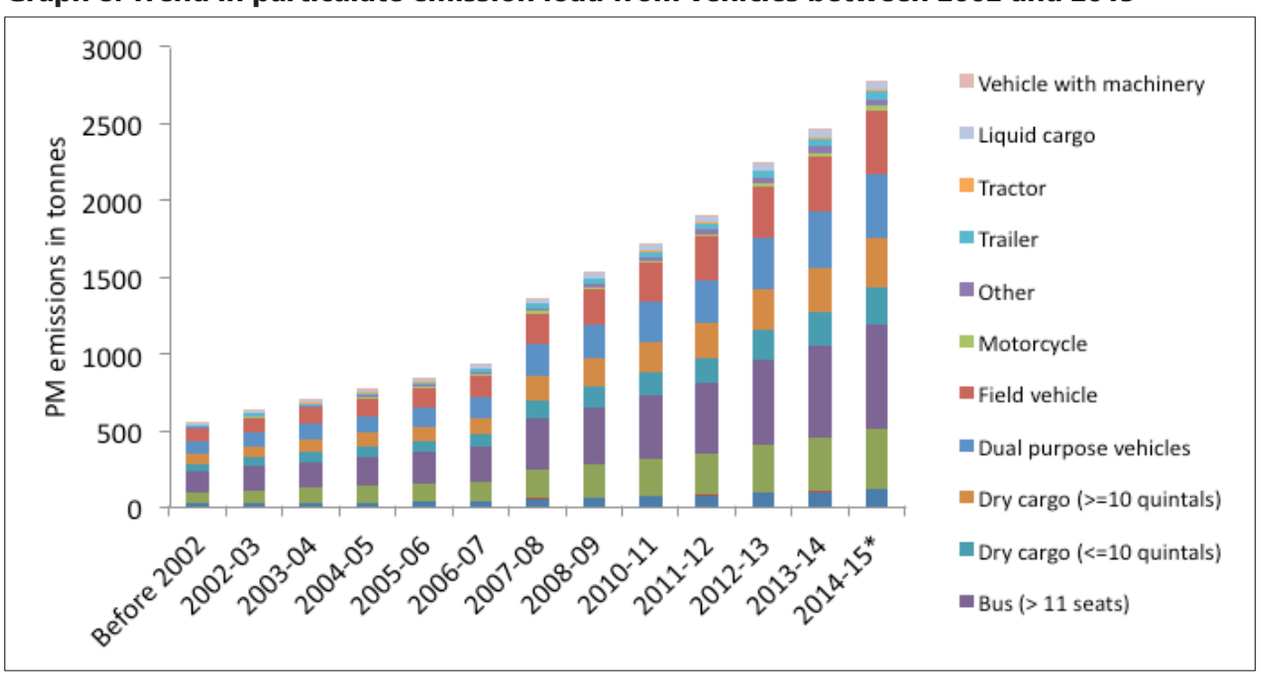
This trend is expected to worsen as an increasing share of daily trips are being made by personal cars that occupy more road space, carry fewer people, pollute more and guzzle more fuel. They edge out pedestrians, bicycles, and public transport. This can further aggravate pollution. Overall motorization rates are still lower in the African region compared to advanced countries and also

Graph 7: Particulate matter emission load from vehicles in Ethiopia



Source: *CSE estimation based on data provided by Addis Ababa Transport Authority*

Graph 8: Trend in particulate emission load from vehicles between 2002 and 2015

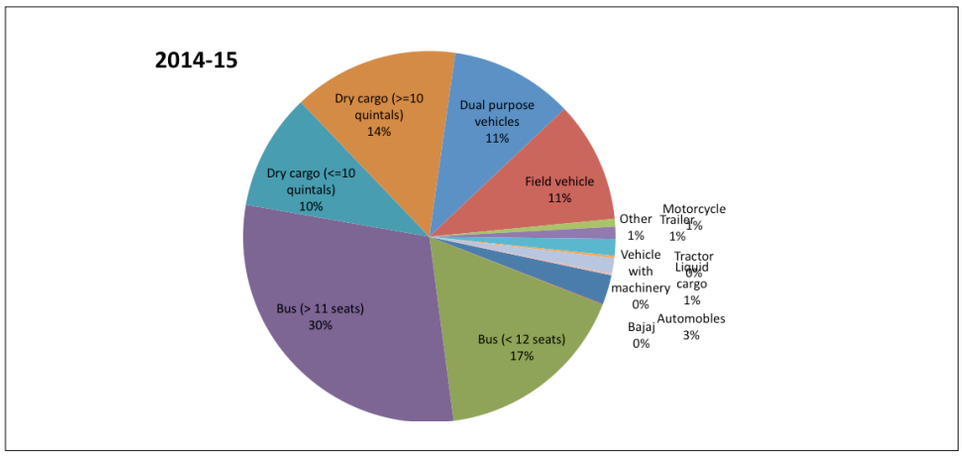


Source: *CSE estimation based on data provided by Addis Ababa Transport Authority*

compared to some Asian cities. However, it is also said that if the estimates of personal vehicles include two-wheeled motorcycles then the rate of motorisation in developing region can be higher in developing world – sometime more than the developed countries. African region is at the early stages of this trend.

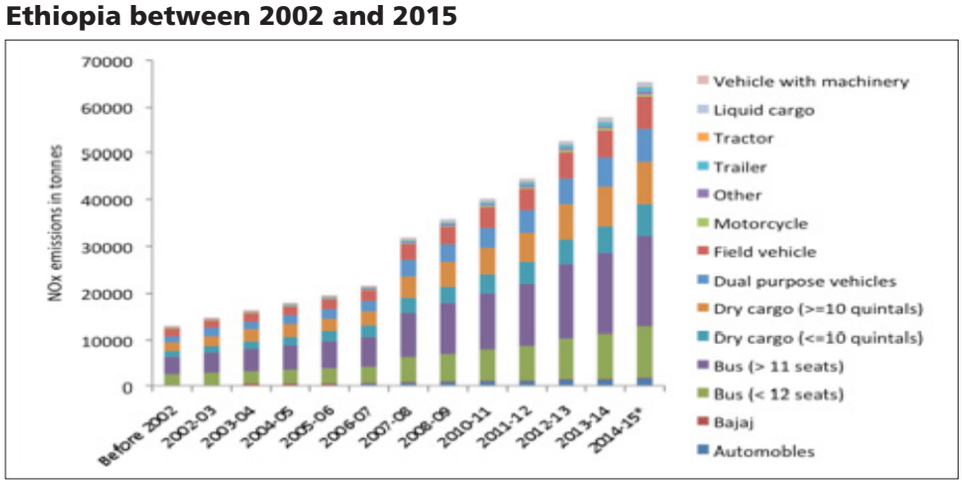
Growing pollution load from vehicles: Most of the motorization is taking place based on very old and polluting technology. Centre for Science and Environment has estimated the pollution load from the increasing vehicle numbers in Ethiopia. This shows that heavy duty vehicles dominate both particulate and nitrogen oxide load from vehicles (freight and buses) that run in diesel – more than half. The share of personal vehicles though comparatively smaller is growing (see Graph 7: Particulate matter emission load from vehicles in Ethiopia and Graph 9: Nitrogen oxide load from vehicles in Ethiopia).

Graph 9: Nitrogen oxide load from vehicles in Ethiopia



Source: *CSE estimation based on data provided by Addis Ababa Transport Authority*

Graph 10: Trend in nitrogen oxide emission load from vehicles in Ethiopia between 2002 and 2015



Source: *CSE estimation based on data provided by Addis Ababa Transport Authority*

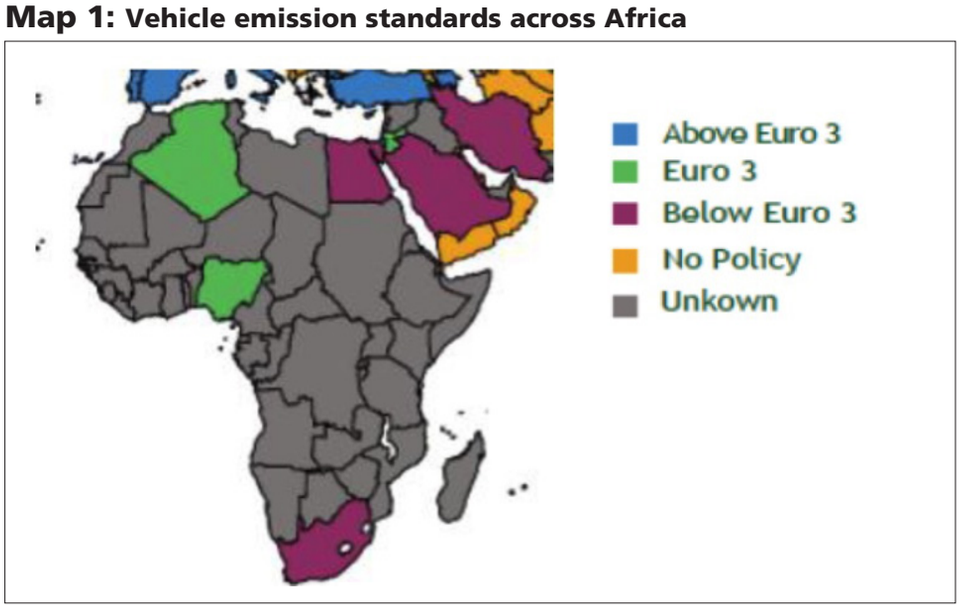
The total pollution load from all vehicles has increased by 5.4 times between 2002 and 2015. This reflects sheer growth in numbers, older vintage, and also increasing number of diesel commercial vehicles. The share of motorcycle and automobiles is also growing steadily (Graph 8: Trend in emission load from vehicles between 2002 and 2015 and Graph 10: Trend in nitrogen oxide emission load from vehicles in Ethiopia between 2002 and 2015).

SECTION 2: Agenda for action

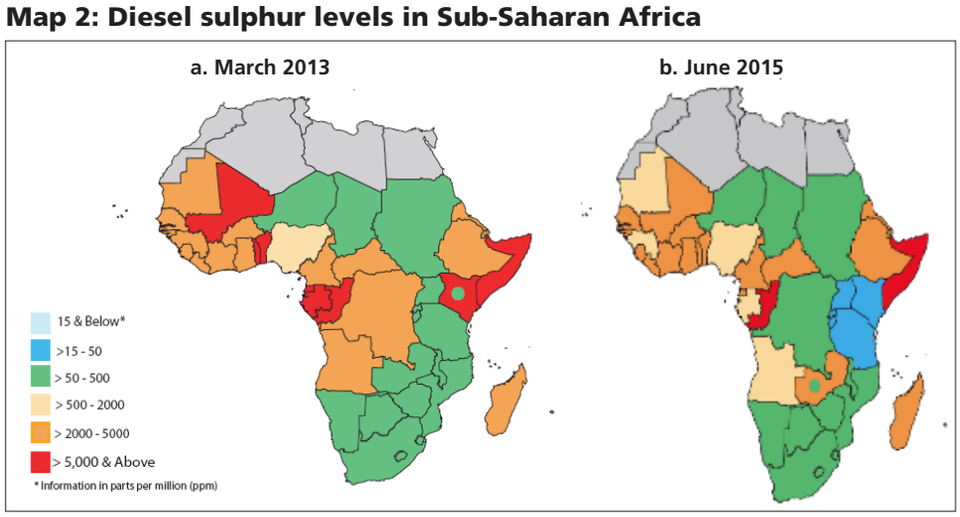
Leapfrog vehicle technology

The technology roadmap has begun to accelerate in the African region. Elimination of lead in petrol is one of the biggest success stories in Africa. The countries have also begun to reduce sulphur levels in fuels to enable use of emissions control technologies. Since January 2015 Kenya, Uganda, Rwanda, Burundi and Tanzania have moved to 50 ppm diesel sulphur fuel within East Africa. South Africa and Nigeria have already implemented the Euro II standards. South Africa has passed the regulation to implement 10 ppm by 2017. Morocco, Tunisia and Mauritius have met 50 ppm. African countries are looking at the future roadmap for the entire Africa to have diesel and petrol sulphur to be reduced to 10 ppm max and EU VI vehicle emissions and introduce metal free petrol *(see Map 1: Vehicle emission standards across Africa and Map 2: Diesel sulphur levels in Sub-Saharan Africa).*

Map 1: Vehicle emission standards across Africa



Map 2: Diesel sulphur levels in Sub-Saharan Africa



Source: *UNEP*

Fuel quality roadmap in Ethiopia: According to a World Bank and UNEP supported 2009 study by the African Refiners Association, annual benefits of introducing 50 ppm diesel, 150 ppm petrol sulphur in the sub-Saharan Africa (SSA) region can be as much as USD 980 million and USD 6,052 million when combined with vehicle emission reduction technology. The health benefits of combined introduction of clean fuels and vehicles over 10 years can be USD 43 billion (net present value basis). The refinery costs of 50 ppm diesel and 150 ppm petrol sulphur in the SSA area is estimated to be USD 6.14 billion by 2020. The incremental cost of upgrading all African refineries to produce low sulphur fuel by 2020 is estimated in the range of 3.66 to 7.09 cents per litre. However the costs would be lower if countries opt for import instead of upgrade.

According to a Health and Refinery study commissioned by the World Bank and the African Refiners Association in 2009, show that implementation of 50 ppm sulphur fuel would save about USD 1 billion annually in the SSA. Health gains of USD 6 billion annually are estimated for lowering of sulphur and cleaning up of vehicles including motorcycles.

The air quality and health benefits certainly justify quick progress in this direction.

Vehicle emissions standard roadmap in Ethiopia: Ethiopia is developing draft emission standards for vehicles. This will address the issues of fuel quality, type and age of vehicles. Ethiopia has already introduced unleaded petrol. The sulphur content in diesel is being lowered from time to time, but it is still very high. The maximum allowable sulphur in diesel fuel is 5,000 ppm and in petrol 1,000 ppm. Quicker introduction of 500 ppm followed by 50 ppm sulphur fuels will enable harmonisation *(see Table 7: Progress towards implementing cleaner vehicular fuels).*

Import strategy for fuel quality improvement

Ethiopia is dependent almost entirely on imported fuel. Manaye Balcha of Ethiopian Petroleum Supply Enterprise (EPSE) informed that overall fuel requirement is increasing at 11 per cent a year. Ethiopia spends over 80 per cent of its foreign earning annually on import of fuels. The fuel import bill is reported to

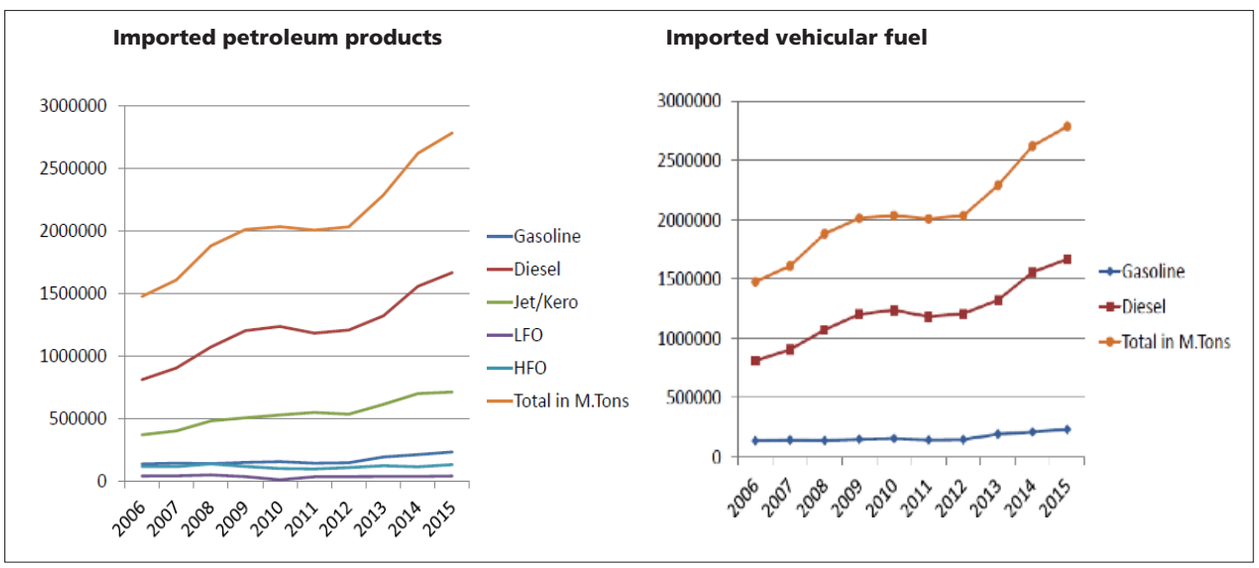
Table 7: Progress towards implementing cleaner vehicular fuels

	Average sulfur content of imported gasoline in ppm	minimum ppm	maximum ppm
2004	610	40	900
2005	150	40	900
2006	560	200	900
2007	750	700	900
2008	391	40	800
2009	380	40	900
2010	120	40	900
2011	244	40	600
2012	550	400	1000
2013	395.6	37	1000
2014	204.75	32	1000
2015	217.5	40	900

Year	Average sulfur in Diesel content ppm	minimum ppm	maximum ppm
2004	9130	7000	9900
2005	6100	3100	9700
2006	4990	1400	9500
2007	4480	2800	4800
2008	4410	4000	9300
2009	4770	3800	4900
2010	4580	3400	5000
2011	4690	4000	5000
2012	4750	4700	4800
2013	1855	243	4800
2014	805	269	1800
2015	925	245	1850

Source: *Manaye Balcha 2015, Transport fuel quality specification, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.*

Graph 11: Import of fuel in Ethiopia



Source: *Manaye Balcha 2015, Transport fuel quality specification, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Demcratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.*

be 20 per cent of total imports equivalent to USD 2.5 billion. A 40 per cent drop in oil prices translates into an annual savings of USD one billion for Ethiopia. Nearly 65 per cent of its imported fuel is consumed by road transport.

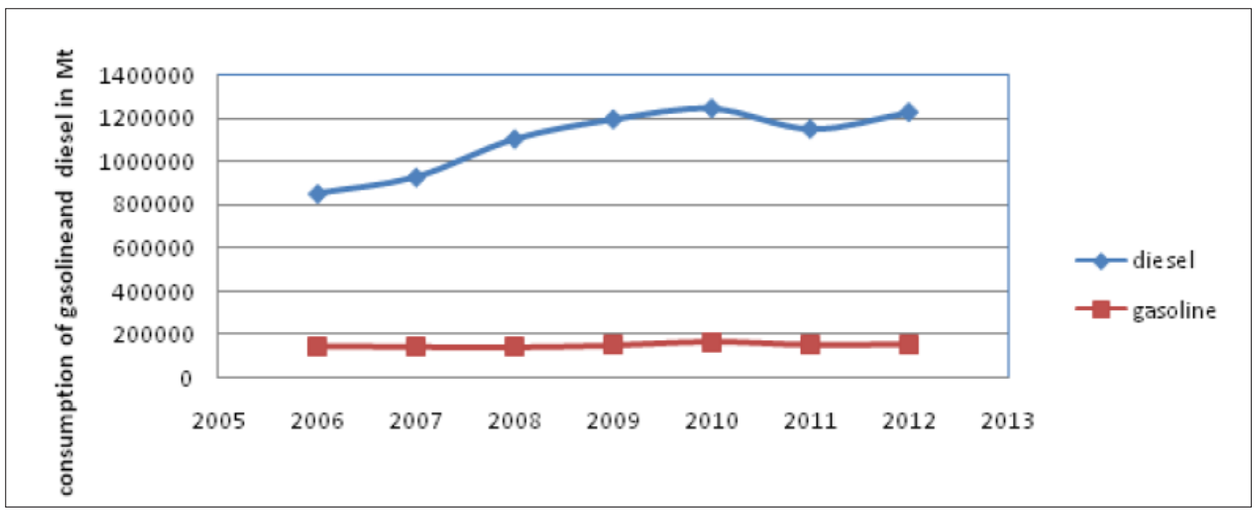
Nearly 2.7 million metric tonnes of fuel have been imported for vehicular use during 2014-15. Diesel constitutes 1.7 million metric tonnes of the total – more than half. The country imports two types of diesel sulphur fuel – 50 ppm and 2000 ppm. Nearly 90 per cent of the diesel is imported from the Middle East. The country plans to move to low sulphur fuel *(see Graph 11: Import of fuel in Ethiopia).*

According to the EPSE, petrol and diesel consumption are increasing over the years. During 2006 to 2011, petrol consumption increased to 27.9 per cent and diesel by 35.61 per cent. While petrol consumption remained flat for the past seven years, diesel consumption, although six times of petrol consumption has tapered off since 2010. By 2012, the country imported 1,232,894 Mt of diesel and 154,238 Mt petrol (see Graph 12: Fuel consumption in Ethiopia).

According to the EPSE, oil demand is growing at 10 per cent annually. In order to meet the increasing demand, the EPSE plans to increase its import by 7.14 per cent in 2015-16. The enterprise had imported 59 billion Birr worth of oil in 2014-15. At present there are 660 refuelling stations in the country. There are plans to set up 160 new stations. The country also plans to construct an oil pipeline from the port of Djibouti to Awash, in order to import oil from Djibouti ports.

The Ethiopian government makes price adjustments of fuel every month. The government has made five price adjustments on fuel prices in 2014. The current price adjustment has regulated the price of diesel, to be sold at 16.10 Birr per litre from 17.49 Birr. During beginning of September last year, the fuel price was 19 Birr for diesel, 20.99 for gasoline, and 16 Birr for kerosene. This however reflects a good practice of keeping nearly no gap between diesel and petrol prices.

Graph 12: Fuel consumption in Ethiopia



Source: *UNEP*

Can Ethiopia adopt import strategy to leapfrog to cleaner fuel? As there is no local refinery in the country it can be an opportunity to link import of fuel to cleaner benchmark. The imported amount is not enormous. But it is evident that while the landed cost of fuel at port is not that high, the transport cost thereafter adds considerably to the cost. It is possible to design a fiscal strategy to meet the cost of import of improved fuel quality.

Leapfrog emissions standards for vehicles: Local assembly plants should be encouraged to manufacture vehicles complying with improved emissions standards. Consider moving to Euro IV by 2017, and Euro VI by 2022. Link emissions standards with vehicle import. Imported vehicles should only be allowed to enter the country if they meet the specific requirements. The EPSE will also be required to import low sulphur fuels accordingly. Ethiopia needs to leapfrog and adopt Euro IV emission standards along with 50 ppm sulphur like other east African countries. The import policy should fix vehicle age limit and mandate importation of vehicles meeting Euro IV standards. This will discourage importation of old second hand vehicles with obsolete technology. Timeline should also be set for Euro V and Euro VI as well. It is therefore important to explore fiscal strategy to address this cost and switch to import of cleaner fuel quickly.

Address diesel pollution to maximize co-benefits

In Ethiopia commercial vehicles are the largest user of diesel and their contribution to particulate matter is the highest. Share of diesel personal cars is still smaller than petrol cars. This is a reflection of a good practice in which diesel prices are close to that of petrol prices. However, Ethiopia would still need a roadmap to clean up diesel quickly not only to reduce public health risk but also global warming risk.

The new science has now implicated black carbon, the dark fraction of the particulate matter, for enhancing climate impacts as well. Most of the diesel particulate core is the dark matter that absorbs light and heat and warms up the climate and fouls up our lungs. High black carbon emissions from explosive increase in diesel vehicle numbers, use of high sulphur diesel, outdated

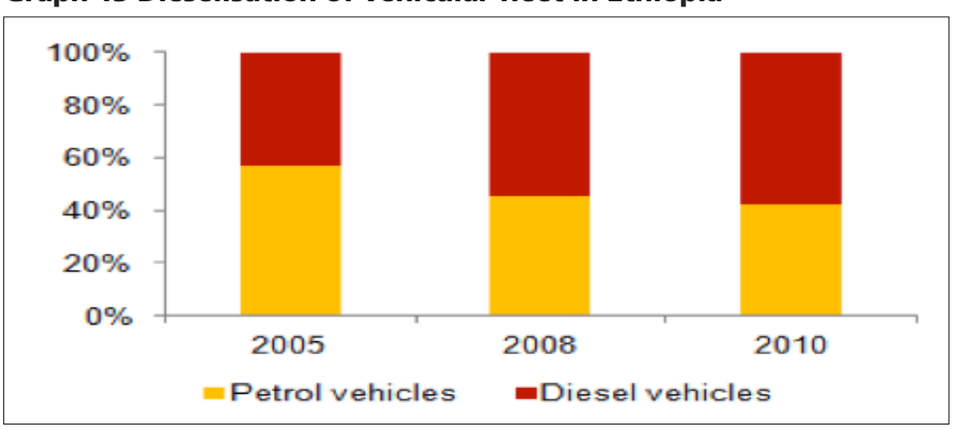
vehicle technology and expansion in road based freight traffic have added to the local health risk as well as the global climate risk. Black carbon is also co-emitted with a range of other toxic and warming gases. This link between local and global impact of diesel particulate now changes the geo-politics around the diesel emissions mitigation as the policies and action on diesel transport varies widely across vehicle producing and vehicle importing nations in developed and developing countries. This sector draws huge investment in vehicle manufacturing and fuel refining and also for transport infrastructure. The vehicle users are also capable of paying for the cost of improvement and for mitigating negative impacts. The question is how the roadmap can be framed with right regulations and fiscal strategies to make the quick transition.

Road transport in the Sub Saharan Africa (SSA) region is typically characterised by a high degree of diesel use, with buses and trucks dominating demand. Diesel accounts for 39 per cent of oil consumption in road transport across the SSA, but the figures are heavily influenced by countries with a comparatively high level of vehicle ownership (such as South Africa, with 42 per cent diesel) and those where petrol prices are relatively low (such as Nigeria, with only 12 per cent diesel). Most of the rest of Africa has diesel shares of around 45 per cent in road transport. In case of Nigeria, higher diesel prices has helped to lower diesel use in cars but diesel is used in buses and trucks which need clean and low sulphur fuel.

According to the studies carried out by Demiss Alemu Amibe of Addis Ababa Institute of Technology and Federal Transport Authority in 2012, as of 2010, the vehicular fleet consisted of 12.7 per cent motorcycles and tricycles and the remaining 87.3 per cent were all other petrol and diesel four wheeled vehicles. While petrol vehicles constitute 42.3 per cent, diesel vehicles have bigger share of 57.7 per cent. The data shows rapid dieselization of the vehicular fleet. In 2005, there were more petrol vehicles than diesel. However, this share dropped to 45.2 per cent in 2008 and 42.3 per cent in 2010. There has been an increasing trend in diesel vehicles since 2005. While diesel vehicles increased by 250 per cent since 2005, petrol vehicles increased by 144 per cent *(see Graph 13: Dieselisation of vehicular fleet in Ethiopia).*

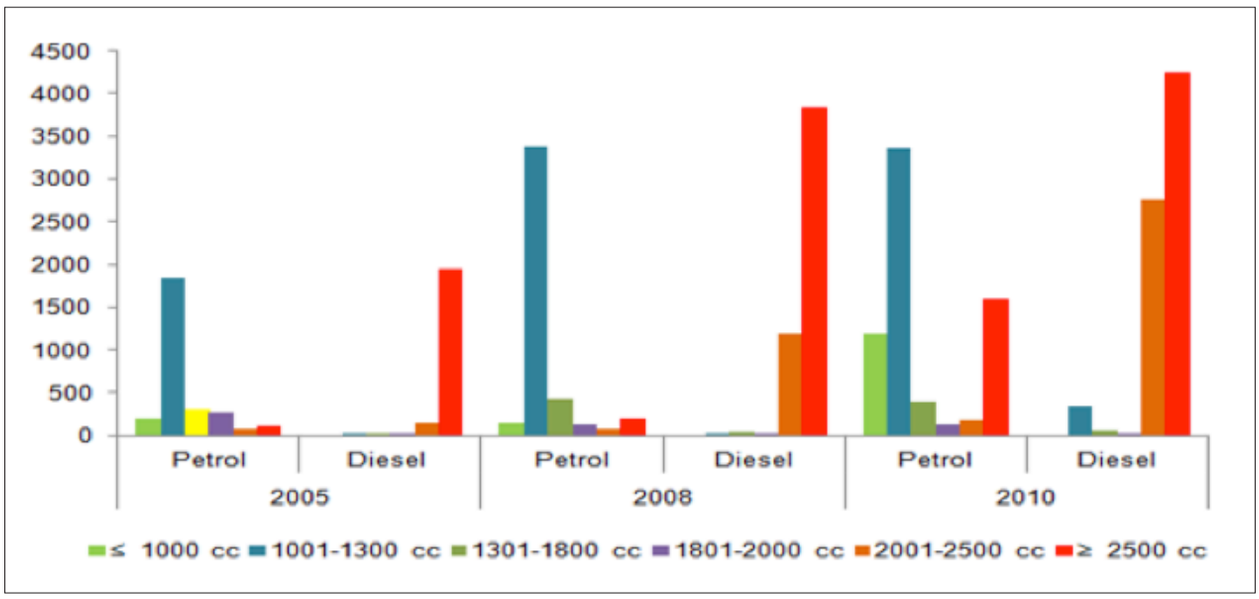
Engine capacity data of vehicles show that the country has more petrol vehicles of small engine size ranging from less than 1,000 cc to 1,801 to 2000 cc (more in the 1,001 to 1,300 cc category). However, diesel vehicles are more in the

Graph 13 Dieselisation of vehicular fleet in Ethiopia



Source: *CSE based on data from Demiss Alemu Amibe 2012, Final draft report on pilot Global Fuel Economy Initiative Study in Ethiopia, Paper presented at the UNEP workshop*

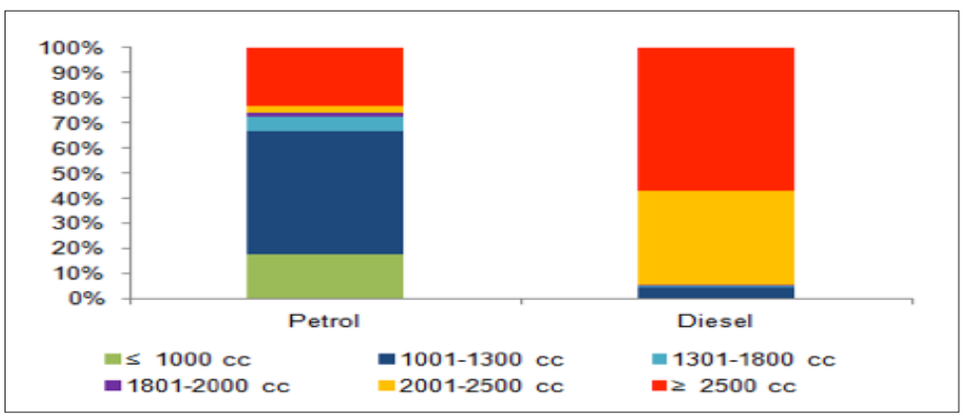
Graph 14: More diesel vehicles in the bigger engine size category in Ethiopia



Source: *CSE based on data from Demiss Alemu 2015, Transport fuel quality specification, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.*

bigger engine size class ranging from 2001 to 2,500 cc to more than 2,500 cc category. This leads to more energy guzzling. In terms of percentage, diesel vehicles increased in the 2,001 to 2,500 cc category and decreased in the greater than 2,500 cc category during 2005 and 2010. The percentage of diesel vehicles in the 2,001 to 2,500 cc category was 6.9 per cent in 2005, 23.3 per cent in 2008 and 37.3 per cent in 2010. More than 2,500 cc diesel vehicles were 92.3 per cent in 2005 and decreased to 75.7 and 57.3 per cent in 2005 and 2010 respectively *(see Graph 14: More diesel vehicles in the bigger engine size category in Ethiopia and see Graph 15: As much as 95 per cent of diesel vehicles of bigger engine size).*

Graph 15: As much as 95 per cent of diesel vehicles of bigger engine size



Source: *CSE based on data from Demiss Alemu 2015, Transport fuel quality specification, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.*

Control dieselisation

Countries cannot afford to dieselise at the current level of fuel and technologies. The PM and NOx emissions and air toxins from increasing diesel fleet will deteriorate air quality. The shift towards bigger diesel cars and SUVs will have energy impacts as well. The International Agency for Research on Cancer (IARC) of the WHO has reclassified diesel exhaust as Group 1 list of carcinogen. Diesel exhaust is now in the same class of deadly carcinogens as asbestos, arsenic or tobacco among others. Other governments consider toxic air contaminant (TAC) unit risk factors to prioritise action. Unit risk represents the number of excess cancer cases per million people per microgramme per cubic metre TAC concentration over a 70-year lifetime exposure. A diesel particulate matter unit risk value is used as a reasonable estimate by the California Air Resources Board, which signifies that the number of excess cancer cases per million people due to lifetime exposure to diesel fumes is 300 as opposed to 29 for benzene, another deadly toxin from petrol.

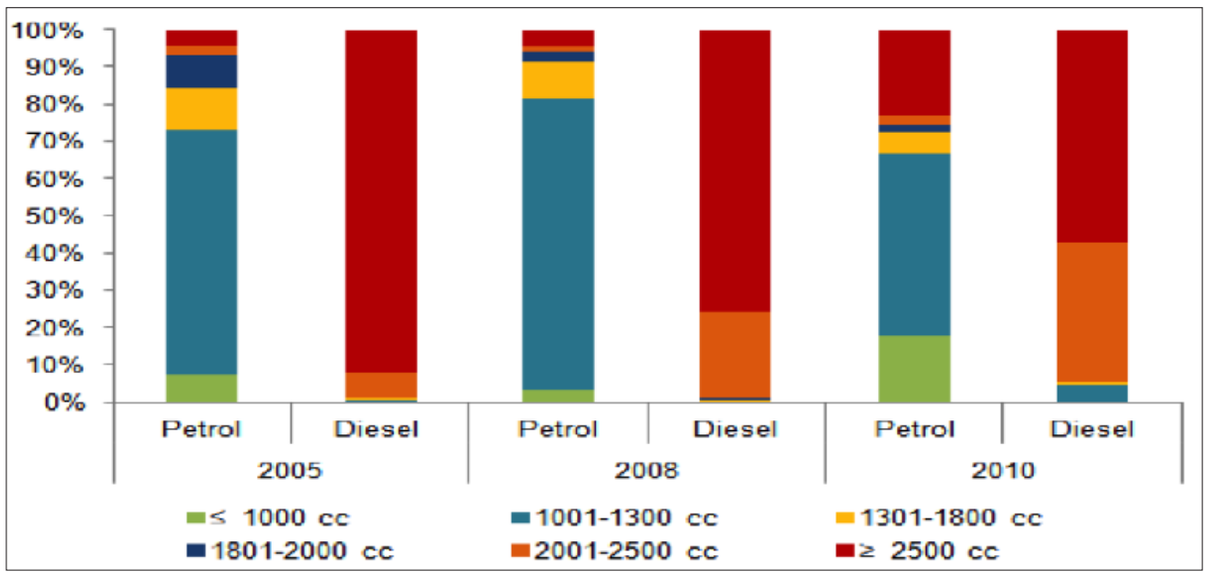
Ethiopia does not subsidise diesel like India; it maintains a narrow gap between the price of diesel and petrol. This is good. The country has to control the increasing number of diesel light duty vehicles. In India, the share of diesel cars in popular car models is now as high as 70 to 75 per cent. However some decline in diesel car sales has been reported after diesel deregulation.

Ethiopia has bigger diesel cars. Ninety five per cent of the diesel cars are in the 2,001 to 2,500 cc and greater than 2,500 cc category. Petrol cars on the other hand have smaller engine capacity cars and only 26 per cent in this bigger engine category. Diesel cars in the 2,001 to 2,005 cc category have increased from 6.9 per cent in 2005, 23.2 per cent in 2008 and 37.3 per cent in 2010. However, the cars in greater than 2,500 cc category though still highest amongst all engine category show gradual decline over the years. Their share was 92.2 per cent in 2005, 75.6 per cent in 2008 and 57.2 per cent in 2010. Even after reduction over the years, the share of bigger diesel cars remains very high. This trend needs to be reversed. Ethiopia is dieselising without clean diesel. Diesel begins to clean up at Euro VI level. There is an urgent move to go to 50 ppm and then to 10 ppm along with advanced after treatment system *(see Graph 16: Diesel cars: More cars in the 2,001 to more than 2,500 cc category and see Figure 1: Global move towards clean diesel).*

Diesel emissions are very toxic. Even with improvement, diesel emissions are more toxic than petrol emissions. Though diesel vehicles are more fuel efficient than their counterparts, they lead to high PM, NOx and black carbon emissions. Black carbon emissions from diesel vehicles are several times more heat trapping than CO2. The European Commission has found lifetime pollution costs of Euro IV compliant diesel cars to be much higher than petrol cars. Diesel also has a rebound effect and has higher carbon content than petrol. If more diesel fuel is burnt, more heat trapping CO2 will escape.

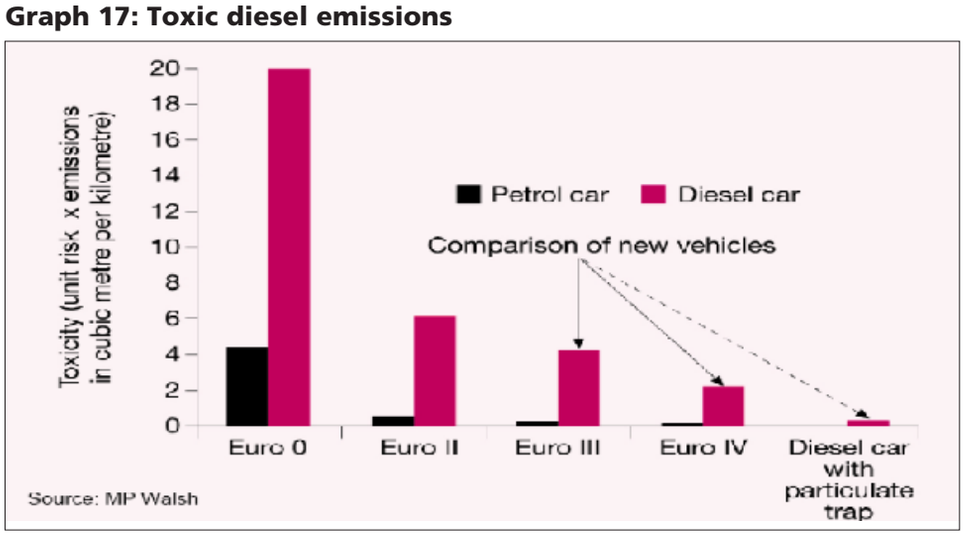
The most recent comprehensive global scientific study on short lived climate forcers, 'Bounding the role of black carbon' report 2013, states that globally diesel black carbon emission is expected to be 20 per cent of the total black carbon emissions. But total emissions from petrol vehicles are less than 10 per cent of diesel black carbon emissions, although petrol vehicles are more numerous *(see Graph 17: Toxic diesel emissions and see Graph 18: Diesel cars emit much more black carbon than petrol cars).*

Graph 16: Diesel cars: More cars in the 2,001 to more than 2,500 cc category



Source: CSE based on data from Demiss Alemu 2015, Transport fuel quality specification, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.

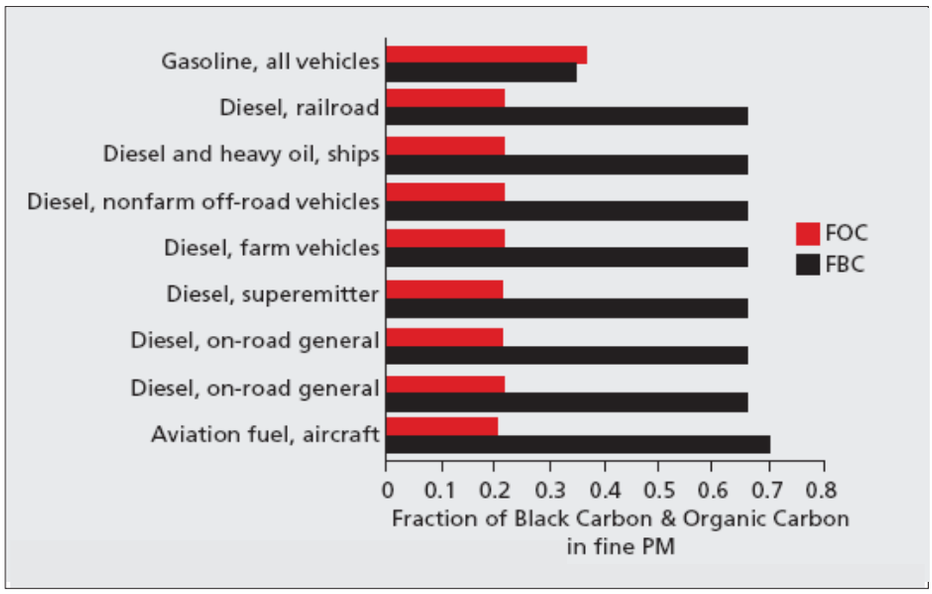
Graph 17: Toxic diesel emissions



Source: MP Walsh

Ethiopia can tap the learning from other countries and impose additional taxes on diesel cars and fuel *(see Box: Dieselisation in India: lessons; Global action on diesel cars; Mauritius: Transition to low sulphur fuel and Vehicle technology and fuel quality roadmap in India).* The country needs to leapfrog to Euro IV emission standards and set a timeline for Euro V and Euro VI. Improvement in emission standards is possible only if there is requisite fuel to enable use of advanced emission-control systems. This requires import of clean fuel with 10 ppm sulphur that is also low on other toxic parameters. Clean fuel will be expensive. But the cost should not delay decision-making and implementation. The government would need fiscal strategy, take additional steps to help fund the transition to clean fuel.

Graph 18: Diesel cars emit much more black carbon than petrol cars



Source: Tami Bond 2012

Dieselisation in India: Lessons

India has experienced very rapid dieselisation in the car segment. Diesel cars accounted for 4 per cent of new car sales in 2000; this increased to 50 per cent by 2013. Price distortion has increased share of diesel consumption in India significantly adding to the toxic risk. This trend encouraged the automobile industry to roll out more diesel car models. In 2009-13, when international oil prices skyrocketed sending petrol prices into a tizzy, the rate of dieselization increased significantly. In 2010-11, the rate of increase in diesel car sales was 34 per cent over the previous year. The sale of SUVs had increased by 43 per cent, largely a result of combination of the lure of cheap diesel and consumer preference for the sale of bigger vehicles.

According to official reports of the Petroleum Planning and Analysis Cell (PPAC) under the Union Ministry of Petroleum and Natural Gas, diesel cars in 2012 were already the second-largest users of diesel in the country at 15 per cent of diesel-fuel use even though diesel is subsidised for agriculture and freight. Cars were using more diesel than agriculture and buses. Thus, rich car owners are the beneficiaries of the fuel pricing policy.

The current level of European standards for cars gives legal sanction to diesel cars to emit more PM and NOx compared to petrol cars. The emission factors from Pune-based Automotive Research Association of India show enormous differences in the actual emission levels of Euro III (Bharat Stage III) diesel and petrol cars. Euro III diesel cars emit 7.5 times more toxic PM than comparable petrol cars. This means that one diesel car is equal to adding 7.5 petrol cars to the car fleet in terms of PM emissions and three petrol cars in terms of NOx emissions. This clearly reflects the flawed emission standards that allow diesel cars to emit more NOx and PM compared to petrol cars. Total air toxics from a diesel car that are very harmful and carcinogenic are seven times higher than petrol cars.

Of late there has been a respite from the increasing dieselization in the Delhi and National Capital Region (NCR). The Apex Court, Supreme Court of India in a landmark judgment on December 16, 2015 banned registration of luxury diesel cars and SUVs (2000 cc and above) in the NCR, barred entry of pre-Euro III trucks into Delhi, doubled the environment compensation charge on all trucks entering Delhi and also mandated all taxis in NCR to convert to CNG. Ban on registration of diesel cars had been extended in the subsequent hearings.

Global action on diesel cars

Globally, governments have either introduced clean diesel or have discouraged diesel cars. All major vehicle producing countries including US, Europe, Japan, South Korea etc have introduced clean diesel with advanced emissions control system. In the US, China and Japan diesel cars are a very small fraction of cars. In addition to this there are other countries that are discouraging diesel cars.

London: Mayor of London has announced that pre Euro VI cars will not be allowed inside the ultra low emissions zone in Central London.

France: French government has said that Euro VI diesel cars will not be included in the new category 1 colour coding scheme that classifies vehicles according to how much they pollute. French cities can use this colour coding to decide if they want to ban diesel powered vehicles. The government has raised excise tax on diesel fuel and removed incentives for diesel car purchase. The green-dot program would be voluntary and place cars in different classes according to tailpipe emissions – all-electric, then classes 1 through 6. The class 1 does not even allow Euro VI diesel cars. The French government has also pledged to "progressively" ban from 2015 diesel vehicles.

Paris: Paris Mayor plans to phase out pre-2011 diesel cars by the end of the decade. It is reported that the Mayor has not ruled out banning diesel engines from roads entirely and support electric and hybrid cars in the future.

Madrid: Mayor of Madrid has proposed to ban polluting diesel cars from the city centre from 2020.

Netherlands: In 1998 the Third National Environment Policy targeted to reduce diesel chare to only 5 per cent in 2010. Dutch registration and circulation taxes for diesel cars are close to prohibitive. It is double that of imposed on petrol cars. This has kept share of diesel cars in Netherland lower than EU average.

Brazil: Sales of diesel passenger cars and commercial vehicles with capacity inferior to 1,000 kg have been banned in Brazil since the 1970s. Brazil has banned the sale and use of diesel passenger cars. Their place is taken by vehicles that run on pure ethanol or on a mixture of ethanol and petrol (Flexfuel). Ethanol and Flexfuel vehicles are widespread. Because of the import restrictions and taxes, vehicles are very expensive in Brazil. Cars are a luxury. This is reflected in the low level of car ownership at around 200 vehicles per 1,000 inhabitants.

Beijing has banned diesel cars as a pollution control measure. China has the lowest diesel car penetration at less than 1 per cent. China taxes do not differentiate between petrol and diesel fuel.

Sri Lanka has imposed several times higher duties for diesel cars compared to petrol cars and have reduced diesel car sales.

Delhi: Banned registration of diesel cars with 2000 cc and above engines to stop misuse of low tax diesel for luxury consumption. Even in India several official committees have asked for special and additional taxes on diesel cars to neutralise the incentive of cheaper diesel fuel.

Mauritius: Transition to low sulphur fuel

Mauritius introduced unleaded petrol in September 2002 and low sulphur diesel of 50 ppm in March 2012. Initially the sulphur levels were 5,000 ppm; it was brought down to 2,500 ppm in August 2001, then to 500 ppm in August 2010 and finally to 50 ppm in March 2012. The country is aiming for 15 ppm now.

The government worked with concerned stakeholders to implement this measure. The State Trading Corporation (STC) is the Government body responsible for the importation of petroleum products into Mauritius. All fuel requirements (Mogas, Gasoil, Jet A 1, Heavy Fuel Oils) are from one supplier. The government is in a three year contract with Mangalore Refineries and Petrochemicals Ltd India. Importing 1.2 million tonnes annually from a single supplier gave the bargaining power to maintain the price of 50 ppm diesel same as 500 ppm diesel. Shift was smooth from a pricing perspective.

All this was possible because there was one fuel importer, STC. Aggressive campaigns were done on radio, TV and all stakeholders were involved. A high powered committee was set up by the government and chaired by the Ministry of Environment. This was a multistakeholder committee which comprised of various Ministries, University of Mauritius, Police force and vehicle dealers association to manage the introduction of 50 ppm sulphur diesel. The Ministry and the University of Mauritius also carried out test to analyse the benefits of low sulphur diesel. The STC conducted press campaigns to explain the public about benefits of using low sulphur diesel – better engine combustion, optimised fuel consumption, longer engine lifetime and less air pollution. The Ministry also organised a national workshop which got nationwide media coverage. The result was a six fold decrease in the SO2 levels in the ambient air with introduction of 50 ppm sulphur diesel.

Source: *Satyanand Buskalawa 2015, Introduction of 50 ppm diesel in Mauritius, Paper presented in Conclave of Champion Cities of Asia and Africa on Clean Air and Sustainable Mobility, Centre for Science and Environment, New Delhi, April 9, mimeo.*

Vehicle technology and fuel quality roadmap in India

India has implemented Euro III and Euro IV emissions standards in about 30 cities and Euro III in the rest of the country. Two levels of emission standards in the country do not allow trucks to move to cleaner fuel and technology and they heavily pollute cities during transit, aggravating pollution in Delhi and NCR as well. The immediate nation-wide introduction of Bharat Stage IV standards will give substantial benefits. Bharat Stage IV standards for cars, especially for particulates, are 50 per cent cleaner than Bharat Stage III standards. Bharat Stage IV particle standards for trucks are 81 per cent cleaner. This will dramatically impact trucks that cause very serious pollution.

The technology roadmap in India is 10 to 15 years behind current emissions standards in Europe (see Graph: Technology roadmap for India). After an active campaign, the Union government recently announced that India will skip Euro V emissions standards and leapfrog to Euro VI standards in 2020. This is good news for India. As India leaps from Bharat Stage IV to Euro VI, particulate emissions from diesel cars will be reduced by 68 per cent; NOx emissions can come down by 82 per cent. Reduction from heavy-duty vehicles will be 87 per cent and 67 per cent for particulates and NOx respectively. As India now gears up to bring in a new genre of emissions control technology, it should also have in-use compliance regulations in place to ensure that these systems work optimally throughout the useful life of vehicles on our roads, and manufacturers are held accountable – as it the global good practice.

Effective emission-control technologies needed to control toxic PM and NOx together become possible only at Euro V level for cars and the Euro VI level for heavy-duty vehicles. In case of cars and light to medium and heavy-duty commercial vehicles, a particle number limit is introduced at the Euro V level that forces the use of a diesel particulate filter. But the Euro V standard does not

establish a particle number limit for heavy-duty commercial trucks and buses. Therefore, PM levels remain high in these vehicles. This is introduced in Euro VI standard which finally forces the use of advanced diesel particulate filter in heavy-duty vehicles.

Even with successive improvement in emissions standards (Euro I, II, III, IV, V, VI), very high ratio of black carbon to organic carbon persists in the emissions. According to the 2014 World Bank study fleet-wide averages taken in a global emissions inventory model shows that while the share of black carbon in the particulate emissions from Euro II model was 80 per cent it has reduced to 25 per cent in the Euro V fleet – but is still a problem. Black carbon reduction technologies become effective for cars at Euro V level and for heavy duty vehicles only at Euro VI level. In absence of any roadmap, it is important for Ethiopia to move to Euro IV by 2017 and plan future roadmap for Euro V and Euro VI.

Fiscal strategies to clean up fuels and vehicles

The cost of technology and fuel quality transition can be met with fiscal strategies. There are important good examples in the region. Investments in fuel upgradation are justified based on the health benefits expected from the investments. For instance, available estimates show that while fuel quality improvement in Kenya is expected to cost USD 6 billion, the benefits from this is expected to be USD 43 billion – to be saved from the reduced health cost of its citizens. In fact, Kenya started by giving subsidy to its refinery to achieve 500 ppm sulphur fuels. But subsequently, along with other oil importing countries have decided to move to 50 ppm sulphur fuels from January 2015. South Africa has also started by giving subsidy to the refinery to improve fuel quality.

In India as well there is a proposal to find a fiscal strategy to move to 10 ppm sulphur fuel by 2020. The fiscal strategy in India to make the transition to clean fuel includes several tax measures. The Union Budget of 2016-17 has announced differentiated taxes on petrol and diesel cars and the revenue to be spent on infrastructure. In Delhi, pollution tax on per litre of diesel sold in the city is paid. Air Ambience Fund has been created from this revenue collected. The Auto Fuel Policy Committee 2014 has proposed special fuel upgradtion cess of 75 paise per litre on petrol and diesel which can generate Rs. 64,000 crore over 7 years and equalization of retail price of Bharat Stage III and IV fuels and the excess collected from the repricing of Bharat Stage III to be called ‘high sulphur cess’. The revenue from these sources are proposed to be spent on refinery upgrades. An additional tax on fuels and diesel car can bring additional revenue that can be used to create Clean Fuel Fund to meet the cost of refinery costs.

Ethiopia should also design financing strategy to leapfrog to clean low sulphur fuels. Fiscal solutions should be linked with stringent emission standards. Tax differential between petrol and diesel should be reduced or eliminated. The fiscal strategy for clean fuel fund should include direct tax incentive for import of clean fuel, differentiated retail prices for clean and dirtier fuel, revenue from higher tax should go to clean fuel fund and even a small tax on each litre of fuel sold can help to offset costs. Additional and differentiated tax on all cars can help bring more revenue for clean fuel fund. Such inventive strategies are needed to prevent pollution disaster *(see Box: Global best practices on fiscal strategy for clean fuels; No fossil fuel subsidies in Ethiopia; and Mauritius: Vehicle excise act).*

Global best practices on fiscal strategy for clean fuels

Several governments have innovated fiscal strategy to phase in clean fuels. These strategies include setting of differentiated tax rates; tax reduction/ credits to refiners that provide lower sulphur fuels; directly subsidising the supply of lower sulphur fuels; incentives targeting consumers, such as tax reductions implemented at the pump – combined with an increased tax at the pump for higher sulphur diesel. Fiscal incentives must be combined with regulatory mandates on clean fuel quality (10 ppm sulphur fuels) for public health and environmental benefits. This should also be leveraged to leapfrog emissions standards within a tight time frame.

Japan - Tax incentive to refineries: The government instituted direct tax incentives in two phases to subsidise refinery investments for reducing sulphur in diesel. Refineries had a choice of 7 per cent deduction in corporate tax or a 30 per cent accelerated depreciation on the purchased equipment. The Tokyo government initiated a two-year incentive program in 2001 to subsidise up to 10 yen per litre to oil companies that supply 50-ppm sulphur diesel fuel.

Hong Kong - Tax differential in favour of clean fuel: To promote the supply of 50-ppm diesel fuel, in July 2000, the government reduced the import duty for 50 ppm sulphur diesel to HK $1.11 per litre. Within two months, 50 ppm sulphur diesel became the main diesel fuel at local filling stations. The following year – although the duty on 50 ppm sulphur diesel rose – the tax differential between the two fuel types (500-ppm vs. 50 ppm) remained at HK $0.89 per litre. The Hong Kong Environmental Protection Department in 2007 issued a HK $0.56 per liter concessionary duty to promote market penetration of 10 ppm sulphur diesel fuel in anticipation of implementing Euro V requirement for all diesel vehicles in 2009. By mid-2008, the duty rate for 10 ppm sulphur diesel was waived altogether and filling stations began to exclusively carry this fuel. The government continued to waive the concessionary duty for 10 ppm sulphur diesel fuel even after the 10 ppm sulphur limit was mandated in July 2010.

Sri Lanka: This is a very interesting case where taking advantage of the lower international fuel prices Sri Lanka has moved to 10 ppm sulphur fuel that has opened up the opportunity to move directly to Euro VI vehicles. Sri Lanka also nearly entirely imports all its fuel and vehicles. This is a good example that represents the situation in Ethiopia.

The UK - Duty differential in favour of clean fuel: The conversion of high sulphur diesel fuel to 50 ppm was achieved six years ahead of the EU schedule and well ahead of most other EU member states. This can largely be attributed to a series of 50 ppm diesel tax incentives. Beginning in the fiscal year 1997, the tax differential was set at 1 pence per liter, and the amount ratcheted up each year until full market penetration of 50 ppm diesel in the market was achieved.

Germany - Duty differential in favour of clean fuel: The government issued an extra tax of 3 pfennigs/litre on fuel with a higher-than 50 ppm sulphur level beginning in 2001, then extended to three pfennigs/litre extra tax on fuel with higher than 10 ppm sulphur content from January 1, 2003. In 2004, virtually all fuel sold in Germany contained 10 ppm sulphur with minimal and short lived fuel price disruption due to competition and gains in efficiency from refining technology.

The US: The government did provide some flexibility to assist refiners in meeting targets such as allowing credit trading among refiners and extension of the target deadline for small refineries. From fiscal years 2003 – 2009, a tax credit of $ 0.05 per gallon of 15 ppm diesel was granted to small business refiners.

No fossil fuel subsidies in Ethiopia

Due to a major drought in 2007, the government found it difficult to cover the food cost and fuel subsidies. It therefore decided to phase out fossil fuel subsidies in 2008. The reform took place in a relatively short period due to strong political leadership. According to Wondwossen Sintayehu formerly at the Environmental Protection Authority in Ethiopia, reform was undertaken both as a strategic choice by the government (as part of the Climate-Resilient Green Economy Strategy elaborated in 2011) and necessity (as Ethiopia is a net importer of petroleum and an important share of GDP is used to subsidise the fuel). The subsidy removal led to 50 per cent increase in price for kerosene and 40 per cent for diesel.

In October 2009, a commission was set up to adjust fuel prices. Since the reform there have been a number of transport sector interventions and investments. For instance, price stabilisation led to investments in major road and railway projects. After subsidy removal, the government introduced ethanol blending in 2011 (10 per cent ethanol and 90 per cent petrol mix). The future plans are to increase the share of ethanol in blended fuel to 25 per cent and support the development of alternative fuels such as jatropha. The government will also introduce fuel efficiency standards for all vehicles and regulations.

Mauritius: Vehicle excise act

The vehicle excise Act of Mauritius promotes energy efficient vehicles taking into consideration CO2 emissions of vehicles. The objective was to reflect polluter pays principle in the vehicle taxation system and to bring a shift in consumer choice from high to low CO_2 emitting cars. In July 2011, the excise Act was amended to include taxation system for cars based on their engine capacity and CO_2 emissions. Designed to be revenue neutral, this Act is applicable to all cars (including hybrid) whether new or second-hand. A CO_2 levy or rebate is based around a dynamic CO_2 threshold of 150 gm per km. A levy is imposed if the CO_2 gm per km exceeeds150 gm per km. A CO_2 rebate is granted when the CO_2 gm per km is below the CO_2 threshold of 150 gm per km. A CO_2 rebate is granted and deducted from the excise duty and a CO_2 levy is payable and added to the excise duty. A standard value of 158 gm of CO_2 per km was set in 2011. In 2013, it was amended and made more stringent with reduction in the standard value of vehicular emission to 150 gm of CO_2 per km. The CO_2 threshold was calculated based on the average CO_2 emission of new cars imported into Mauritius in 2011 and 2012 using the international measurement standard UNECE101.

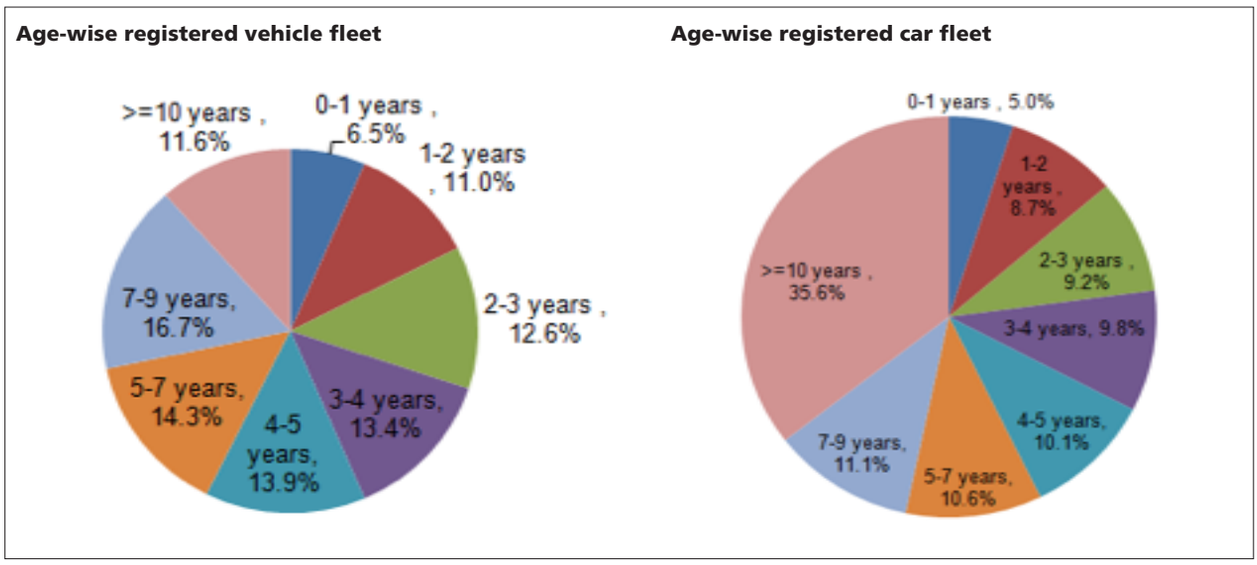
The CO_2 threshold was expected to be reviewed in January 2015 based on average CO_2 emissions of new cars imported into Mauritius in 2013 and 2014. The Budget 2015-2016 made provision for review of the CO_2 levy/rebate scheme. At present the CO_2 emission threshold used for determining the Levy or Rebate chargeable is computed by the average of the CO_2 emission for new cars imported during the previous year. This threshold is currently set at 150 gm/km. The provision in the Excise Act will be reviewed to fix the threshold by regulations. The implementation of the vehicle excise act resulted in an increase in sales of new cars compared to second hand imported cars and a significant shift towards small engine capacity.

Source: *Satyanand Buskalawa 2015, Dialogue of the South on Clean Air and Sustainable Mobility, Paper presented in Conclave of Champion Cities of Asia and Africa on Clean Air and Sustainable Mobility, Centre for Science and Environment, New Delhi, April 9, mimeo.*

Unique challenge of second hand vehicle imports

This is a special challenge of African cities where import of second hand vehicles dominates. Secondhand or used vehicles from Japan, Europe and other countries swamp the market. Because of the high price of new vehicles, people prefer buying used vehicles. Very few vehicles are new. Some of them are locally assembled or manufactured as in South Africa or in General Motors assembling plant in Ethiopia. Addis Ababa faces a rapid increase in air pollution due to increasing number of secondhand vehicles which do not follow emission standards set by various environmental agencies. Use of secondhand vehicles also leads to high fuel consumption and increased emissions. Lack of retirement policy for the vehicles worsens the problem.

Graph 19: Age-wise break up of vehicles in Ethiopia



Source: *CSE based on data provided by Addis Ababa Transport Authority .*

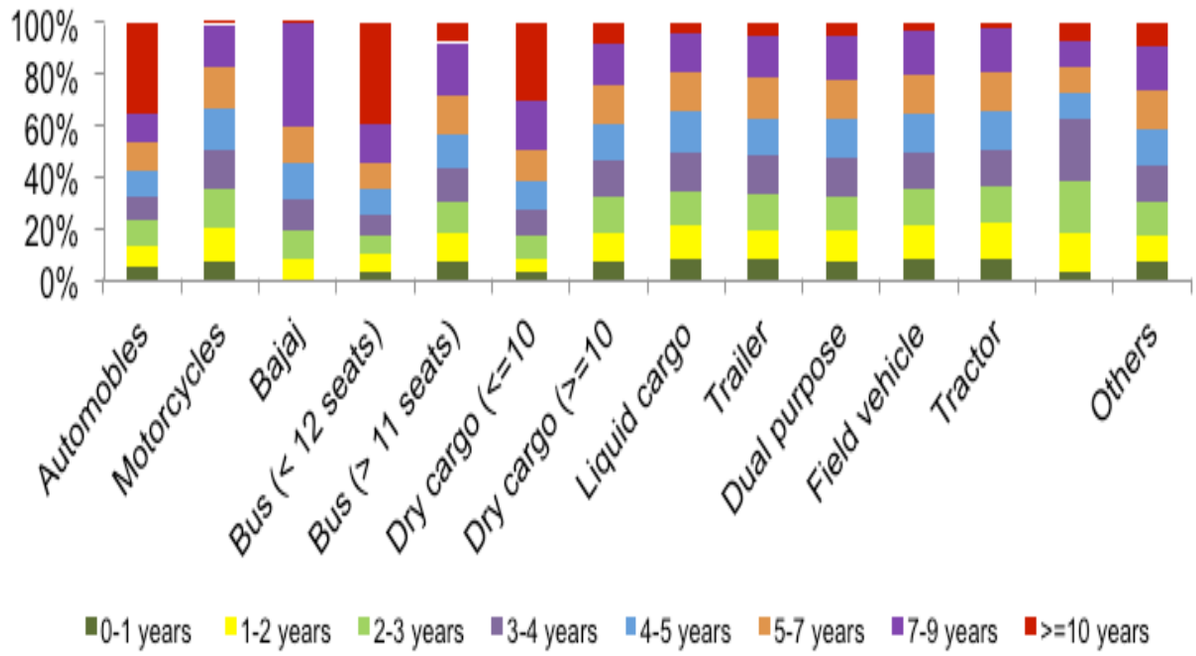
This causes enormous emissions and requires urgent attention. Zerihun Abate, Lecturer, Mechanical and Industrial School, Addis Ababa University Science and Technology suggested for establishing vehicle emission standards, introducing stringent fuel sulphur requirement and setting age limits on importation of second hand vehicles.

CSE has analysed the 2014-15 vehicle registration data form Addis Ababa Transport Authority. This shows that only 18 per cent of the registered vehicles in the country are below two years of age. Nearly 71 per cent of the vehicles are in the range of 2 to 9 years. However, 11.6 per cent vehicles are more than 10 years. Category wise vehicle data shows large number of old vehicles. Only 14 per cent cars are of two years, 50 per cent are from 2 to 9 years and the rest 36 per cent are of 10 years or more.

There are more old motorcycles in the 2 to 9 years category. While 20.5 per cent motorcycles are of two years, 79 per cent are from 2 to 9 years and 0.6 per cent of 10 years and more. Other vehicles show similar trend. The vehicle registration data does not distinguish between new and secondhand vehicles. However, this seems to be the imported secondhand vehicles data according to service age. The analysis of the import data also shows that motorcycles are highest in numbers as compared to cars and other vehicles. While motorcycles were 22.2 per cent, cars were 16.2 per cent followed by Bajaj 2.7 per cent, buses 10 per cent, cargo and trailer 20.3 per cent, tractor 0.5 per cent and other vehicles at 28 per cent. This is in contrast to the vehicle registration data which show cars to be larger in numbers than the motorcycles.

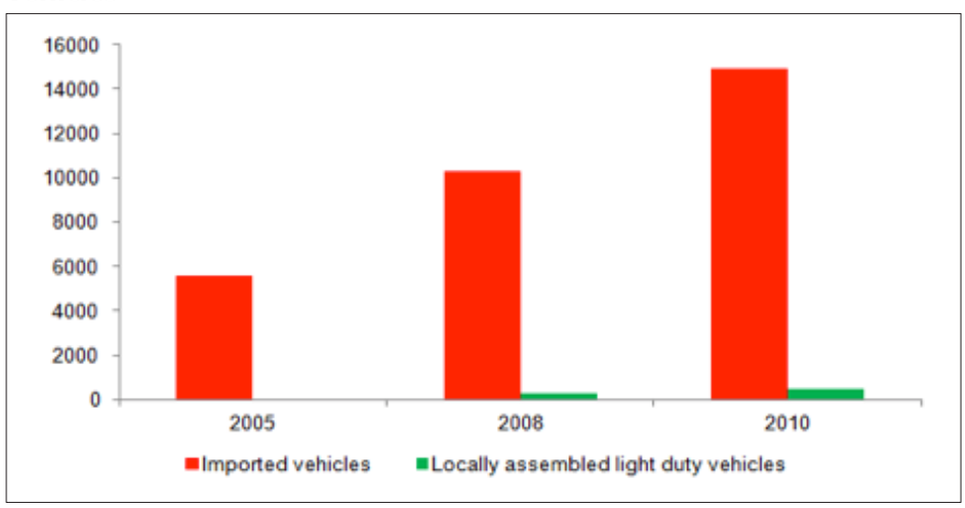
According to an older estimate, most of the vehicles are imported and only a few are new vehicles. In fact imported vehicles outnumber new assembled vehicles in Ethiopia. Data also shows Toyota is the biggest importer of vehicles *(see Graph 19: Age-wise break up of vehicles in Ethiopia; Graph 20: High share of old vehicles amongst cars, bus less than 12 seats and dry cargo less than 10 quintals; and Graph 21: Imported vehicles outnumber the locally assembled vehicles).*

Graph 20: High share of old vehicles amongst cars, bus less than 12 seats and dry cargo less than 10 quintals



Source: CSE based on data provided by Addis Ababa Transport Authority.

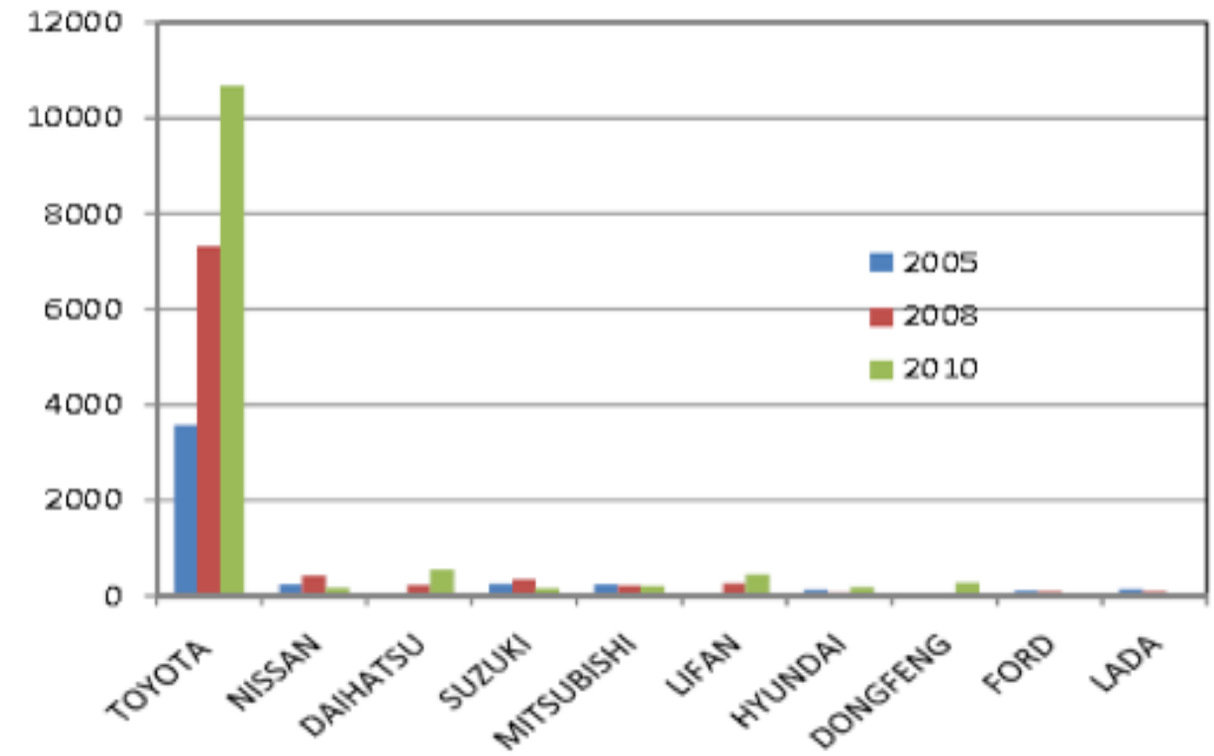
Graph 21: Imported vehicles outnumber the locally assembled vehicles



Source: Demiss Alemu Amibe 2012, Final draft report on pilot Global Fuel Economy Initiative Study in Ethiopia, Paper presented at the UNEP workshop

Vehicles and fuel account for 8 per cent and 17 per cent of the imported commodities. A large number of vehicles in Ethiopia are of Toyota make. The spare parts also need to be imported. This adds to cost. Motorcycles are imported from India (Bajaj and TVS) and China (Lifan). Other vehicles like cars, light-duty vehicles, buses, minibuses and trucks are imported from other countries such as Japan, China and Italy *(see Graph 22: Toyota: The dominant importer in Ethiopia).*

Graph 22: Toyota: The dominant importer in Ethiopia



Source: Demiss Alemu Amibe 2012, Final draft report on pilot Global Fuel Economy Initiative Study in Ethiopia, Paper presented at the UNEP workshop.

According to the experts, the excise tax on importation of vehicle parts and additional excise tax after assembly makes locally assembled vehicles more expensive. During importation parts of a 1,000 cc automobile is subjected to 30 per cent excise tax among other taxes. After assembly the vehicle price includes an excise tax for the incremental value added to the car. For example, a 2014 Lifan 620 new model is sold for 418,000 Birr. But an older 1989 to 1990 Toyota Corolla locally dubbed Weyane DX model is sold between 290,000 and 320,000 Birr.

Reduce importation of second hand vehicles and promote new vehicles: Several governments in the African region have begun to take steps to address the problem of importation of secondhand vehicles. This is being done by fixing the age of vehicles, putting higher taxes on the older vehicles and also by introducing vehicle inspection programme for in-use vehicles.

In September 2015, Kenya adopted an age-based taxation scheme for imported second hand vehicles. This raises tax for imported second hand vehicles older than 3 years by 150 per cent and reduces tax to 30 per cent for vehicles less than 3 years. The Bill also provides tax-breaks for vehicles with smaller and more efficient engines. Ethiopia can promote new vehicles with fiscal measures *(see Box: Best practices from African region on importation of secondhand vehicles).*

The priority action for Ethiopia therefore is to first fix the age of vehicle importation, increase taxation on second hand vehicles with stringent road worthiness and inspection system, less taxes on new and locally assembled vehicles and spare parts. In several Indian cities the taxes are being designed

Best practices from African region on importation of second hand vehicles

Ethiopia and other countries including Burkina Faso, Cameroon, Central African Republic, Democratic Republic of Congo, Ethiopia, Mali, Malawi, Zambia do not impose import restriction on vehicle age basis. However, many other countries have taken the progressive step of vehicle age importation.

- **Angola:** Automobile companies are not allowed to import used vehicles however, individuals are allowed to import regardless of age
- **Benin:** Since December 29, 2000, vehicle import age restriction is 10 years for light duty vehicles and 13 years for tourism vehicles. There is also requirement for emissions control
- **Botswana:** Maximum of 100,000 kms on the vehicle
- **Chad:** Vehicle inspection upon importation
- **Côte d'Ivoire:** A fine of FCFA 150.000 is imposed on vehicles older than 10 years and an additional FCFA 10.000 for every year
- **Eritrea:** Used vehicles must be less than ten years old
- **Gabon:** Used vehicles must be less than four years old
- **Ghana:** Used vehicles over five years old pay graduated penalty according to year of manufacture and capacity
- **Kenya**, Réunion and Lesothe: Used vehicles must be less than eight years old
- **Mauritius:** Has a three year age restriction
- **Mozambique:** Used cars and vans must be less than five years old and nine years old respectively
- **Niger:** Used vehicles from outside of the SACU area must be less than five years old. However, there is no age limit for SACU-originating used vehicles
- **Seychelles:** Used vehicles must be less than five years old
- **Sudan:** Imported second-hand vehicles are illegal, except for immigrants, vintage and racing cars, vehicles adapted for physically disabled, and donated vehicles for welfare organisations
- **The Gambia:** Import of second hand vehicles restricted through taxation – increase in vehicles exceeding 10 years and roadworthiness must be proven before import
- **Zimbabwe:** Banned importation of vehicles older than 8 years old and recently increased import duty

to increase with the age of vehicles *(Box: Green tax imposed on old vehicles in India).*

Improve fuel economy of fleet to reduce energy and climate impacts of motorisation

Ethiopia is yet to develop fuel economy regulations for vehicles. In Kenya, the Energy Regulatory Commission (ERC) in partnership with the University of Nairobi is carrying out a baseline vehicle fleet analysis, including vehicle imports, and will undertake a cost and benefit analysis on fuel economy and cleaner fuels and vehicle policies. The UNEP and its partners are assisting the Mauritius government in the review of the implementation of its Excise Bill (2011) that sets forth a CO_2 levy on motor cars or the granting of a CO_2 rebate from the excise duty payable on cars. This is probably the first "feebate" system in the developing world. India has framed fuel economy regulations for cars and is now working on heavy-duty fuel regulations. Global Fuel Economy Initiative has contributed to this assessment.

Green tax imposed on old vehicles in India

Several Indian states have imposed higher taxes on older vehicles. This tax is called the green tax and is linked with the environmental objective of accelerating renewal of older fleet of vehicles. However, in most states, the revenue from the green tax is not earmarked for any specific environmental objective. It flows into the general kitty of the government. Only in Rajasthan, a part of the revenue is taken into the urban transport fund.

Maharashtra: The Maharashtra government levies a green tax under the Bombay Motor Vehicles Tax (Amendment) Ordinance, 2010. Public and private vehicles, which are over eight and 15 years old respectively, have to pay a green tax every year. The 15-year-old two-wheelers and cars that run on petrol pay a tax of Rs 2,000 and Rs 3,000 respectively every five years. Diesel cars pay a tax of Rs 3,500 every five years14. The Maharashtra government earns approximately Rs 171 crore annually through its green tax.

Tamil Nadu: Section 3-A of the Tamil Nadu Motor Vehicles Taxation Act, 1974 requires motor vehicle operators to pay the green tax. Commercial vehicles that have completed seven years of age from the date of their registration have to pay Rs 200-500 per annum as green tax. Personal vehicles — two-wheelers and cars — that have exceeded the age of 15 years, pay Rs 500 and Rs 1,000 respectively as green tax for five years. As of now, revenues from this tax have not been earmarked for any specific purpose.

Karnataka: Green tax was introduced in the state in 2002. Commercial vehicles that are more than seven years old pay at the rate of Rs 200 at the time of the annual renewal of permits. Two-wheelers and cars that are more than 15 years old pay at the rate of Rs 250 and Rs 500 respectively at the time of renewal of their registration, after 15 years from the date of purchase and the first registration.

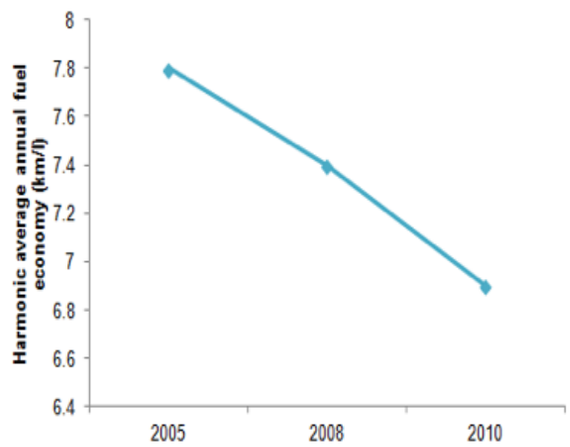
Rajasthan: The state government has implemented a green cess on all commercial vehicles registered in the state, including trucks and buses. This cess was prescribed under the powers conferred by section 4-D of the Rajasthan Motor Vehicles Taxation Act, 1951 (Rajasthan Act No 11 of 1951), the state government prescribed these rate of cess called Green tax for different class of vehicles16. This generates about Rs 35 crore annually. A part of this goes to the Rajasthan transportation fund.

Demiss Alemu, Head, Mechanical and Industrial School, Addis Ababa University Science and Technology Institute informed that 0.3 million light-duty vehicles (LDVs) emit about 2.3 million tonnes of CO_2 per year.

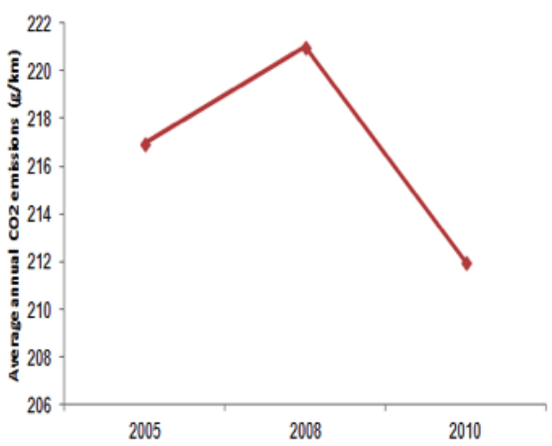
A study was done to set a baseline and develop a national vehicle database for indicating the fuel economy trend. The average fuel consumption for light-duty vehicles in Ethiopia was found to be 8.4 l/100 km in 2005 and 2008 respectively and 7.9 l/100 km in 2010 with corresponding CO_2 emissions of 217, 221 and 212 gCO2/km respectively. It is to be noted that the fuel economy slightly decreased to 7.9 l/100 km in 2010 with corresponding CO_2 emission of 212 gCO_2/km. Diesel fueled LDVs were found to travel less kilometer per liter of fuel as compared to their petrol counterparts and emitted more CO_2 than petrol fueled vehicles. Alemu added that these results are in lower regime when compared to that of reported in the literature [ICT2012], which is caused by importation of second hand vehicles and relatively larger share of vans, SUVs and pick-ups in the total import of LDVs *(see Graph 23: CO_2 profile and Graph 24: Average vehicle CO_2 emissions data).*

Graph 23: CO^2 profile

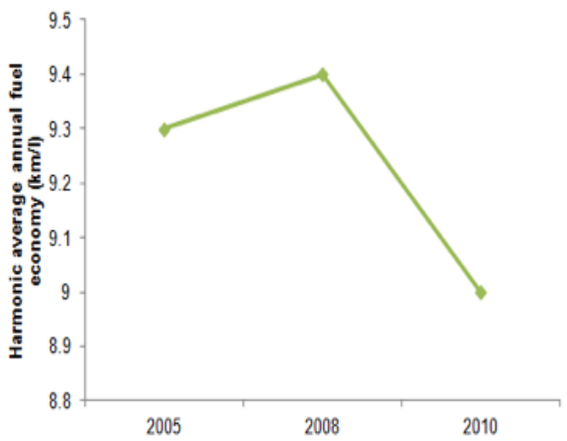
HAAFE Vs Registration Year for all LDVs



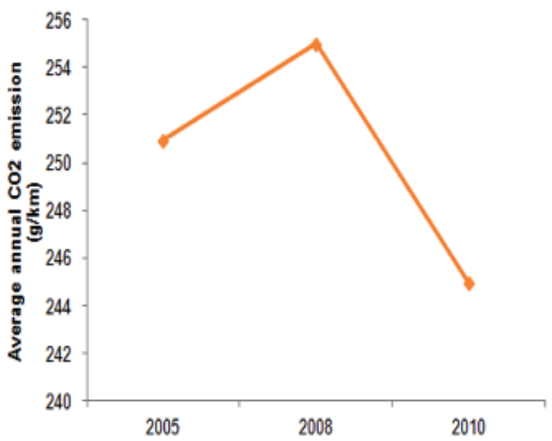
AA CO_2 Vs Registration Year for all LDVs



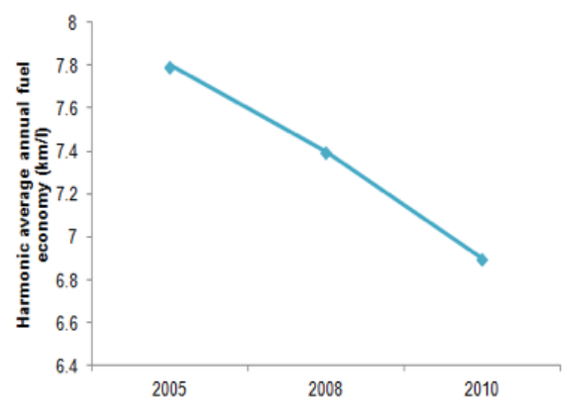
Average fuel economy Vs registration year for diesel LDVs



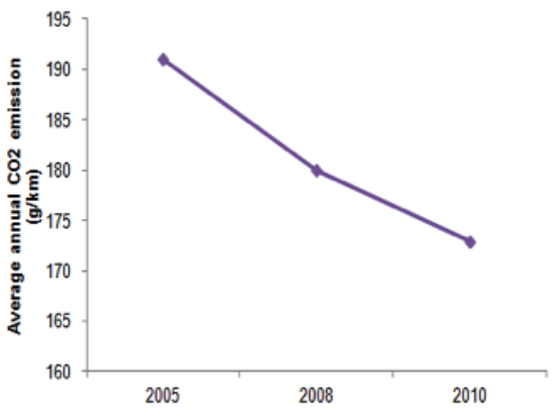
Average annual CO_2 Vs registration year for diesel LDVs



HAAFE Vs registration year for petrol LDVs

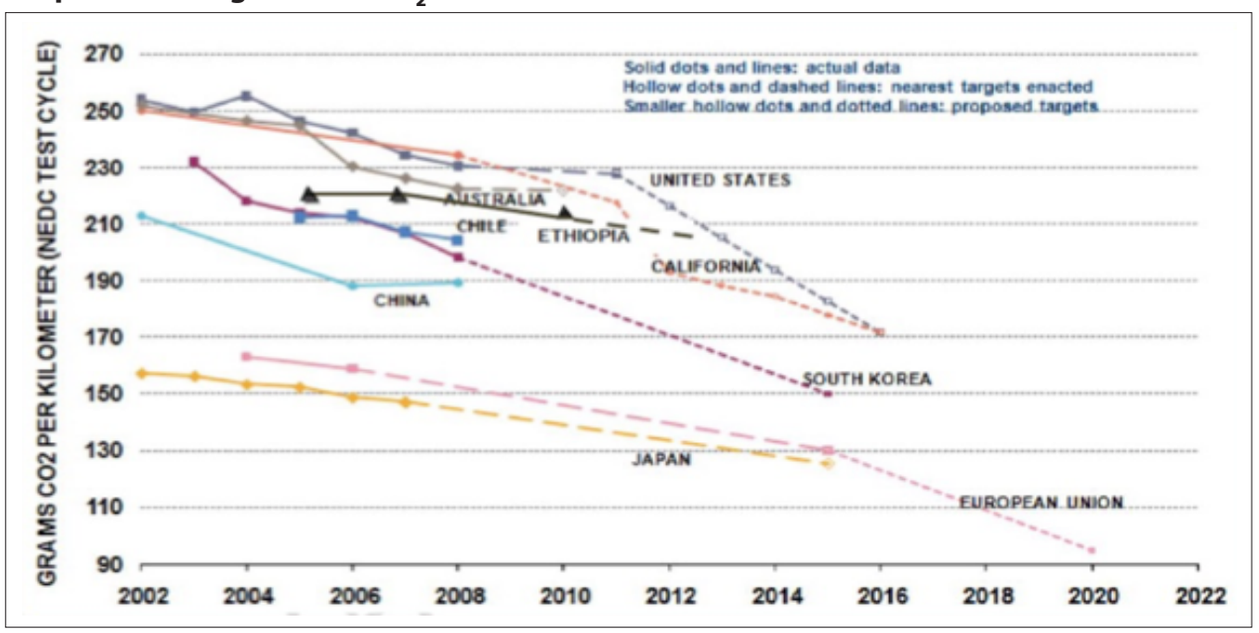


AA CO_2 Vs registration year for petrol LDVs



Source: *Demiss Alemu 2015, Baseline setting for vehicle fuel efficiency improvement and CO2 emissions, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Demcratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.*

Graph 24: Average vehicle CO_2 emissions data



Source: *Demiss Alemu 2015, Baseline setting for vehicle fuel efficiency improvement and CO2 emissions, Paper presented at the Stakeholder Workshop on Air Quality and Transportation Challenges in Ethiopia and Agenda for Clean Air Action Plan, Ministry of Environment and Forest, the Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo*

The country aims to increase the vehicle fuel efficiency by identifying and implementing policy measures. There is a need for fuel economy regulations to guide and benchmark vehicle import and production. It is also important to promote fuel efficient vehicles with fiscal incentive.

Use of alternate fuel to reduce emissions

As the mainstream fuels - diesel and petrol are taking time to improve, several cities in Africa and India have leveraged availability of alternative fuels to run vehicles to cut pollution. Fuel substitution is a unique opportunity in our cities that have natural gas/other alternative fuel to step around the problem of toxic diesel. This is also an important strategy to leapfrog to move forward quickly.

Ethanol blending in Ethiopia: Ethanol is being used as an alternate fuel. The biofuel strategy was issued by the Council of Ministers in September 2007 to produce biofuels from domestic resources to substitute imported petroleum products. Since October 2009, 5 per cent ethanol is being blended with petrol and the ratio has been increased to 10 per cent. While the E5 blending started with one sugar factory and one blender company (Fincha and Nile petroleum), E10 blending started March 2011 with two sugar factories and three blender campaniles (Fincha, Metehara and Nile petroleum, Oil Libya and NOC). These require more than 17 million litres per year of ethanol. More than 44 million litres of ethanol have been blended with petrol. This could save more than 35 million USD. According to an estimate of the Ministry of Water, Irrigation and Energy, Ethiopia has saved around 38.9 million USD over the past six years due to ethanol blending with petrol. Around 50.3 million liters of ethanol was blended with 46.8 million litres of petrol during the same period.[24] It is however not clear the type of vehicles which ply on ethanol.

CNG programme in African and Asian cities

Ethiopia plans to export natural gas in three to five years following discovery of huge reserves in the country's Somali region. According to Ethiopian Mines Minister, Tolossa the country expects to make in excess of USD 1 billion in annual foreign exchange earnings from gas exports. A Chinese company has discovered 4.7 trillion cubic feet of natural gas and that the country will start exporting gas after satisfying local demand. This creates the opportunity to plan an alternative vehicle programme based on compressed natural gas (CNG).

There are important examples of such initiatives in African and Asian region

The launch of the Clean Energy Transport Scheme in major cities across Nigeria has commenced. The scheme involves introduction of CNG run vehicles and retrofitting of diesel engine to CNG. The scheme has Asiko Energy as the lead Partner in the Gas flare down programme introducing CNG to Borno State, Kaduna. Nimco and the PPMC have already started operations in Benin city of Edo State with over 50 per cent of taxi operators converting to CNG. Tata Motors and Tower Group have delivered a new investment package to complement government's Green Entrepreneur Scheme, a scheme that empowers unemployed youths to run only CNG buses on a hire-purchase basis. This drive resulted in significant infrastructure development within and around Benin City. Use of natural gas instead of petrol translated into significant savings for taxi drivers in the area as Green Gas refuels over 4,000 taxis and cars with natural gas and this is growing on a daily basis. In Cairo, Egypt under the regulatory initiative, Traffic Law, owners of mass transport vehicles (e.g. taxis) that are greater than 20 years old are not eligible for operating licenses. This programme was initiated as a voluntary programme in 2009. About 85 per cent of all taxies were 22 years old. Nearly 50,000 taxis were eligible for replacement. Financial incentives were provided to the fleet owners to purchase new vehicles. Old taxies were replaced and scrapped. The new fleet runs on CNG.

Delhi CNG programme: Delhi has implemented one of the largest natural gas vehicle programme. Close to 6,000 buses, 60,000 three-wheelers and substantial numbers of taxis are running on CNG in the city. This has helped to curb the toxic diesel emissions. This had also helped Delhi to stabilise pollution problem. About 40 cities of India have access to CNG and have implemented CNG programme of some scale. But Delhi experience shows that for successful implementation of this programme it is important to set up appropriate emissions and safety regulations, and introduce fuel pricing policy that allows to maintain an effective price differential between CNG and diesel to ensure people prefer to use CNG and not diesel. Policy and regulatory support from the government is needed to launch incentives similar to those of other fuels in the country as well as to speed up the construction of needed fueling infrastructure.

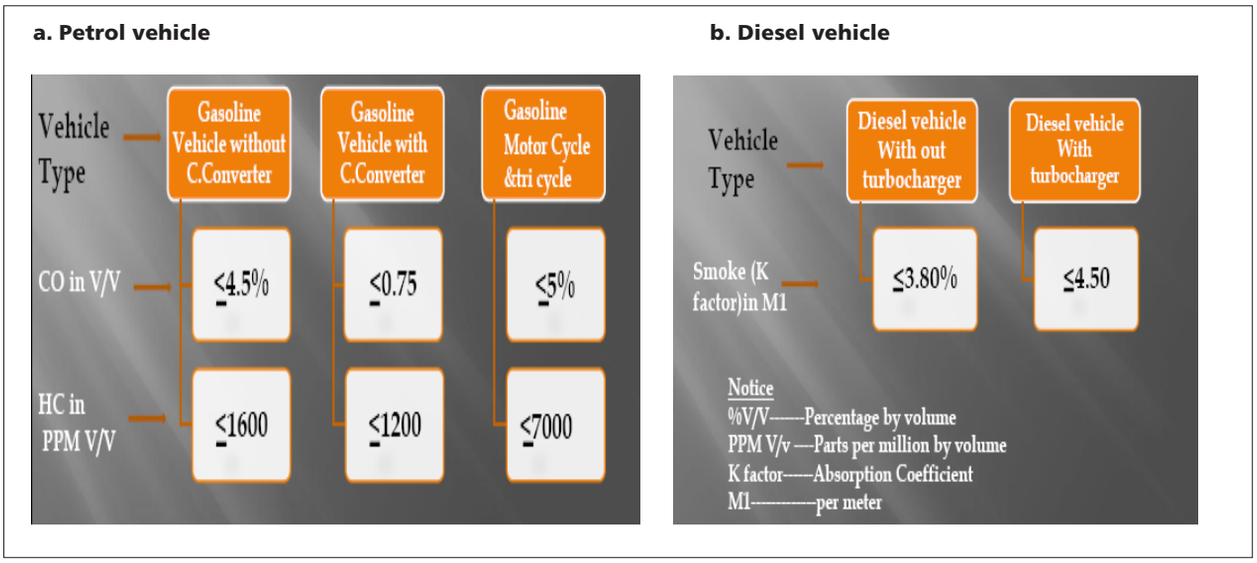
Ethiopia is implementing the ethanol programme. The country needs to assess its impact and develop a future roadmap. As natural gas reserves have been found in Ethiopia, the country can explore the option of CNG vehicles in the future *(see Box: CNG programme in African and Asian cities).*

Vehicle inspection to reduce in-use emissions

Emissions from the on-road vehicle fleet pose a serious pollution challenge. An ageing fleet and poor maintenance can increase emissions much more than vehicles are designed to emit. Sometimes even inbuilt technical defects that go unnoticed can escalate emissions.

Efforts are being made in Ethiopia to organise the vehicle inspection centre to address the problem of in-use emissions. The Road Transport Authority under the Ministry of Infrastructure in Ethiopia is the nodal agency responsible for vehicle inspection. According to the Authority regulations all vehicles are required to undergo annual technical inspection at a designated vehicle inspection centre. Vehicle road worthy test is being conducted along with exhaust emissions measurement against the standard set by the Authority. The standards are subject to revision *(see Figure 2: Inspection stickers)*. Implementation challenges do occur.

Figure 2: Inspection stickers



Source: *Tsehaynesh Tefera undated, reducing Vehicle Emission in Ethiopia*

There are 0.59 million vehicles in Ethiopia. Keeping emissions low during the useful life of the second hand imported vehicles is a challenge and requires stringent emission inspection. In Ethiopia, vehicles are subjected to annual vehicle inspection to address in-use emissions. The country has 40 per cent of cars and two-wheelers. While majority of cars are old, greater than 11 years, two-wheelers are in the age range of 7 to 9 years. Most of the other vehicles like Bajaj, buses, cargo and trailers and other vehicles also fall within 2 to 3 years till 7 to 9 years. Some exceed more than 11 years.

The vehicle age distribution clearly shows that the country has old fleet contributing to emissions. In order to address the in-use emissions issue from these polluting second hand vehicles, it is important that personal vehicles should be subjected to vehicle inspection including emissions testing in every 3 or 6 months. Other vehicles like Bajaj, taxis and mini-taxis should undergo inspection in every six months. Heavy-duty vehicles like buses and trucks should also undergo technical inspection at the inspection centres in six months and an annual fitness test. Grossly polluting vehicles will have to be tackled with good inspection programme and smoky-vehicle checks. Smoky-vehicle inspection based on spot check and on-road surveillance, high penalties and instant removal from the road can make a difference inside the city as well as along various entry points.

Reducing emissions from on-road vehicles

This is a critical strategy in a scenario where the old imported vehicles dominate the vehicle fleet in Africa. While these vehicles emit hugely with age, poor maintenance further worsens their performance. Several vehicles can become gross polluters.

Ethiopia can roll out a new and upgraded programme with several elements in it. This can be phased in from a simple programme to a more complex one later.

Smoky vehicle programme: It is important to catch the visibly polluting smoky vehicles and penalise them. Even volunteers can be trained to spot visibly

Action on trucks in Delhi

Freight traffic operating on diesel also contributes to urban air pollution. It is observed that a considerable portion of freight which passes through a city polluting its air is not destined for the city. In Delhi, series of orders were directed from the Supreme Court to reduce truck pollution. These include banning entry of non-destined trucks from January 15, 2002, no corridor joining different highways should pass through Delhi and directed construction of bypass roads to take non-destined trucks away from the city. All trucks entering Delhi have to pay environment compensation charge (ECC) based on polluter pay principle. The revenue from this charge is to be spent for air pollution control. After implementing this measure, drop in night time pollution in Delhi was observed during 2015-16 winters (see Graph: Impact of action on trucks on night time pollution in Delhi).

Therefore it is important to ensure that all non-destined heavy freight vehicles should bypass the city and should not transit through the urban areas. There should also be a provision of alternative routes/ bypasses around the city so that a heavy goods vehicle which is non-destined for the city can bypass and diverted.

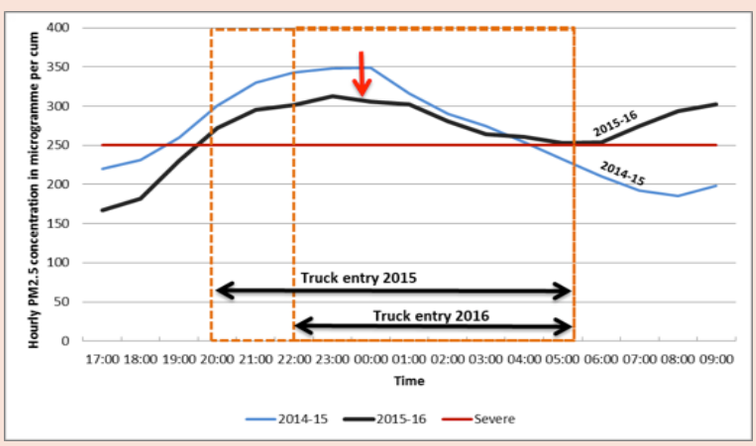
On the basis of polluter pays principle, ECC should be imposed on the goods vehicles entering the city. The ECC collected from them can be utilised for augmenting public transport infrastructure, improving the street design and providing pedestrian and cycling facilities. Improvement in public transport and non-motorised transport modes and infrastructure will reduce dependence on private vehicles, thereby decongesting the city roads.

Installation of Radio-Frequency Identification (RFID) should be made mandatory for goods vehicles and also all other vehicles. The RFID scheme will enable electronic payment and track the heavy-duty vehicles electronically as they pass through the tollbooths. This will help to identify non-destined trucks with greater precision and avoid heavy traffic jams at the major arterial roads as the toll can be collected and transferred to account and a vehicle need not to be stopped at the toll booth and traffic can flow smoothly.

Emissions levels from trucks cannot be lowered effectively if trucks continue to run on outdated technology and highly polluting fuel. Stringent emission standards like Euro-IV should be adopted for trucks.

There is need to install 'weigh in motion brides' at the toll plazas so that overloaded trucks cannot enter as they emit more pollutants.

Graph: Impact of action on trucks on night time pollution in Delhi



Source: *CSE*

polluting vehicles and report. Officials and police can be empowered under law to penalize such vehicles on the spot and send them for repair. This will require effective penalty provision.

Ban or fix age of old vehicles import, set emission standards for imported vehicles and tax older vehicles more: A combination of strategies can work effectively. Ideally, import of used vehicles should be banned or fix the age of imported vehicles. Impose higher taxes on older vehicles, and cap the age of commercial vehicles.

Regulate movement of road based truck traffic through the city: Among vehicle segments trucks pollute the most while passing through cities. Cargo causes

maximum pollution from vehicular sources and technology lag worsens the pollution. Cities therefore need green freight strategies. Do not allow long haul trucks to enter city during day time. Trucks that do not have business in Addis Ababa should not enter the city at all only to pass through. Regulate timing of freight traffic through cities. Trucks that are largely from the old technology vintage emit profusely while moving through the city. Therefore the non-destined trucks should not be allowed to enter in cities. Stringent enforcement should be adopted to check overloading in trucks as it leads to high pollution. Delhi now imposes environment compensation charge on all trucks that enter Delhi daily. From this charge the Delhi government has already raised Rs 100 crore in only three months. This fund is now dedicated and available for only pollution control efforts in the city *(see Box: Action on trucks in Delhi).*

Therefore it is important to ensure that all non-destined heavy freight vehicles should bypass the city and should not transit through the urban areas. There should also be a provision of alternative routes/ bypasses around the city so that a heavy goods vehicle which is non-destined for the city can bypass and diverted.

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There is need to install 'weigh in motion brides' at the toll plazas so that overloaded trucks cannot enter as they emit more pollutants.

Introduce vehicle inspection programme: The programem will have to be appropriately designed based on the profile and age of the vehicles. The annual vehicle insurance should be linked up with the test to ensure compliance. There is a need to set up and expand testing facilities. Norms and testing procedures should be improved especially for diesel vehicles.

Scrappage policy: Ethiopia can consider scrappage policy for commercial vehicles in which very old vehicles are scrapped and the incentives are given to the owner to replace the vehicles with new vehicles. But such a programme should be linked with effectively cleaner emission standards for new vehicles that will replace older vehicles. Import vehicles from countries that have end-of-life regulations for vehicle manufacturers to ensure more than 90 per cent of the material used in vehicles is recyclable. The scrapped vehicle should be replaced only with new vehicle meeting tighter emissions standards and not used vehicles.

On road emission testing in India and Asia: Snapshots

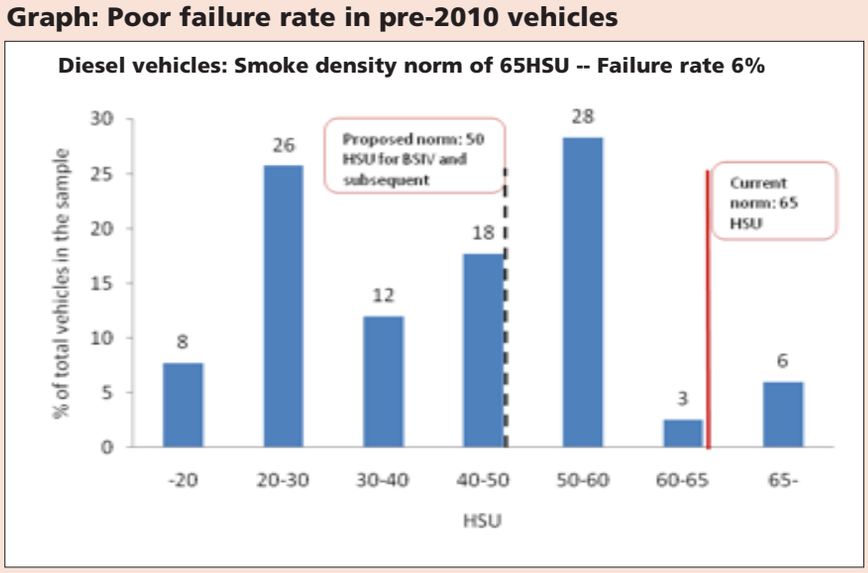
India had started with a nominal and a weak on road testing programme called pollution under control certificate (PUC) in 1992. Originally petrol vehicles were tested for 3 per cent carbon monoxide concentration and diesel vehicles for smoke density (75 HSU). Several challenges exist with this system such as this was designed for carburettor technologies and old diesel vehicles and not effective for advanced emissions control systems; difficult to ensure compliance, authenticity and correctness of tests; challenging to prevent false passes and cheating; standards do not match technology levels; decentralied centres difficult to audit and poor public acceptance of the programme. There were problems with idle CO testing in case of two-wheelers. The reason being large number of two-wheelers pose a challenge; idle CO check was ineffective and vulnerable to cheating; proper extension pipes are not used; chances of leakages leading to inappropriately low readings and carburetor was adjusted to pass the test.

The norms were subsequently revised in 2004. Now cars are tested for both carbon monoxide and hydrocarbons along with lambda (that indicates the optimum condition needed for proper functioning of catalytic converters). Diesel vehicles are tested only for smoke density.

Though the system has improved somewhat for petrol vehicles, that for on-road diesel are particularly too lenient to fail vehicles. Only for the Euro IV compliant diesel vehicles the smoke density norms are 50 HSU. But for Pre-BS-IV vehicles it is as lax as 65 HSU. In case of pre-2010 vehicles, 6 per cent failure rate was observed (see Graph: Poor failure rate in pre-2010 vehicles). In Singapore and Pakistan this norm is 40 HSU; in Indonesia, Thailand, Hong Kong, Malaysia it is 50-HSU for all genre of vehicles.

Indian cities follow a decentralized model of testing. Delhi has more than 500 PUC centres and setting up more. This makes quality control and assurance very difficult. This makes supervision of testing very difficult that can lead to unreliable data and frauds. However, Delhi has taken the lead to link all testing centre to a central server housed in the transport department. The test results are automatically and

Graph: Poor failure rate in pre-2010 vehicles



In several developing country cities there are some rudimentary tests that are available for both diesel and petrol vehicles. But most of them are weak in terms of lax norms, poor enforcement and poor quality test procedures. Periodic inspection is carried out in terms of testing of carbon monoxide and hydrocarbon concentration in the exhaust when petrol vehicles idle. Some countries do only carbon monoxide concentration tests. In diesel vehicles only smoke density test is carried out. These tests and standards will have to be designed after profiling the type of vehicles in the country *(see Box: On road emission testing in India and Asia).*

instantaneously transfer to the server that makes manual manipulation of results difficult. But frauds can still remain a problem. Globally, centralized testing centre capable of carrying out high volume tests, fully automated are preferred as this minimizes the interference. This can also ensure high quality tests. This requires bigger investments.

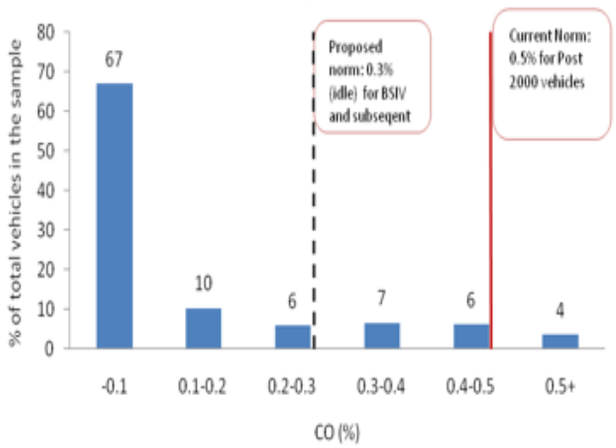
India is now looking at ways to integrate On Board Diagnostic Systems (OBD) in post 2013 vehicles. OBD fitted with vehicles are capable of detecting and recording emissions related malfunction. This can be read with a scanner and appropriate remedial action can be taken. If a problem or malfunction is detected, the OBD II system illuminates a warning light on the vehicle instrument panel to alert the driver. This warning light will typically display the phrase "Check Engine" or "Service Engine Soon," and will often include an engine symbol. The OBD system stores important information about any detected malfunction so that a repair technician can accurately find and fix the problem. Smog Check inspections in USA for post 2000 model vehicles are now primarily based on an inspection of the OBD II system; Tailpipe testing is no longer required. Identifies emission-related components covered under warranty. This eliminates unnecessary repairs; give information about area of malfunction or a specific component; this reduces cost of warranty repairs / customer satisfaction; allows early detection of malfunctions; and prevents malfunctions detect misfire before catalyst damaged etc.

China and Hong Kong have already taken steps to tighten tests and standards for on-road diesel vehicles: The new systems now allow test of on-road diesel vehicles on chassis dynamometer in inspection and maintenance centres (I/M) that can simulate driving conditions on roads. This makes the emissions test more rigorous, China is further developing a nationwide I/M system for evaluating NOX emissions from in-use HDVs.

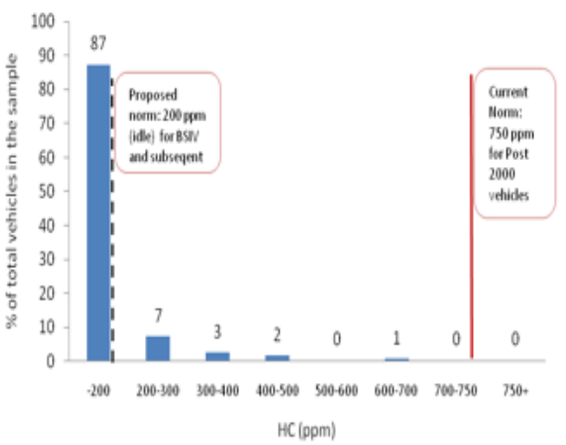
Hong Kong additionally has a strong smoky vehicle programme. People are trained to spot visibly smoking vehicles. These are taken off the road for testing, penalty and repair. This ensures strong vigilance.

Graph: Petrol norms for pre-Bharat Stage IV compliance vehicles cannot make a difference

a. Carbon monoxide for post2000 cars 0.5% (idle) 4% fail, 96% pass



b. Hydrocarbons norms for post 2000 cars 750 ppm (idle) 100 % pass



Such a regulation is difficult to implement in markets that import old and used vehicles. If Ethiopia is promoting assembly of vehicles it can consider early introduction of in-use compliance regulations for new vehicles and limit age for older vehicles *(see Box: Rwanda: Vehicle emissions testing; and Kenya: Vehicle inspection centre).*

Rwanda: Vehicle emissions testing

The Rwanda National Police and Rwanda Environment Management Authority are implementing the vehicle emissions testing programme. All vehicles are subjected to undergo emissions inspection. Norms for roadworthiness and emissions are being implemented. Commercial vehicles have to undergo test every six months and private vehicles every year. Traffic Police can ask for impromptu emissions testing for any grossly polluting vehicle. If a vehicle fails, it is impounded or high monetary penalty is imposed.

Kenya: Vehicle inspection centre

Kenya has 19 vehicle inspection centres across the county including one at Likoni Road, Nairobi. The centre mainly caters to public service vehicles and commercial vehicles -- matatus, buses, tuk-tuks, taxis and trucks come for annual inspection. From January 2015, all private vehicles more than 4 years were to undergo the inspection. At present only visual tests are done. Its basically seen if the vehicles are fitted with a speed governor and are in good mechanical condition. There are plans to do emissions testing. Emissions testing is however limited.

Countries need strong compliance regulations to ensure on-road emissions performance for its useful life on road

As the vehicle fleet is modernizing across the markets another challenge that is surfacing is that on real world emissions performance of vehicles. Even in Europe and the US today vehicles even after meeting the most stringent standards are being found to be emitting several times more than their certification level.

The US has introduced a programme of vehicle recall if vehicles of a particular manufacturer is found emitting more due to manufacturing defect, the manufacturer is asked to recall the entire batch of that vehicle from the customers fix at their cost and return to the customers. This has not been impmeneted anywhere else yet.

In developing countries, there is no system like that in the US etc, to allow testing agencies to select any vehicle, anywhere, and at any time, without prior notice to the manufacturer. These rules are needed for government and manufacturer to remove noncompliant vehicles. Mandatory recall policy for noncompliant vehicles is needed to ensure that manufacturers design vehicles to comply with emission standards for the duration of their useful life.

In fact, China has taken steps to move in this direction. China has recently revised its programs to allow the selection of vehicles at random without any prior notice. Furthermore, COP testing in China is now corroborated through inter-laboratory round-robin testing, which adds an additional level of scrutiny.

There is need for independent authority to check emissions against standards to be set for half life and full life of the vehicles; issue recall of vehicles by companies if they are found non-compliant; levy fines on defaulting companies; and withdraw approval of sale if vehicles do not conform with the stated emissions targets. An independent authority without the influence of the industry should monitor this process. Only such a system will make non-compliance with regulations more expensive for the companies than compliance with regulations and ensure implementation.

CHAPTER 3: Mobility strategies to control air pollution

SECTION 1: Status of the problem

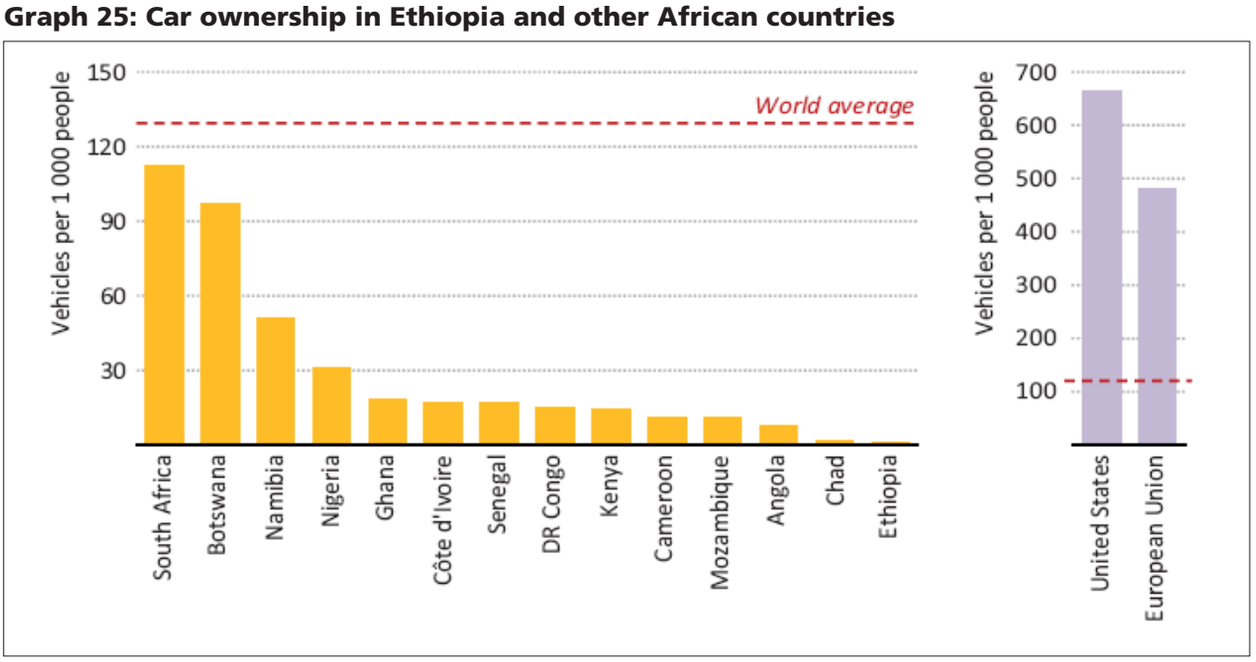
Ethiopia is in early stages of motorization. Overall numbers are still low but growing. Ethiopia has less than 1 million vehicles – about 0.59 million registered vehicles. Personal vehicles, cars and two-wheelers together constitute 20.5 per cent of the registered fleet. There are more cars than two-wheelers. While there are 14.2 per cent cars, two-wheelers are 6.3 per cent of the vehicular fleet. The remaining are buses and mini-buses, three-wheelers and other vehicles.

However, nearly 62 per cent of the country's registered vehicular fleet ply in Addis Ababa alone. Addis Ababa is already in grip of motorization and early action can prevent worsening of pollution and congestion.

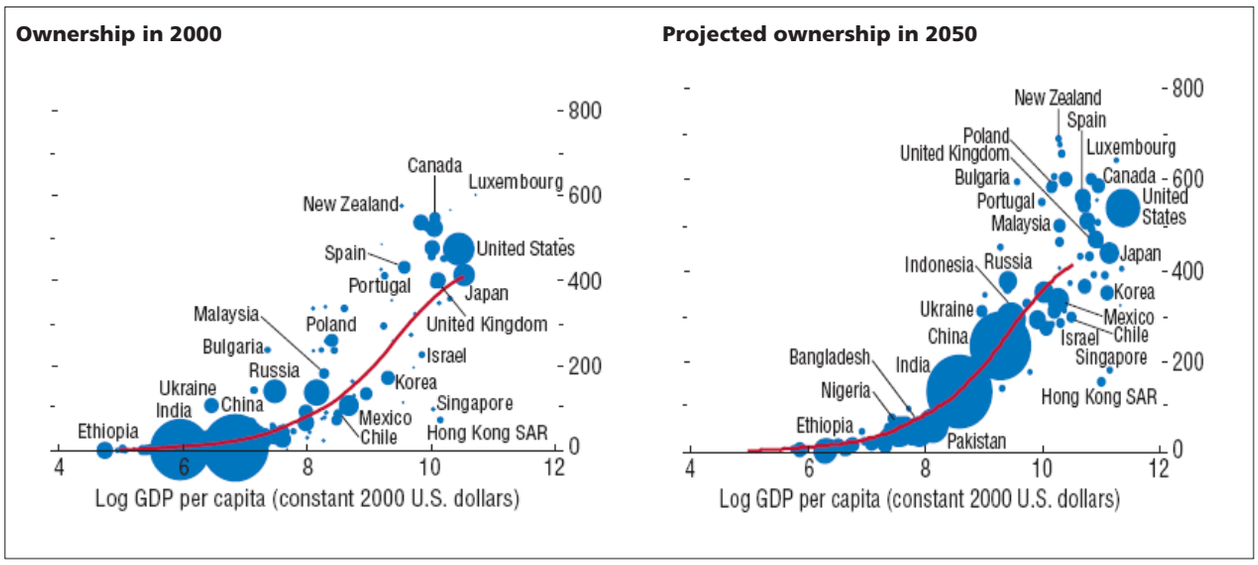
Low car ownership but growing

Car ownership is low in Addis Ababa compared to many other rapid growing developing country cities. It is below 100 vehicles per 1,000 population.[25] In 2012, the motorisation rate was 65 vehicles per 1,000 people.[26] It is expected to increase rapidly due to economic growth and introduction of low cost private cars in the local market. According to 2007 World Bank data, the ratio of vehicles to people in Ethiopia was one of the lowest at 3 vehicles for every 1,000 people, 1 passenger car per 1,000 people and 5 vehicles per km of road. Ethiopia had the lowest vehicle ownership even by Sub Saharan Africa (SSA) standards. Other countries like Sudan, Tanzania and Uganda had 34 vehicles per 1,000 population and 7 vehicles per 1000 population each during the same year. Kenya however had 25 vehicles per 1,000 people in 2011. Though Ethiopia has fewer than 10 cars for every 1,000 people but road traffic deaths are twice as high as in India and seven times higher than in the UK *(see Graph 25: Car ownership in Ethiopia and other African countries).*

Graph 25: Car ownership in Ethiopia and other African countries



Source: *World bank (2014a); country communications; IEA databases and analysis.*

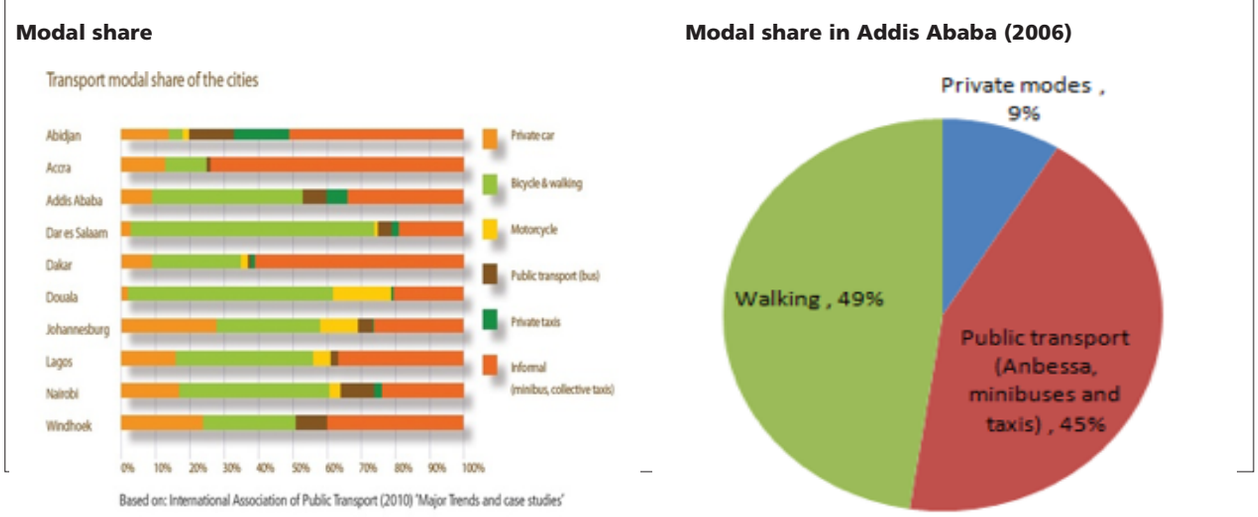


Source: *International Road Federation, World Road Statistics; World Bank, World Development Indicators (2007); and projections from Chamon, Mauro, and Okawa (2008) https://www.imf.org/external/pubs/ft/weo/2008/01/c4/Box4_1_1.pdf as viewed on February 10.*

High walking and public transport modal share

More than one third of the country's population lives in Addis Ababa. Since early 2000, there has been an increase of 4 per cent population every year. According to UN-Habitat forecasts, 10 million people will live in Addis Ababa by 2025.[27] According to a mobility survey in the city majority daily trips are by walking and public transport. Walking constitute 55 per cent of daily trips followed by public transport at 35 per cent. The private vehicles constitute 10 per cent trips.[28] Another data on modal share for 2006 shows 45 per cent modal share for walking followed by public transport at 46 per cent and private modes at 9 per cent.[29] This is the strength and advantage of Addis Ababa that 91 per cent of people walk and use public transport even today *(see Graph 26: Modal share in key cities of Africa and Addis Ababa).*

Graph 26: modal share in key cities of Africa and Addis Ababa



Source: *Anon 2012, Transportation challenges in a booming city, Background paper for CODATU XV, Addis Ababa City government, October 22-26.*

Congestion impacts

Even at the current level of motorization Addis Ababa is already facing serious congestion, high transport costs, and long travel time. The transport policy of Addis Ababa states that high congestion occurs at road intersections and squares.[30] Traffic congestion results in high transport costs and travel time. A study of East-West Corridor shows that on an average about 18,000 veh-min or 38 Veh-day and about 169,000 per-min or 352-person-day are wasted at each major intersection entry. The city incurs cost of about 5-8 million Birr per intersection for vehicle and fuel cost annually. Due to congestion, the average traffic speed is about 10km/hour during peak hours in the city. This reduces overall efficiency of public transport services. On an average, one needs to wait for at least 15 to 25 minutes for a bus or taxi during rush hours. A normal commuting time has increased significantly during peak hours. Cities are paying a very high price for congestion. Traffic jams lead to fuel wastage, more pollution and serious economic losses.

It is important for Addis Ababa to learn from Delhi that more roads and flyovers are not the answer. Delhi has not been able to solve its problem of pollution and congestion by building more roads and flyovers for cars. Delhi is most privileged to have more than 21 per cent of its geographical area under road space. Delhi has built the maximum roads and more than 70 flyovers. Yet its roads are gridlocked. Peak hour traffic has even slumped to below 15 kmph. Cars and two wheelers in Delhi occupy 90 per cent of the road space, though they meet less than 20 per cent of the travel demand.

Cities need to improve the capacity of roads to carry more people by influencing travel choices. Even during peak hours, a car carries only 1.5 persons as opposed to a bus carrying at least 40-50 people. Two cars occupy same space as one bus, but carry 20 times less people. If this trend continues, the capacity of roads to carry more people will reduce drastically. The planning challenge is to improve modes of mass transit and the people-carrying capacity of roads, as per the principle of the National Urban Transport Policy that states 'plan for people, not vehicles'.

Walk, cycle and road safety

Walking and cycling and public transport share still dominates cities in the African region. Compact and closely built cities allow shorter travel distances. The average trip length in most African cities is less than 5 km making cities accessible and walkable. In African cities where a majority of people walk, policies on walking and cycling infrastructure are still nascent. About 4 million trips are generated daily in Addis Ababa. According to the 2005 Urban Transport Study, walking accounts for 60.5 per cent of all trips. These range from 78.4 per cent in Keterna sub city to 39.7 per cent in the Bole sub city.[31] Share of minibuses and city buses in total trips are 20.6 per cent and 10.9 per cent respectively. Cars are 4.7 per cent of all trips[32] *(see Table 8: Income versus modes of travel in Ethiopia).*

Another estimate by the UN-Habitat states that non motorized transport and walking trips constitute 62 per cent of the total daily trips. In Akaki Kaliti and Araba districts, walk trips account for 94.5 per cent and 69.2 per cent respectively. The Urban Transport Study of 2005, states that a 16 hour pedestrian volume count found that there was high pedestrian flows – as much as 23,000 to 79,000 persons. The average motorized trip length is 4.3 km and that of walk

Table 8: Income versus modes of travel in Ethiopia (in per cent)

Birr/month	Upto 300	300-500	500-800	800-1000	1000-2000	2000-4000	>4000
Walk	80	71	61	52	47	30	22
Car	1	1	2	8	9	17	29
Mini bus	10	12	13	10	10	6	8
Bus	8	14	20	25	30	40	40
Others	1	2	4	4	5	7	1
	100	100	100	100	100	100	100

Source: Binyam Bedelu et al 2008, Simplified travel demand modelling for developing cities: The case of Addis Ababa, World Transport Policy and Practice, Eco-Logica Limited, Lancaste, Vol 14, No 2.

is 1.5 km.[33] Even though the city has large share of walking trips, facilities for pedestrians is inadequate. Over 60 per cent of the street network lack footpaths.

According to the Ethiopian Road Authority study of 2005`, the total travel demand generated on an average day in the city is 11.05 million passenger km. Minibuses have the highest travel demand at 34 per cent.[34] Lack of proper infrastructure is leading to more road accidents in the city. Road accidents are increasing at 12 per cent every year.

While sidewalks are normally provided with new infrastructure, they are not scaled to the volume of pedestrian traffic. They are built with poor access to adjacent properties or neighborhoods. Many road facilities in the city are wide, with no signalization, striping, or pedestrian islands, but with long gaps between marked pedestrian crossing points, making pedestrian movement across these difficult.

Transport Policy for Addis Ababa has drawn attention to non motorized transport in the preparation of the master plan and road plan of the city. It has asked for promotion of non motorized modes. The Addis Ababa City Road Authority which is involved in designing, construction and administration of the city roads and also infrastructure for pedestrians such as sidewalks, pedestrian over bridges etc, has begun to make walking and cycling infrastructure. According to the Authority, 20 per cent of the city has road network. This includes 3849 km and 5365 km at 7 metres width. About 2006 km of pedestrian walkways have been provided on different types of roads. The sidewalks have 3 m to 8 m width and accessible height. Many overpasses and underpasses have been constructed on the Ring Road. The city however caters to the car centric infrastructure and has fenced the medians at many places. It is important to give safe crossings at grade.

The city's Local Development Plan aims to "promote cost-effective movement systems" and "accessibility through improving relationships between people, places and activities". At present there are not adequate facilities for cyclists.[35] The city terrain also makes cycling difficult in many areas of the city. Addis Ababa Municipality is involved in 'Share the Road program' with UNHabitat and UNEP. About 2 per cent of the urban road network is provided with cycle lanes. Cycle network is expected to be expanded in the southern part of the city.[36]

All cities need reform in engineering and environmental guidelines for walkways and make their implementation mandatory. Ensure these guidelines are incorporated by all road building agencies. Need a comprehensive Road users act for targeted pedestrianisation; segregation of road space according to users; and penalty to prevent encroachment in pedestrian space. Urban local bodies must implement walkability audits of pedestrian ways. Public transport plans must include pedestrian plan for multimodal integration.

Street design guidelines must give priority to the comfort of the movement of people. Increasingly, cities are trying to remove people from the roads by barricading medians and putting foot over bridges to minimize conflict between people and vehicles. This will be counterproductive. If people cannot cross at frequent distances, or are forced to climb foot over bridge it will discourage walking and public transport usage. A survey in Nairobi has shown that the most common reasons cited for not using the pedestrian crossings and foot bridges were ignorance of traffic regulations (26 per cent), people in hurry (23 per cent) and lack of road safety awareness (11 per cent). Others reasons cited include footbridges that are not strategically placed. But as the experience in India has shown that foot over bridges are very inconvenient for people and this force people to walk on the roads and get exposed to safety risk. People must always remain on surface and be given safe crossings.

Road safety

Urban road design that gives priority to vehicle speed and movement also compromises road safety. This discourages walking and public transport usage and adds to pollution. Africa is said to have high road injury risk. Africa has less than 3 per cent of the world's motor vehicles, but more than 11 per cent of global road fatalities.[37] This can even be more. Nigeria and South Africa have the highest road traffic death rates (33.7 and 31.9/100,000, respectively) and together with the Democratic Republic of Congo, Ethiopia, Kenya, Tanzania and Uganda, account for 64 per cent of all road traffic deaths in the African region.[38] Ethiopia's Ministry of Health was developing a three-year strategic plan to prevent injuries and establish emergency medical services. Ethiopia also had created a national road safety coordinating office, in line with WHO recommendations.

African countries face the problem of under reporting of accident data. According to the WHO, countries in SSA under-report road crashes by over 500 per cent. Reported data in African region is only 7.2 per 100,000 people. But the modelled data shows it is as high as 32.2 per 100,000 people – a five time increase. The 2009 WHO Global Status Report on Road Safety suggested significant under-reporting of the problem. It was found in 2013, India under reported road death estimates by 78 per cent when official estimates were compared with death registry data. Studies in Ethiopia inform about under-reporting of accident data and pedestrians as vulnerable users. *(See Box: Under reporting of road accident data in Africa).*

Pedestrians are most vulnerable: A study done by researchers from Centre for Accident Research and Road Safety, Queensland University of Technology and presented in the Australasian Road Safety Research Policy and Education Conference in 2013 analysed reported crash data of six years (July 2005 - June 2011) consisting of 12,140 fatal and 29,454 injury crashes on the country's road network. The 12,140 fatal crashes involved 1,070 drivers, 5,702 passengers, and 7,770 pedestrians, totalling 14,542 fatalities, an average of 1.2 road user fatalities per crash. It was found that more than half of the fatalities in Ethiopia involve pedestrians. The majority of the crashes occur during daytime hours, involve males, and involve persons in the 18-50 age group. Crashes frequently occur in mid blocks or roadways. The predominant collision between vehicles and pedestrians was a rollover on a road tangent section. Failing to observe the priority of pedestrians and speeding were the major causes of crashes attributed by police. Trucks and minibus taxis were involved in the majority of crashes, while small vehicles were less involved in crashes relative to other vehicle types, partially because small vehicles tend to be driven fewer kilometres

Under-reporting of road accident data in Africa

A study published in PLOS Journal in 2014 by Teferi Abegas and his fellow researchers on one of the busiest highways in Ethiopia, the Addis Ababa – Hawassa highway during June 2012 to May 2013. The police independently reported 224 deaths and 446 injuries/billion vehicle kilometer while hospitals reported 123 deaths and 1,046 injuries/billion vehicle kilometer. Both sources captured 73 deaths and 248 injuries/billion vehicle kilometer in common. Taking the two data sources into consideration, the capture-recapture model estimated the incidence of deaths and injuries ranged 368–390 and 1,869–1,895 per billion vehicle kilometer, respectively. The police source captured 57.4 to 60.9 per cent of deaths and 23.5 to 23.9 per cent of injuries while the hospital sources captured 31.5 to 33.4 per cent of deaths and 55.2 to 56 per cent of injuries. The traffic police also under reported deaths and injuries among females, younger age victims, cyclists/motorcyclists and pedestrians. The study concluded that neither of the two sources independently provided accurate coverage of road traffic incident related deaths and injuries.

Source: Teferi Abegaz et al 2014, Road traffic deaths and injuries are under-reported in Ethiopia: A capture-recapture method, *PLoS,* Vol 9, No 7.

per annum. These data illustrate and justify a high priority to identify and implement effective programs, policies, and countermeasures focused on reducing pedestrian crashes.[39]

The WHO report of April 2014 indicates traffic accidents in Ethiopia account for death of 37.28 persons per 100,000. This places Ethiopia twelfth in the world in traffic accidents having 2.77 per cent of the total deaths in the country caused by traffic accidents. The number of accidents in the Addis Ababa increased from 2,067 in 2010-11 to 2,379 in 2011-12 then to 2,966 in 2012-13 and 3,003 in 2013-14. Data from the Addis Ababa Police Commission (AAPC) indicate 391 deaths occurred during 2013-14, while 1,484 heavy injuries and 1,128 light injuries were sustained. During half-year of 2014-15, there was 224 fatalities.[40] Ethiopia also loses about 65 million USD annually due to traffic accidents.[41] Another assessment of road accidents in Ethiopia highlighted that the country has one of the world's worst accident records 170 fatalities per 10,000 vehicles. On the other hand, the fatality risk per head of population was one of the lowest, at 3 per 100,000 population in 1994-95, due to the low level of motorisation. The accident cost analysis made during the study gave an estimate economic cost of traffic accident between 340-430 million Birr which is 0.8-0.9 per cent of the gross domestic product in 1999. The study further noted the worsening and the likely more severe situation due to under reporting.[42]

The report of the National Road Safety Coordination Office (NRSCO), Ethiopia has recorded the high accident's fatality risk record of 136 deaths per 10,000 vehicles globally in 2001. According to the Transport Research Laboratory, there occurs an economy loss of 350-400 million Birr per annum occurred to the country exchequer due to road accidents.[43] According to a study done by Addis Ababa University, there were 125 major accident black spots in Addis Ababa. Distribution of black spots show 10, 11, 24, 10, 21, 10, 20, 6, 4 and 9 in Kirkos, Bole, Arada, Yeka, Lideta, Nifas-Silk/Lafto, Addis-Ketema, Akaki, Kolfe and Gullele sub-cities respectively.[44] According to the Ethiopian Roads Authority (ERA) 2005, there was on an average a loss of 1,700 lives in road accidents and 7,000 reported injuries every year in Ethiopia. Nearly 42 per cent of all injuries in the country happen in Addis Ababa and over 90 per cent of these injuries involve pedestrians.[45] The actual casualty figure could be double as these figures are only those that are reported to the police. Safe access is needed to promote clean and sustainable modes of transport.

SECTION 2: Agenda for action

Addis Ababa is starting its action with a strong baseline -- majority in Addis Ababa are already using sustainable modes of transport. The objective of the clean air policy will have to be to protect this baseline and improve upon it.

Safe walking and cycling

Walking should be given priority in road design and transport planning. If non-motorised transport is compromised, public transport and last mile connectivity will be undermined. Walking and cycling are also means of zero emission mobility that cities need to cut down the killer pollution. Nearly 45 to 60 per cent of daily commuters walk in Addis Ababa. The right to safe walking and cycling has to be protected and scaled up. Short trip lengths that evolve informally imply that the "corridor" concept is less significant for pedestrians than when planning for vehicles.

Many cities around the world are creating walkable neighbourhoods and fully pedestrian spaces. Copenhagen has done extensive pedestrianisation. So has Kaufingerstrafe in Munich, Nanjing Road in Shanghai, Zurich and Oxford streets. Buenos Aires, Curitiba, Sai Paolo, Shanghai have begun to create car free shopping streets. Studies show pedestrianisation of shopping areas has positive effect on business volume. There is also European Charter for Pedestrian Rights. Cities are also adopting explicit traffic calming measures. More ambitious projects have come up in cities of Europe that are car free housing and car free centres.

Ethiopia needs a non-motorised transport policy emphasizing the need of most vulnerable pedestrians, cyclists and public transport users. The policy needs to include:

- Need legal framework to protect pedestrian rights, protection of pedestrian and cycling infrastructure, pedesrianisation and safe access for all
- Make pedestrian plans mandatory to infrastructure funding
- Reform and mandate guidelines for pedestrian infrastructure to make it people friendly
- Mandate urban local bodies to conduct walkability and safety audits
- Need zero tolerance policy for road accidents
- Involve communities on decisions on use of road space
- Need pedestrian network plan and adopt traffic volume reduction plan

Efficient informal public transport system: Needs regulation and integration

A unique challenge in cities of Africa and Asia is dominant role played by the intermediate public transport system. In many cities their modal share can be as high as 40 to 70 per cent. This indigenously created, operated and organized service is most affordable, reliable, frequent and inclusive service.

Unfortunately, there is very little understanding and appreciation of these systems and often in the name of modernization and formalization of public transport, these services are removed and destroyed. It is not easy to replace this with formal systems like bigger buses and metro rails. If these are curtailed, dependence on personal transport – cars and two-wheelers, will only grow.

These are popular because these systems have flexible routing, wider geographical coverage and connect doorsteps efficiently. They are cost effective

and space efficient. They can flexibly and easily meet the needs of changes in demography and land use. It can cover areas with lower travel demand. Per person emissions are several time less than cars.

These informal public transport modes (white and blue mini buses/vans, matatus, boda bodas, autorickshaws, cycle rickshaws etc) should not be destroyed rather integrated with the overall transport system. These informal modes have a very high throughput of passengers and provide reliable and frequent service during peak and non-peak hours. As these have least number of interchange the cost of travel is lower. Demand for this service will remain strong in cities with high population densities. Being informal they have an image of being chaotic.

These high frequency and low occupancy vehicles are critical for last and first mile connectivity, integration of formal transport, meet the needs of all sections of the income. But these systems can be well organized, regulated and efficiently deployed. There are instances now in the developing region where such systems are being reorganized. In Nairobi for example, matatus or mini buses are the only form of public transport operating in the city and meets nearly 70 per cent of the travel demand. These are very important for last mile connectivity and as feeders to public transport. These systems should be reorganized well to improve efficiency and deployment. In Kenya, matatu operators have been reorganised as cooperatives. Eighty seven cooperatives or Saacos have been formed in Nairobi. Matatu routes were organized into eight major corridors used to codify clear routes and bus stops. This structure was used to develop a coding system based on branching and rotation to give each stop and route a unique, logical identifier. The initiative of Digital Matatus is an important one. This transit data is over the publicly accessible GTFS exchange. In Delhi similar efforts are being made to reorganise the auto rickshaws with GPS systems, permit rationalisation etc to integrate them with the overall transportation system.

In Delhi three-wheeler policy – motorized and non motorized -- is evolving, All three-wheeler drivers are to get public service vehicle badge and smart cards including GPS connectivity to improve the meters and compliance. They are being deployed to integrate with mass transit system. In other African cities operators are being organized as cooperatives and association to organize the system.

In Addis Ababa, minibuses/minivans known as blue donkeys with a capacity of 11 passengers are the lifeline. Around 10,000 minivans ply in the city. These are privately run but operational zones are regulated by the government. They have set zones and destinations. But these tend to choose own routes to avoid traffic. Though these are overcrowded, polluting and known for dangerous driving, yet these are the city's lifeline due to their cheap and affordable fares. These are estimated to carry 60 per cent of passengers. These also move upcountry for example from Addis Ababa to Bahir Dar.

In 2011, an assessment by Ethiopian Institute of Architecture found that transport fares increased much more than household income in the last three years. This has made bus services unaffordable for a large percentage of the population. Bigger formal systems like LRT and BRT will be more expensive and also increase interchange points. However, mini taxis are affordable. Such systems should not be destroyed and need support systems. Congestion will worsen if these are replaced by cars.

Improve intermediate public transport

Regulate informal public transport system: Effort has been made in Addis Ababa to organise this system by making 13 owners' associations based on zoning system in 2011. The number of members in each association varies, with a minimum number of 500. These associations do service route management. This system should be protected and scaled up. The 13 minibus taxi owners associations are being reorganized into two big share companies. Members of the associations will be expected to change their vehicles into midi buses, with a capacity of up to 24 passengers.

Plan deployment of these services as feeder and connect interchange points: There is speculation that minivans might face threat from light rail system. These will be phased out and replaced by larger midi-buses to be feeder to the new LRT. Behailu Sentayehu, AA-LRT project Manager of Ethiopian Railways Corporation (ERC) said, the light rail will only take the passengers along the current corridor under construction. But travel demand on the secondary roads is still huge. Therefore, these modes of transport will be efficiently used in the city.

Organise shuttle services as feeders to formal public transport systems with assured frequency. Assess availability in different zones

Meetings with associations to ensure cooperation, organized operations and prevent over-charging. Organise Dialing- services

Improve technology levels of these vehicles. There is a strong potential of small zero emissions electric vehicles.

Formal public transport system

Buses provide the bulk of public transport services: Cities need well managed, well organised modern buses that deliver efficient public transport services at affordable rates. Buses allow greater flexibility, greater geographical coverage, cost effectiveness, and space efficiency. New bus routings can flexibly and easily meet the needs of changes in demography and land use in cities. A bus occupies twice the road space taken by a car but carries 40 times the number of passengers. Bus can displace anywhere between 5 and 50 other vehicles and allow enormous oil and pollution savings. Poor people are the most dependent on affordable public transport to access jobs and services. Urban poor can use upto 25 to 30 per cent of their income on transportation. Buses minimize interchange and reduce cost of travel. The per person emissions is several time less than cars.

Bus service is still very inadequate. According to the World Bank's Urban Transport Indicators database, the average number of bus seats per thousand urban residents of Latin America, Asia, the Middle East, and Eastern Europe is around 30 – 40. In Africa the average number is only 6 bus seats per thousand residents. The average cost of a one-way trip is about 0.30 $, which is high in relation to the average household budget. These unaffordable fares are clearly linked to poor people's decision to walk.

However, bus reforms and investments are just not about buying new buses but about efficient deployment of reliable and attractive services. Cities require immediate improvement in service level of bus service in terms of frequency,

reliability, coverage, reliable information, ITS enabled passenger information service, improvement in ticketing system, bus priority, signaling, GPS enabled deployment strategy, among others. These service conditions will have to be fulfilled. This will also determine the costs. Buses will play a crucial role in the mobility transition in the big and medium rung cities.

Public transport system in Addis Ababa: The Addis Ababa City Roads Authority is taking action to construct overpasses at Gofa Mazoria, CMC Michael, Imperial and Bole Micheal. The design for the Gofa Mozoria has been completed and preparations are underway to start construction on the CMC Michael project. The design preparation for the remaining locations will be completed soon. Overpasses connected with the Addis Ababa Light Rail Project are nearing completion at Megenagna, Lem Hotel, Zerihun Bld., Wuha Limat, Urael and Buna Ena Shay are expected to significantly reduce traffic congestion in the city.

The public transport system consists of Anbessa City Bus (red and yellow buses owned by the government), midi-bus and mini-bus taxis carrying 2.2 million passengers per day. The mini-bus taxis have the largest fleet size of 10,500 and 73 per cent modal share followed by 750 Anbessa buses with 19 per cent modal share and 439 midi-bus (Higer) with 8 per cent modal share *(see Table 2: Modal share of public transport modes).*

Table 2: Modal share of public transport modes

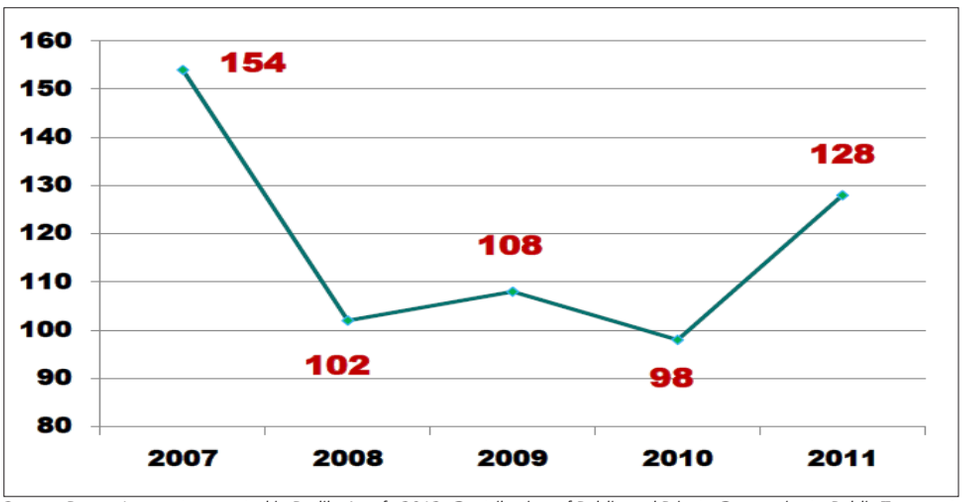
Public transport mode	Seating capacity	Fleet size	Passenger carried daily	Share %
Minis bus taxi	11	10.500	1.6 million	73
Midi bus (higher)	25	439	180,000	8
Anbessa bus	100	750	420,000	19
Total	-	-	2.2 million	100

Source: *Bureau's report presented in Bedilu Assefa 2012, Contribution of Public and Private Companies to Public Transport Growth The Case of Anbessa City Bus Company, CODATU, Addis Ababa, October 25*

Amongst these, Anbessa is the formal public transport mode and operates as a company. The fleet size of 759 buses consists of 300 old DAF buses and 459 new buses. The buses operate for 13 hours in two shifts. While 70 per cent of the services offered are standard scheduled, special premium account for 20 per cent and the rest 10 per cent as feeder services. Around 415 buses operate on 104 routes from 4 terminals. An average of 1.1 million trips is made by buses every year. About 8 per cent of the trip connects the sub-urban commuters to the city. The daily ridership is about 400,000 commuters. The daily kilometer run for the scheduled service is about 48,589. The bus ridership has declined by 17 per cent from 2007 to 2011. Since 2010, there is an increase in the ridership. About 65 per cent of the buses are assembled in the country. Anbessa, at present is running as a loss making enterprise. Reforms are needed to revive the enterprise and make it profitable *(see Graph 27: Anbessa bus transport ridership (million).*

In October 2015 the Anbessa City Bus Service Enterprise planned to offer 2.6 million shuttle travel transport service with 773 buses. It has planned to launch eight new service routes. The World Bank has allocated 18 million USD for the enterprise to build modern transport information technology and additional depots. The enterprise has also planned to collect 50 million Birr from advertisement, maintenance service and others. The enterprise would

Graph 27: Anbessa bus transport ridership (million)



Source: *Bureau's report presented in Bedilu Assefa 2012, Contribution of Public and Private Companies to Public Transport Growth The Case of Anbessa City Bus Company, CODATU, Addis Ababa, October 25*

work in collaboration with stakeholders to curb corruption in bus transport services *(Box: Anbessa City Bus Service: Low operational performance)*

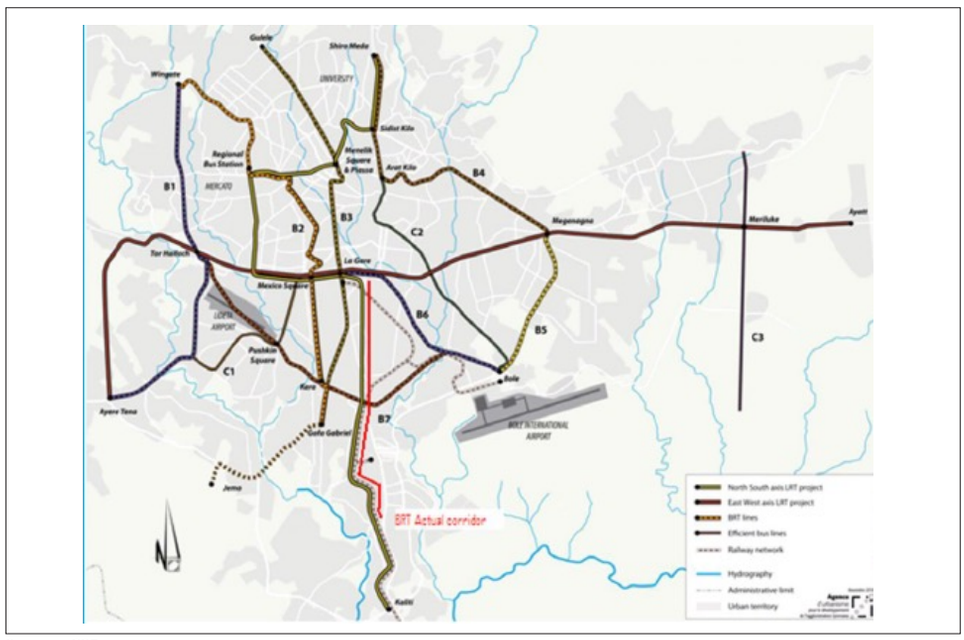
According to the World Bank, the current public transport modes and services are not integrated in terms of network coverage/routes, fares, schedules and facilities. The two main passenger transport modes, Anbessa bus and the independently operated mini-bus-taxis are somewhat weak in planning, organisation, operation, productivity and quality. There is no integrated passenger transport agency within Addis Ababa Road and Transport Bureau to effectively manage comprehensive network design responding to public needs. Various transport service associations in Ethiopia are about to import 500 buses in order to ease the ever increasing high demand of the public transport in the capital. The Ministry of Transport recently adopted a plan to reform public transport and invest in mass rapid transit solutions. The Ministry aims to implement a network of seven BRT corridors, as well as two LRT routes in the next few years.

Anbessa City Bus Service: Low operational performance

A study done by the Addis Ababa Institute of Technology assessed the existing operational and financial performance of the Anbessa City Bus Service Enterprise (ACBSE). The ACBSE has significantly low operational performance in almost all the evaluated parameters as compared to standards. The average fleet utilisation was 50.53 per cent. As compared to standard of 70 per cent, ACBSE has very low operational performance with regards to its fleet utilization but has improved with slight fluctuation. The load factor in some months though was close to 73.86 per cent showing fair improvement on the average bus loadings, but was still low as compared to the standard, between 80 to 90 per cent with mean of 85 per cent. The ACBSE consumed an average of 58.36 litres of fuel in every 100 km it covered.

The overall performance indicates high fuel consumption per 100 km. The ACBSE is running on loss with consistent losses ranging from 3.852 to 22.42 million Birr with average losses of 10.42 million Birr. The operations show that the total costs even before taxes consistently exceeded total revenues (mainly from passenger fares or traffic revenues). Though there are many new buses in the enterprise, the operational fleet includes many more than 10 year old buses, which adversely affect the performance with regard to fuel consumption and distance covered. Moreover, the cost to revenue ratio is less than one mostly even after excluding the depreciation cost, indicating that the enterprise is operating at a loss even before tax.

Map: Proposed transit lines in Addis Ababa



Source: *CSE*

The two LRT lines will include 32 km with 32 stations, and 10 will be hub stations. One LRT line was launched in September 2015. The LRT project costing USD 470 million is the first amongst Sub-Saharan Africa. The One BRT line of around 12 km is in the planning stage with a further six possible lines identified. Based on preliminary assumptions about the future BRT system, the ICCT's modeling of city-wide pollutant emissions, fuel consumption, health impacts, and time saved suggest that a BRT system in Addis Ababa will result in considerable overall benefits in the range of $41 to $45 million per year in 2035.

It is important that NMT infrastructure and improvements are also done along with the public transport. As per the public transport development strategy for Addis Ababa (2012-2022), the city will have a multimodal public transport system (taxi, mini bus, Higer bus, Anbessa, BRT, LRT) in the near future *(see Map: Proposed transit lines in Addis Ababa).*

The 2002 City Development Plan (CDP) provided a long-term vision of the city's future development based on a mass transit backbone. The 2006 transportation master plan focused on this. The revision aimed to correct the weaknesses of the former master plan (1986) and build on its strengths. The revised CDP has planning principles such as the organisation of mass transit system for a city of more than 10 million inhabitants in the long run; create mass transit links along the backbone connecting the CBD and the main centre to the sub-centres; transform the city into a polycentric metropolis to reduce congestion of the centre and Mercato; adopt "mixed land use" except for heavy industrial areas and freight areas; develop urban design along the avenues, in open public spaces and in the districts for a better quality of life and image to attract investors among others.

The Transport System Plan for Addis Ababa – 2020 follows the CDP and is designed to develop a policy framework to cover integrated planning, system management, public mass transport system development including technology, resource mobilization and institutional reforms; develop a structured arterial road network (outer ring road, ring road, city radial/axial routes, alternative

corridor); public mass transport system development; upgrading of Anbessa Bus Service; introduction of BRT/LRT system along major corridors; promotion of mini bus taxi services; development of city bus terminals (including mini buses) in all sub-centres proposed in the CDP; development of La Gare as a multi-modal, integrated, passenger terminal; recommendation for pedestrian facilities; transport system management including an immediate improvement plan for the east-west corridor (closure of median openings, pedestrian management and safety) and a traffic management plan for the Mercato area and strengthening of institutional framework.

The first evaluation of the master plan by Lyon Town Planning Agency and Mathewos Consult in 2010 concluded that CDP has introduced a new paradigm, by providing shared, clear guidelines for Addis Ababa and by influencing the planning processes of Ethiopian urban centres. The degree of implementation during the last eight years has varied from rather good (transportation, housing) to rather weak (centrality, market hierarchy).

Second assessment was done by Ethiopian Institute of Architecture in 2011. It stated, 'The implementation process of the CDP had somehow failed to either interpret the full meaning of the strategic concept and/or to apply it completely and consistently. The LDP's lack of integration is mainly due to a sectoral approach to the issue and poor critical understanding of space and developments factors. The current huge number of LDP's cancels de facto the idea of strategic planning that needs to focus on a few main objectives.' On transportation, it further observes, extensive road network development has been carried out in Addis Ababa; transport fares have increased much more than household income in the last three years making the services unaffordable to large population; lack of coordination between the different public transport services providers, Anbessa, minibuses etc; concentration of public transportation on a few major roads chosen for their profitability and routes considered to be unprofitable suffered from poor levels of service; need traffic management unit, particularly during the implementation phase. The Bureau of Road Transportation was set up for this purpose in 2011 *(see Box: Policy initiatives on transport).*

Policy initiatives on transport

- **Transport policy:** The transport policy has outlined eleven key policy issues and implementation strategies. These include integration of landuse and transport plan; expansion of transport infrastructure; enhance transport service provision; ensure traffic safety; employ integrated and modern traffic management system; improve environmental protection and energy use; focus on social issues; strengthen financial capacity; capacity building and coordination of transport services providing institutions; equipping with the necessary legal framework and establish regional and international partnership.
- **Climate Resilient Green Economy (CRGE):** Ethiopia has adopted the CRGE and aim to be carbon neutral by 2025. It was estimated that in business as usual scenario, vehicle emissions will increase from 5 million tonnes CO2 in 2010 to 41 million tonnes CO2 in 2030. The CRGE strategy in the transportation sector aim to reduce demand of passenger cars in Addis Ababa by a light rail transit system and a BRT; improving vehicle fuel efficiency by setting fuel efficiency standards; promoting clean fuels by blending ethanol with gasoline with biodiesel; adopting hybrid and plug-in electric vehicles and shifting freight transport from road to an electric rail network.
- **Global Fuel Economy Initiative (GFEI):** As part of the GFEI, Ethiopia aims to improve new car fuel efficiency by 30 per cent by 2020 and 50 per cent by 2030 in a cost effective way. The measures include improvement of conventional vehicle technologies, dissemination of new vehicle technologies by creating a conducive environment; hybrid electric vehicles and electric vehicles; creating awareness to change driving habit; and reducing traffic congestion.

Improve and scale up public transport and last mile connectivity

Addis Ababa needs to revive and improve the Anbessa bus transport system. The bus fleet needs augmentation. Bus route and service improvement plan are needed to increase coverage and frequency of quality bus service. The buses should be GPS enabled for tracking and monitoring of operations. Integrate all modes to enable seamless and easy transfer of commuters with effective last mile connectivity. This should be implemented in a time bound manner.

Need bus transport augmentation plan to maximise bus fleet utilization and increase services.

Augment bus fleet and bus infrastructure: Need bus fleet augmentation and bus depot and terminal infrastructure with proper maintenance and repair facilities. Buses will require clean technology benchmark.

Improve fleet utilization. Put maximum number of buses into service. This would require preventive maintenance and repairs. Breakdown of buses should be minimised

Improve bus load factor

Ensure service level guarantee and compliance by the fleet operators: Regularity and frequency of bus service during peak hours must be assessed and improved.

Need proper planning to reduce wasted kilometers and cancelled trips. This will require a good network of bus depots and terminals.

Need route rationalization: Ensure all neighbourhoods are served efficiently. Identify routes with high load factor to intensify services. These routes would have high existing demand as well as latent demand. Identification of such trips will help to increase bus trips and frequency on these routes. Add new bus routes.

Identify routes to introduce stratified services with premium and express bus services with higher ticket charges. Introduced with limited stops to attract the new demand

Need IT based good monitoring of bus operations: On a regular basis monitor average speed of buses, average headway of buses, number of passenger trips per bus and cycle time, number of hours and miles per bus. Use the ITS based traffic monitoring system. Share the data with the public to demonstrate the effectiveness of the system. Buses to be monitored at designated bus stops for route timetable and to check missing trips or delayed trips and to take action.

Adopt bus fare policy to keep it affordable for the majority.

Improve overall economic efficiency of bus transport. Reduce/eliminate tax load on buses.

Advance and common ticketing to reduce the load on conductors during the peak hours and also to avoid slow down monthly bus passes can be sold through.

Identify road networks to establish bus rapid transit system to provide dedicated right of way to the buses so that they can move seamlessly to improve journey speed and time for the bus commuters. Buses caught in congestion can become very unattractive. Adopt robust design principles for BRT system and operations.

Public outreach and public information systems on bus service

Integrate all formal public transport systems for convenient interchange. Design public transport network in a way that it minimises the need for interchange. Otherwise public transport becomes unattractive and more expensive. All transport systems including buses, BRT, LRT, informal and intermediate public transport systems and walkways should be integrated. Well designed and safe pedestrian facilities should be expanded to support public transport. The interchange points of LRT, BRT and bus stations need to be planned and executed carefully for easy transfers and access. A common ticketing should also be adopted for seamless transfers.

CHAPTER 4: Reduce vehicle miles travelled to control air pollution

SECTION 1: Status of problem

Car restraint measures are needed to reduce crippling congestion and pollution. Only improving public transport system will not help. Personal vehicle owners need to pay the full environmental, health and social damages that they inflict. The existing policies allow hidden subsidies to cars as the use of urban space for parking and roads and health damages, pollution and other social impacts are not recovered through taxes and road pricing. Reversal of such policies has already begun in other countries. Singapore actually demonstrates that how beginning early with traffic restraint measures, even before the mass transit systems were in place, can effectively cap the car boom.

Vehicle taxation policy and parking policy as demand management tool are the critical approaches to restrain use of personal vehicles to achieve clean air. But use of fiscal instrument is still very nascent in developing country. But this will have to evolve quickly as it has enormous potential to change behavior while augmenting the revenue for the local government that can be spent on personal vehicles.

Restraint measures are very important to control the number of cars. All efforts to improve emission levels of vehicles and scale up public transport can be negated if car restraint strategies are not in place. Globally, cities are implementing restraint measures to control the number of cars.

An uncontrolled increase in the number of cars is not sustainable as is evident from the experience of Chinese cities including Beijing, Guangzhou and Shanghai. It may be noted that in Beijing after the car sales exploded to reach an annual sales figure of 8,00,000 cars in 2010, the Chinese government clamped down to cap the number of car sales that can be sold in a year. Cars are now offered on lottery to prospective buyers. The cap started with 2,40,000 cars a year, that is just 30 per cent of actual car sales in 2010. But the actual demand, as is evident from the numbers applying to buy cars, stands at a staggering 15,15,449 a year. Beijing cannot sustain that kind of growth. Cities also need to learn from this.

Two critical restraint strategies have been outlined here as the first generation vehicle restraint measures that Ethiopia can explore and develop. These include i) vehicle taxation measure and ii) Parking policy as a demand management measure. These strategies can be quickly deployed and is within the technical and institutional capacity of the city governments. These strategies will have to be deliberately and directly linked with clean air action plan.

Fiscal measures - Vehicle taxation as a restraint measure

It is ironical that across developing regions – India and several African countries, buses are made to pay more taxes than cars. Almost all state governments in India tax the buses higher than cars. This will have to be reversed. Currently bus operations are treated as commercial operations and taxed high. Buses bear high tax burden than cars and two-wheelers. But cars will have to be taxed higher than buses *(see Box: In developing country cities public transport pays more taxes than cars).* But Ethiopia is an exception and a good practice.

In developing country cities public transport pays more taxes than cars

This practice of taxing the public transport buses more than personal vehicles creates distortions and wrong incentives that defeat the purpose of clean air action.

In Delhi cars a pay a miniscule amount of one time road tax when they are purchased. But buses are made to pay much higher taxes annually. If lifetime tax is amortised then car pays roughly Rs 300 per year. But buses pay about Rs 13,000 per year – 43 times more than cars. Thus, penalised for carrying more passengers. This also leads to increase in bus fares. If bus fares are raised, a substantial public transport ridership can be lost to two-wheelers with running cost of just Rs. 1/km. For example -- Delhi with nearly the highest per capita income and car pays the lowest taxes.

In Kenya vehicles have to pay a varied range of taxes when they are imported. But minibuses up to 29 seater have to pay all taxes as applicable on cars. Buses more than 30 seater and above are required to pay import duty and VAT like cars. This should be rationalised. Public transport services are for public good and should pay lower taxes. Cars are unsustainable modes and should pay higher taxes. If bus fares increases people will move to motorcycles that have much lower operational costs than even the bus fares. This will aggravate the problem of motorisation and pollution.

Therefore, cities need to correct distorted taxes to lower the tax burden on public transport, offset the revenue loss with higher taxes on personal vehicles, and use innovative taxation policies to influence commuting choices and generate additional revenues for urban transport funds. Motorists should pay the full external costs that include congestion, pollution, ill health, and climate change. This can bring additional revenue to pay for the alternatives like public transport, walking and cycling infrastructure. Very few cities have taken green fiscal steps to tax the bad and fund the good. The principles of correcting taxes, applying polluters-pay and users-pay principles, or using innovative fiscal mechanisms are not yet the mainstream policy. A few small and tentative steps in cities only indicate the direction and potential for change.

Progressive vehicle taxation and exemption/ low tax on public transport in Ethiopia: Ethiopia has set a good example of lowering taxes on public transport and imposing higher taxes on personal vehicles. Cars are treated as luxury goods and pay more taxes. This is a good practice among the developing countries. However, there is no distinction between new and second hand vehicles. Public transport type vehicles (diesel/semi-d) with seat capacity greater than or equal to 15 passengers pay a duty rate of 10 per cent which is three times less than cars, no excise and sur tax is charged, however, there is VAT charge of 15 per cent. But compared to cars the tax structure for public transport sets a good example.

In Ethiopia, unless exempted by law, a car is liable to five different taxes imposed by the Ethiopian Revenue and Customs Authority (ERCA). These include customs duty, excise tax, VAT, surtax and withholding tax. High capacity passenger vehicles are exempted from paying excise tax. Vehicles with a seating capacity greater than 15 passengers, including the driver, are charged 10 per cent customs duty and no excise tax. Vehicles with a seating capacity greater than 10 but less than 15 passengers, including the driver, are charged 35 per cent customs duty and no excise tax. Vehicles with a seating capacity of less than 10 passengers are charged customs duty as well as other taxes including excise tax.

The excise tax to be levied depends on the engine capacity of the vehicle. Higher excise tax on bigger vehicles. Vehicles with 1,000 to 1,300 cc engine capacity,

1,300 to 1,800 cc engine capacity and exceeding 1,800 cc engine capacity are liable to pay 30 per cent, 60 per cent and 100 per cent of excise tax. Vehicles are subject to high import taxes and duties. Vehicles up to 1,500 cc incur 70 per cent of value declared by Customs. Vehicles exceeding 1,500cc incur taxes up to 96 per cent of value declared by Customs *(see Table 9: Vehicle taxation in Ethiopia).*

Table 9: Vehicle taxation in Ethiopia

S. No.	Vehicle category	Taxes
1.	Vehicles with spark–ignition engine capacity of 1,000-1,300 cc	Duty rate: 35% Excise tax: 30% VAT: 15% Sur tax: 10% Withholding tax: 3%
2.	Vehicles with spark–ignition engine of capacity of 1,300-1,800 cc	Duty rate: 35% Excise tax: 60% VAT: 15% Sur tax: 10% Withholding tax: 3%
3.	Vehicles with spark–ignition engine of capacity greater than 3,000 cc	Duty rate: 35% Excise tax: 100% VAT: 15% Sur tax: 10% Withholding tax: 3%
4.	Diesel vehicles with capacity not exceeding 1,300 cc	Duty rate: 35% Excise tax: 30% VAT: 15% Sur tax: 10% Withholding tax: 3%
5.	Diesel vehicles with capacity of 1,300-1,500 cc	Duty rate: 35% Excise tax: 60% VAT: 15% Sur tax: 10% Withholding tax: 3%
6.	Vehicles for the transport of goods	Duty rate: 10% Excise tax: 0% VAT: 15% Sur tax: 0% Withholding tax: 3%
7.	Public transport type vehicles (diesel/semi-d) seat capacity greater than or equal to 15 passengers	Duty rate: 10% Excise tax: 0% VAT: 15% Sur tax: 0% Withholding tax: 3%

Source: *Customs Proclamation, No. 622/2009, Council of Ministers Regulation No. 133/2007, Ethiopian Revenue and Customs Authority Database, http://www.2merkato.com/articles/customs/69-customs-duty-tariff-and-taxes-in-ethiopia as viewed on September 1.*

We need to understand the implication of the new fee scheme that says that vehicles with up to five seats will be charged an annual fee of 125 Birr, while mini buses used as taxis, with up to 12 seats will pay 150 Birr annually. Higer buses, with 27 seats will be charged 200 Birr. While the minimum fee is 125 Birr, there is a maximum fee of 800 Birr for vehicles with over 44 seats (see Box: Vehicle licence renewal fees imposed for road development).

Vehicle licence renewal fees imposed for road development

A new regulation has been approved by the Council of Ministers for vehicle licence renewal fees to be collected across the country starting from this fiscal year. Known as Axle Load Based Annual Vehicle's Licence Renewal Fee, it will be levied annually on any vehicle on the basis of its loading capacity or on the number of seats.

- Vehicles with up to five seats will be charged an annual fee of 125 Birr, while mini buses used as taxis, with up to 12 seats will pay 150 Birr annually. Higer buses, with 27 seats will be charged 200 Birr. While the minimum fee is 125 Birr, there is a maximum fee of 800 Br for vehicles with over 44 seats.
- The renewal fee for freight trucks starts from 300 Birr for vehicles with a loading capacity of 15qt, while those with capacities of 180qt will pay 2,500 Birr. A minimum 750 Birr fee is levied on fuel or liquid loading trucks with up to 10,000 lt (long ton) loading capacity with the maximum fee reaching 2,000 Birr for above 14,000 lt loading capacity.
- Motorcycles and off-road operating vehicles will also make an annual payment of 50 Birr and 300 Birr respectively.

The Federal Transport Authority will oversee the collection of the license renewal fee, which will be collected along with the annual technical inspection and registration. Sixty five per cent of the total fund is to be disbursed to Ethiopian Roads Authority while regional rural roads authorities get 25 per cent from the fund and the rest is distributed among city's roads agencies. The Road Fund Office is expected to collect a total amount up to 150 million Birr from vehicle's license renewal fee this year.

SECTION 2: Agenda for action

Design fiscal policy to accelerate change to achieve clean air

Globally it is accepted that motorists need to pay for the costs they impose on the society. Policies must recover these costs based on polluter pay principle, which will not only restrain the bad choices, but also generate additional income for pollution control and other welfare measures.

Differentiated taxes on imported used cars and diesel vehicles vis a vis new car and vis a vis petrol cars: Though Ethiopia imposes engine capacity wise taxes on vehicles the taxes are similar for both polluting second hand vehicles and also new vehicles. It is important to differentiate between a clean vehicle and a polluting vehicle and therefore high taxes need to be imposed on polluting second hand vehicles with high emissions. All second hand vehicles should be required to pay additional taxes as compared to their counterparts. Green tax/ levy can be imposed on old polluting vehicles. Polluting diesel cars should also be subjected to pay additional taxes. Diesel vehicles both old and new should be subjected to pay environment compensation charge. This will disincentivise people from buying old, fuel inefficient and dirty fueled vehicles.

Impose higher taxes on cars than on buses: Public transport is for public good and should not be taxed. It should not be treated as commercial enterprise. Minimise tax burden on public transport and offset this with higher taxes on cars and two-wheelers.

Create urban transport fund through innovative fiscal strategies: Public transport improvement cannot sustained only through fare box collection and advertisement. Tap revenue from other revenue heads such as parking revenue, vehicle taxation, etc to create dedicated urban transport fund that can be further invested in public transport and pollution control measures. The revenue heads can also include non-conventional funding sources like higher property taxes along the transit line where there is land value gain etc.

Parking policy as a travel demand management measure to reduce air pollution

Nearly all cities have some rudimentary parking policy to bring order in the chaos that parked cars create. These are currently oriented towards supplying more and more parking spaces to meet the infinite demand for parking from the ever increasing vehicle numbers. But global experience shows that parking policy can also designed as a demand management tool to restrain demand for parking as well as use of personal vehicles.

Parking is a wasteful use of cars. A car is parked for about 90 to 95 per cent of the time. Parking generates insatiable demand for land and involves iniquitous use of land. The same expensive land earmarked and utilised for parking can be used for other social and public amenities. An example from Delhi shows how much valuable space is being wasted for parking, which is huge loss to households. A 100 sqm plot built to the full allowable FAR (315 sq m) needs 161 sq m of parking space by law more than half. If provided in the built up area it will gobble up one and half storey or space of 4 EWS dwellings of 40 sqm each. Parking also takes away walkspace from pedestrians and as a result, urban common, green spaces and walkways are at risk.

Globally, the governments are adopting measures to restrain use of cars. This is being done either through tax policies, road pricing or parking policy. The first generation restraint measures include parking policy as a demand management tool reduce parking demand and also use of personal cars. This is easier to implement in developing cities.

Conventional parking policies in most of our cities have aimed at increasing parking provisions to meet the growing demand for parking by earmarking as much public land as possible; by constructing multi-level car parks; and by mandating all buildings to provide minimum parking spaces. The underlying assumption has been that demand for parking will continue to grow with motorisation and therefore the local governments should set aside adequate parking spaces to meet this demand. But this policy assumption is now under attack. Decades of experience across the world has shown that parking demand is insatiable that only locks up valuable urban land that have more important usages. Moreover, uncontrolled parking supply incites more driving, more car ownership and defeats the purpose of reducing automobile dependence, pollution and congestion. This has led to serious policy rethink.

Parking policy can be redesigned in such a way that instead of encouraging unlimited parking supply and car usage it can be leveraged to restrain parking demand and thereby personal vehicle usage. But there is very little policy or public understanding of the key elements and principles of parking policy that can make it a tool for reducing parking demand and car usage to cut decongestion and pollution in cities. The key principles for parking policy as a travel demand strategy include parking district management plan; parking management and enforcement framework; paying for parking and variable parking pricing to reduce parking demand and parking strategy in areas with good public transport connectivity (transit oriented areas).

Unlimited parking supply lead to more automobile dependence and congestion. This increases pressure on public land. For as much as 95 per cent of the vehicle lifetime these vehicles remain parked somewhere. This creates enormous demand for urban land which is limited, valuable and is needed for more important usage. Depending on the size of the cities and rate of motorisation the annual demand for additional parking spaces can be equivalent to as much as 310 football fields in Delhi.

Indian cities are also framing several strategies. These include variable and increased parking pricing; parking district management plan, no car without proof of parking; barring parking on green areas etc.

Parking demand in Addis Ababa

The number of vehicles that are registered in Addis Ababa has created demand for land areas as big as 110 football fields. On-street parking is rampant in the city and contributes to congestion. The transport policy states, ‘There is lack of off-street parking facilities and over utilisation of on-road parking. The Government shall encourage the private sector partnership to develop parking facilities and enhance their participation in transport service provision.’ Cheap and free parking is a subsidy to rich car owners and loss to the local government exchequer. The costs of using valuable urban land for parking of personal vehicles are not recovered through proper taxes and pricing. Parking rates even in expensive parking structures are minimal and are not adequate to recover the cost of investment. This is a subsidy. This subsidy amount will

work out to be much larger if the rental or the land cost is taken into account. Increased investment in expensive and prime areas of the city further enhances this subsidy as the parking rates are not expected to recover this cost.

Parking pricing in Addis Ababa

Addis Ababa has taken the lead to introduce priced and variable parking to reduce demand for parking and car usage. The Addis Ababa Municipality manages parking in the city. Parking charge is in accordance with a specific pricing structure for each zone (0,5 to 1 Birr for one hour). According to a study parking charge is directly related to the vehicle size and duration of stay in Addis Ababa. The parking charges vary from Birr 0.6 to 9.2 depending on the vehicle size and parking duration.

Parking infrastructure

The thrust is towards creating parking infrastructure. Aimed at addressing the increasing traffic congestion and parking problem in Addis Ababa, 20 multi-

Principles for parking policy

- Adopt flexible parking standards and move towards maximum caps to account for improved public transport access and reduction in personal vehicle travel.
- Take area approach towards parking management – off-street and on-street
- Stringent controls and enforcement
- Reforms parking pricing for good management -- Minimise free parking, restrict on-street parking, use variable parking rates, avoid fixed annual payment, price parity between surface and multi-level parking etc. Discard one time parking charge
- Integrate parking design with multi-modal integration; Parking strategy for buses, IPT, freight
- No parking on green spaces, pavement, NMT lanes etc. Non-negotiable.
- Need parking strategy for residential areas and mixed land use areas. Promote priced, shared, common parking
- Use parking revenue for local area development, public transport; Stringent penalty on parking violations.
- Develop parking strategy for special localities like hospitals, railway station, cinemas, shopping malls, schools, high impact events etc
- EIA of large commercial buildings to assess parking impacts and seek mitigation

Global cities are capping the parking requirement: Setting maximum limits

- Shifting from minimum requirement to maximum/caps
- Flexible standards: For example In Hong Kong parking provision is decided based on accessibility of an area. In Tokyo parking norms in CBD lower than Delhi
- Rigid norms can create over capacity: Account for improved accessibility to limit future expansion and reduce parking demand
- Sites may change from parking deficit to parking surplus. The parking plans must account for the changes in parking demand with improvement in public transport. For example, -- In Connaught Place parking demand dropped by 10 per cent after introduction of metro.
- The feasibility study for Mangalam Place projects shift in modal split in favour of public transport after metro. The Delhi Metro Rail Corporation study shows that in Vikas Marg metro can reduce the trips of different modes. That will indirectly impact upon parking demand.
- Opt for common and shared parking. Discourage individual – private parking

story parking garages are to be constructed in the capital. The Addis Ababa Transport Bureau (AATB) is to build the first of six smart parking facilities with an outlay of 80 million Birr, in Kirkos District near the Palace Commercial Centre, at the junction of Menelik II Avenue and Zewditu St, across from the Menelik II Palace, the Prime Minister's residence and office. This will be part of 48 parking facilities which the Bureau is planning to erect as part of the Addis Ababa and Oromia Integrated Master Plan, Addis Ababa and Surrounding Oromia Integrated Development Plan (AASOID). Eight of these, called 'park-and-ride', will be dedicated to parking services alone, each resting on two hectares with a capacity of holding 2,604 vehicles at a time. Six of the remaining 40 will be smart parking. The smart parking facilities will be different in that the vehicles

Global best practice: Countries implementing parking as a car restraint measure

Capping parking supply

- **Boston** has frozen parking requirements at 10 per cent higher than the 1973 levels. This has helped Boston to meet the federal clean air standards.
- **Portland, Oregon** set an overall cap of 40,000 parking spaces downtown. This increased public transport usage from 20-25 per cent in the 1970s to 48 per cent in mid 1990s.
- **Seattle** allows a maximum of one parking space per 100 square metres of downtown office space.
- **San Francisco** limits parking to seven per cent of a downtown building's floor area
- **Zurich** considers total NO2 emissions when determining the amount of parking to be allowed.

Parking pricing strategy to reduce car usage. Benefits public transport

- **New York:** Very high parking fees and limited parking supply have lowered car ownership far below the average rates in other US cities.
- **Bogota:** Removed limit on the fees charged by private parking companies. The additional revenue goes to road maintenance and public transit service improvement.
- **Shenzhen:** Hike in parking fees during peak hours leads to 30 per cent drop in the parking demand.
- **Bremen:** No free parking in city centre. Parking charges higher than public transport cost.
- **Barcelona:** Parking revenue directed to a special fund for mobility purposes.
- **London**: parking income channeled to transportation projects.
- **Amsterdam:** Parking fees expanded to meet EU directives regarding NO2 and PM10 emissions standards. Car plate numbers are registered with emissions information. Trucks are allowed to unload for a maximum of 15 minutes in spots where they are not allowed to park.

Strong enforcement and penalty

- **Tokyo:** Enforcement against parking violations cuts congestion drastically. Private firms allowed to issue tickets for parking violations. This makes on-street parking expensive.
- **Antwerp:** parking fines are invested into mobility projects

Free up public space

- **Paris:** Street space freed for bike sharing and trams
- **Copenhagen:** Streets freed up for bike lanes etc

Restraining cars ownership and usage

- **Japan -** proof of parking regulations and ban on night parking on streets: Vehicle owner procures a "garage certificate" from the Police department for vehicle registration. This is re-issued in case of change of ownership or address.
- **Singapore and Hong Kong** have stringent approaches towards restraining car ownership and usage. Hong Kong has been more effective in restraining car ownership – about 60 cars per 1000 people vs 110 cars per 1000 people in Singapore. Singapore has three times more private car kilometres of travel per person than Hong Kong, which has more expensive parking.

Cashless parking pricing in Nairobi

The Nairobi City County manages parking in the capital city of 0.5 million registered vehicles. The County is responsible for regulating on-street and off-street parking, parking enforcement, imposing fines, revenue collection and developing parking standards for new development. However, it does not control residential parking once built and the ones that it does not own or run.

On-street parking in Nairobi

Majority of the parking lots are in the central business district (CBD). Of the total 14,864 parking lots, 26.5 per cent are on-street, 25.8 per cent are off-street and 47.7 per cent are in buildings. In terms of utilisation, on-street parking is utilised to a great extent around 140 per cent followed by 95 per cent off-street parking. However parking lots in buildings are under utilised (only 50 per cent). The city has variable priced pricing. While cars have to pay 300 KSh for an entire day in an on-street parking, in off-street, one has to pay 50 KSh for entry and thereafter 30 KSh for every 30 minutes The per hour parking charge is around 12.5 KSh for on-street parking and 110 KSh for off-street parking. The County should rather increase the on-street parking pricing. According to a JICA study on effect of increasing parking fee, increase of on-street parking fee would make car users shift from on-street parking to usage of building parking and also more than 50 per cent of private car users would change their transport mode.

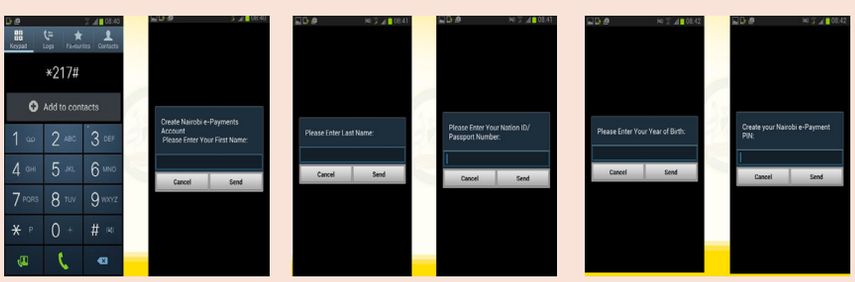


Illustration: Wallet creation

In 2014, the County initiated a pilot project of cashless parking pricing system. This was aimed to increase the parking revenue as well as overcome the challenges of inadequate parking facilities, poor enforcement and manual records of revenue collection being practiced in the County. Christine Adongo Ogut, Chief Officer, Roads, Public Works and Transport, Nairobi City County explained, 'The County thought of initiating the cashless system as there was a growing demand for improved service delivery, monitoring and evaluation of revenue collection by zone and performance of parking attendants and culture of non-payment. The other challenges include inability to realize the due revenue collection, lack of adequate revenue collection and enforcement personnel. Parking attendants also reported late to work; absenteeism and shortages in revenue collected etc.'

How does it work?

The cashless parking payment system is very simple. It does not involve paper parking tickets, rather payment is done through phone. It allows the motorist to create an electronic wallet for the County from where County services can be paid. Money to transact can be loaded from other channels e.g. Visa Card, Master Card, Mpesa, available registered agents (such as banks). Three key steps for the electronic payment include wallet creation, wallet top up and the payment.

Electronic wallet can be created (see Illustration: Wallet creation). The next step is to load wallet with money. Money to transact is loaded from other channels e.g. Visa Card, Master Card, MPESA, available registered agents (banks). As the County has many services

to pay for the wallet provides a menu for each available services. To top up from MPESA, one has to go to MPESA menu, enter the paybill number, the mobile number of the user is to be entered as the account number and indicate the amount and click ok.

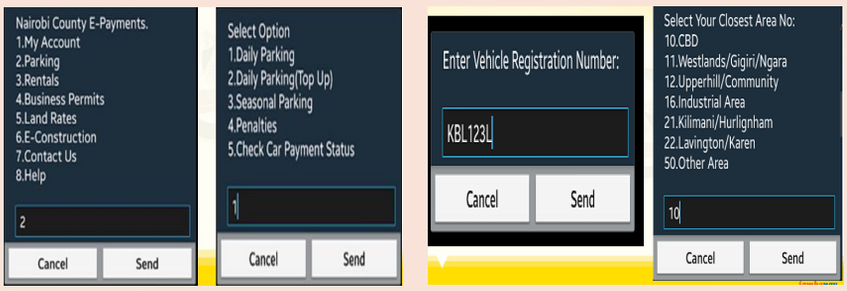


Illustration: Wallet transaction

MPESA transfers money to the wallet and a notification from the County is received about receipt of money in the wallet. The wallet is now ready for the payment. The wallet can be accessed through the mobile phone by dialling *217# which gives a USSD menu below.

Once payment is done, an enforcement application is used where the enforcement officer keys in the vehicle registration number and confirms about the payment. In case of non-payment, the registration number is forwarded to the clamping team with the location of the vehicle to be clamped manually. The vehicle is also clamped on the system to ensure the penalty is charged to the customer. According to a County official, people who do not pay for parking, their cars are clamped and a penalty of 2000 KSh is charged which is to be paid within 2 hours of clamping the vehicle. Thereafter, the car is towed and impounded for which the car owner has to shell out 2500 KSh for towing and 3500 KSh for impounding.

This system in the initial stage was not favoured by the cars owners/drivers. They were skeptical about it use and convenience. According to the County, this system has many benefits. The customer's time is saved as they do not need to look for the attendant to pay for parking. The transaction process is easy and convenient as one can pay the parking fee remotely. The system is also secure as there is no involvement of cash in the payment process. In addition, the management gets to know about the revenue collection in real-time. The County officials are of the view that it is not difficult to come up with innovations and use technology, the challenge is to get user acceptance and behavioral change.

Source: Christine A Ogut 2015, Cashless priced parking in Nairobi, Paper presented at Conclave of Champion Cities, Centre for Science and Environment, New Delhi, April 9, mimeo.

Residential parking

Residential parking planning and management is often neglected in our cities. Parking can be unbundled from property and sold separately. This will allow sharing and more efficient usage of available spaces and its management as public facility. True cost of parking should be charged from owners and tenants. Residential parking permits are an option.

Several benefits for the residents include assured parking spaces in the neighbourhood; pricing allows equitable sharing of local parking spaces - one car owner versus 5 car owner; will control multiple car ownership as permits will limit their numbers; people by deciding not to buy multiple cars can save on permit fee, which incentivises lower car ownership and will also prevent invasion and encroachment from neighbouring colonies.

Proof of parking before registration of car is allowed in Sikkim and Mizoram in India

- **Sikkim:** Sikkim transport department notification makes it mandatory for buyers to produce an availability-of-parking-space certificate before registering vehicles. The superintendent of police issues certificates after physical verification of the parking space. This is followed by an inspection by motor vehicles inspector, who submits details to the transport department along with a rough map of the site. Car dealers cannot sell cars without the proof of parking.
- **Aizawl:** According to the Mizoram Gazette notification in 2010 the vehicle owner must obtain a certificate from the ….transport department saying he has a garage, within his own residential or business compound or in some other place, or a garage to hire from other person, for parking the vehicle he intends to purchase.

will be lifted by elevators, which will place them in parking spots. These will be entirely assembled from imported parts and are expected to be completed in the 2015/16 fiscal year. The remaining parking lots will be eight storey high with the top four used for parking, and those below for offices and commercial purposes. The construction, which will take place on 2,200 sqm of land which the bureau received in March 2015, is based on a design that is being developed at Addis Ababa University. The design is expected to be completed in April.

Normally developers need to provide one parking space per large apartment, one parking space per 5 moderately-sized apartments, one parking space per 10 small apartments, and 1 parking spot for every 70 square metre of commercial space provided. But these standards are poorly enforced. It is often found that there is non-compliance or the parking space is used for other purposes.[46]

According to a World Bank report, parking is identified as one of the key infrastructural challenges in the transport policy of Addis Ababa. The nature of the problem as identified in that document is essentially that there is not enough off-street parking, and too much on-street parking. Under the critical issues in the transport sector in the policy, lack of off-street parking facilities and over utilization of road space by parked vehicles is high on the list of infrastructure issues. The issue of parking – especially the overutilization of road space by parked vehicles, lack of off-street parking facilities, and the need to create and incentivize the use of park-and-ride facilities related to mass transit services – is indeed an important area of concern for sustainable transport policy.

However, this phenomenon is better understood as a market failure, rather than as a problem of infrastructure. While there are instances when developers flout the law and do not provide the necessary off-street parking or illegally convert parking to other uses, the main issue is that parking in general is not appropriately recognized as a commodity and regulated as such. Integrating transport with land-use development has also proven to be very difficult in Addis Ababa. There is only a very weak off-street parking requirement that is required of the land-development process. Parking can be a useful tool to help shape streets as the building blocks of neighborhoods. The preparation of a city-wide parking strategy and implementation of measures such as priority paid parking schemes and strengthening enforcement actions are needed.

Addis Ababa and other cities of Ethiopia should come up with a parking policy as a car restraint measure. Parking pricing is already being implemented in Addis Ababa at some locations. Free parking should be eliminated and instead high and variable parking charges should be imposed in all public and commercial areas. Residential permits with fees can be introduced in residential areas. Good parking pricing trigger many commuting decisions as commuters tend to combine trips, avoid peak time, share car with family members and colleagues, look for cheaper parking areas off-street, take a taxi, just walk or cycle, take metro or a bus especially in case of long term parker. It also influences parking duration and purpose of parking.

Manage the available parking well before looking for more areas for parking. This needs judicious use of on-street parking. This can lower demand for land for expensive off-site parking which is scarce. Off-street needs more space for access and this adversely affects walkways and open areas. Entry exit from high capacity parking structured adds to local traffic circulation and congestion. International experience shows that efficient management and proper utilisation of legal parking lots can increase parking capacity by at least 20-40 per cent.

Parking management

Parking management

Poor parking management worsens parking chaos: Poor management leads to chaotic parking stress on roadside but many off-street parking areas remain underutilised. Mostly uncontrolled parking supply except in some designated areas and yet parking shortage. Large share of private residential parking remains underutilised. Poor management of parking queues, lack of design for enforcement. No survey and inventory on available parking spaces in an area. Spillover from commercial areas on residential streets is inevitable but requires management; resident participation. Through traffic vs search traffic. Huge search traffic contributes to congestion. Need design solutions. Green areas, footpaths, common areas vulnerable night parking.

Upgrade parking management: The agreement with the parking contractors would need technical upgrades. A protocol is needed for contract and competitive tendering and should include the following:

- Set management rules
- Signages and pricing meters and mode of payments like the smart cards
- IT systems for information and enforcement; prevent illegal parking that can compromise safety
- Facilities to clamp or tow away vehicles
- Parking monitoring
- Parking data collection and analysis for policy feed back
- Street design and management of queues
- Street reconstruction services
- Carry out proper surveys to know the expected revenue.
- Link parking pricing with linked with parking management goals. The co-benefit is revenue and local area development

A complete street management is needed for good parking management. Streets have to accommodate many street uses such as pedestrian traffic, hawking, bus stops, other street services, parking, loading and unloading, stops for para transit and rop off and pick up for schools.

Deepen public awareness about the benefits of parking management and restraint

Parking management benefits all – car users, non-car users, urban local bodies etc. Additional benefits include public health and climate benefits. Reduced dependence on cars reduces air pollution, GHG emissions, congestion, noise level and fuel loss. Public support for parking tool that restrains car usage can be stronger if people understand the benefits of parking management.

Car user will benefit:

- Reliable and predictable information about parking availability reduce cruising time, fuel cost and pollution
- Efficient billing makes payment more transparent and accurate
- Chances of finding a space improves and reduces waiting time
- Decreases traffic chaos due to indiscriminate on-street parking
-

Non-car user will benefit:

- Protects footpaths and allow barrier free walking
- Frees up public spaces for cycle tracks, rickshaw parking, autoriskshaw-parking, play grounds etc
- Improves access to bus-stops, metro stations
- Improves safety of children, women and elderly people
- Improves visibility of shops, shopping experience and throughput of customers
- Improve overall environment, green areas and public recreational spaces
- Makes it easier for emergency vehicles like ambulances, fire trucks, police, etc. to negotiate

Urban local bodies to benefit: Public revenue generation for transportation projects

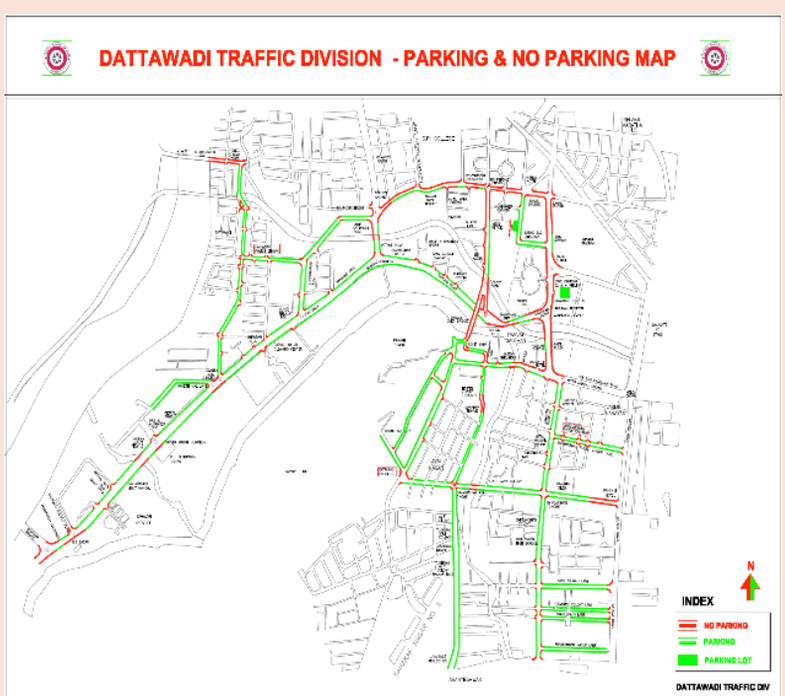
Global awareness campaigns on parking regulations

- **Downtown Pasadena, California Redevelopment:** Parking Meter Zone (PMZ) dedicated revenue from parking to area improvements included new street furniture and landscaping, police patrols, street lighting, more street and sidewalk cleaning, pedestrian facility improvements, and marketing. Each parking meter had a sticker saying, 'Your Meter Money Will Make A Difference: Signage, Lighting, Benches, Paving.'
- **Ventura, California Municipality introduced a byelaw:** "All moneys collected from parking pay stations, and meters shall be placed in a special fund, devoted to purposes within the parking district. This encouraged the residents to support.
- **Aspen, Colorado Downtown parking Pricing:** Marketing campaign to let motorists know about the meters and parking violation. This reduced parking problems and was supported in a municipal election by a 3-to-1 margin.
- **City of Regina, Canada Parking Awareness Campaign** to help residents avoid getting parking tickets. Linked parking management to public safety – for example violation if parking is too close to a fire hydrant or parking too close to an intersection blocking sight lines. This built public support.

Enforcement: Tame the chaos

A example from Pune, Pimpri Chinchwad, Maharashtra on parking enforcement details out the following:

- **Map out high and low demand area**
- **Open up underutilised off street parking for public parking**
- **If managed well on-street can meet most of the demand**
- **Demarcate legal parking spaces. Organise them well.**
- **Inventorise the parking spaces. Put out the list on the website**
- **Prevent encroachment of walkways**
- **Put up signages and information systems**
- **Introduce metering**
- **Impose penalty**
- **Move motorists to low demand streets during peak time to address spill over**



Parking should be banned along pavements, green areas and neighbourhood parks. Encroached pavements should be made free from parking with proper enforcement. Parking area-management plans will be very useful to plan and implement legal parking, ban and penalise illegal parking and rationalise on-street and offstreet parking. There should be parking provisions for public transport and commercial vehicles. Delhi is not being able to buy buses because of lack of parking and depot space. Facilities for bicycle parking should also be planned.

In Delhi for example, parking district management plan is included in Delhi Master Plan and needs implementation. Parking is also prohibited in green areas and play ground. In other cities such as Aizawl, Gangtok and cities of Rajasthan, a car cannot be bought without submitting proof of parking.

Ethiopian cities therefore need to develop parking district plans to limit legal parking areas, demarcate legal on-street parking, impose high penalty on illegal parking, enforce high and variable parking charges, promote park and ride in LRT stations and planned BRT corridors, promote park and walk in pedestrianised areas and ban on parking in green areas and walkways. The policy should address all the three key aspects – parking pricing, parking management and enforcement.

Another caution for cities is not to treat off site multilevel parking structure in isolation. These should be constructed only if these are needed as part of the overall parking district plan and in areas near public transport stations. Example from Delhi shows that an expensive multilevel car parking created in a busy commercial area remains underutilized as these are not integrated with the larger surface area parking management. Integrate multilevel parking with local area parking planning to reclaim public land and create pedestrian plaza. Parked cars adversely affect the shopping experience. One parking slot of shop owner can be used by 7-9 shoppers in a day leading to higher volume of business. Globally, customers agree to pay high parking charges if they get good shopping and pedestrian environment. This increases parking turnover as well. With integrated local area planning more open spaces can be freed up and reduce congestion.

Step forward on parking: Develop parking district management plan

Enforcement and management in public spaces

Prepare parking district plans. Demarcate and organize legal parking in different zones: Inventorise the available legal parking spaces on road and off-road. Demarcate authorized parking sites on ground.

Delimit and cap legal parking areas

Implement variable parking rates as a demand management system

Enforce strict action against illegal parking and impose high penalty. Protect pavements from parking. Enforce strict penalty for violation of parking regulations and walkway encroachment

Develop integrated management for both on-road and off-road. The same management can efficiently price and deploy parking as it is available over an area.

Set up public information system to inform people about availability of parking. As people are approaching through ITS they can know in advance if parking is available and where. This reduces cruising time and pollution.

Introduce metering in all parking spaces.

Introduce park and walk and park and ride in prominent commercial areas: People can do remote parking in the closest metro/BRT stations and take feeders/cycles. For long term parkers like the shop keepers create remote parking and provide feeders.

All parking facilities should be public, shared and priced

Design parking for multimodal integration – park and ride

No parking in green areas

Parking pricing in public spaces

Parking rates should be market driven. Introduce variable parking rates according to landuse categories.

High penalty should be imposed for illegal parking.

Variable parking rates in commercial areas according to peak and non-peak hours (price should be variable by the hour so that it changes behavior); duration of stay; commercial importance of areas; according to weekdays when demand is high, and weekends and holidays when low. Lower parking charges for park and ride on LRT or BRT; for park and walk; and remote parking can be cheaper in the heart of the city.

Introduce residential priced parking permit for using public spaces in residential areas for parking. A monthly fee can be paid for this. This is also needed to control multiple car ownership

Free parking should be allowed only to bicycles and battery operated vehicles and public transport buses.

Stop the current practice of paying one time lump sum payment for parking: This allows unlimited use and do not reduce demand. Commuter behaviour will remain unresponsive and will not shift to other modes and reduce car travel.

Along with legal parking enforcement also introduce proof of parking policy. People would need to show proof of parking for purchase of vehicles.

Meet the parking needs of public transport buses, non-motorised transport and freight..

Improve parking revenue. This can augment revenue of the urban local body for the local area improvement. This will also help to build public support for these initiatives.

CHAPTER 5: Other key sources of air pollution in cities

There are several other sources of air pollution that need to be controlled to meet clean air goals and reduce exposure in cities. These include air polluting industries, power plants, generator sets, open burning, road and construction dust and use of solid fuels for household cooking to devise strategies for each one of them.

Action agenda for air polluting industries

Air pollution from air polluting industries needs to be controlled. There are air polluting industrial hubs including industries like cement, electroplating, petrochemical and fertilizers around Addis Ababa and in other parts of the country. Though emission standards for industry have been notified, next steps are important.

Step up action on monitoring and compliance mechanism; adopt siting policy to have polluting industry away from densely populated areas; ensure stack monitoring; industry should also be liable to monitor and report data to the government based on continuous emissions monitoring system. Strengthen environment impact assessment procedures and implementation.

Power plants

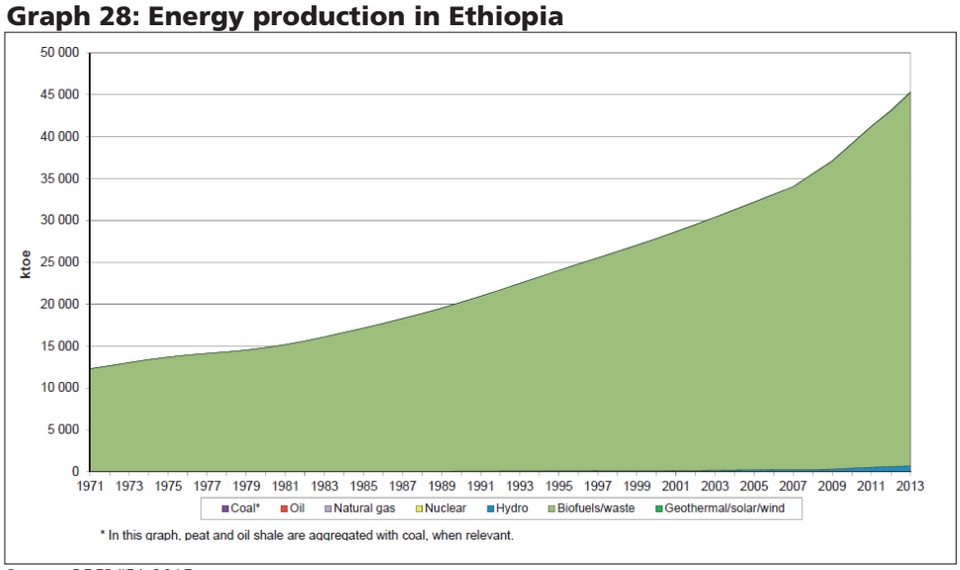
Coal based thermal power plants are not a very big concern in Ethiopia due to their small numbers. However, measures need to be taken to combat pollution from the existing thermal power plants. The country generates a large portion of the electricity from hydropower. The energy policy lays emphasis on hydropower resource development and encourages energy mix with renewable such as solar, wind and geothermal based on their cost competitiveness. 9.9 per cent of the installed electricity generating capacity (2.061 million KW in 2010) is from fossil fuel and 89.7 per cent is from hydropower and the rest 0.4 per cent from various renewable sources. Ethiopia is also building Africa's largest hydroelectric and geothermal plants. These plants will triple the country's power production.

According to the five-year Growth and Transformation Plan, Ethiopia's installed electricity generating capacity was expected to reach 10,000 MW by the end of 2014-15 with 75 per cent electricity coverage of the country. Hydropower constitutes a major share in the total energy mix (92.5 per cent) and the thermal energy 7 per cent. As of 2014, Ethiopia had 2,000 MW of installed power generating capacity of which 99 per cent is generated from hydropower plants. The rest 0.6 per cent and 0.4 per cent is contributed from thermal and geothermal sources respectively. According to reports, Ethiopia has focused more on large hydropower but small hydropower, solar and wind potential are yet to be developed. (See Graph 28: Energy production in Ethiopia ad Graph 29: Electricity generation by fuel in Ethiopia).

Action agenda for power plants

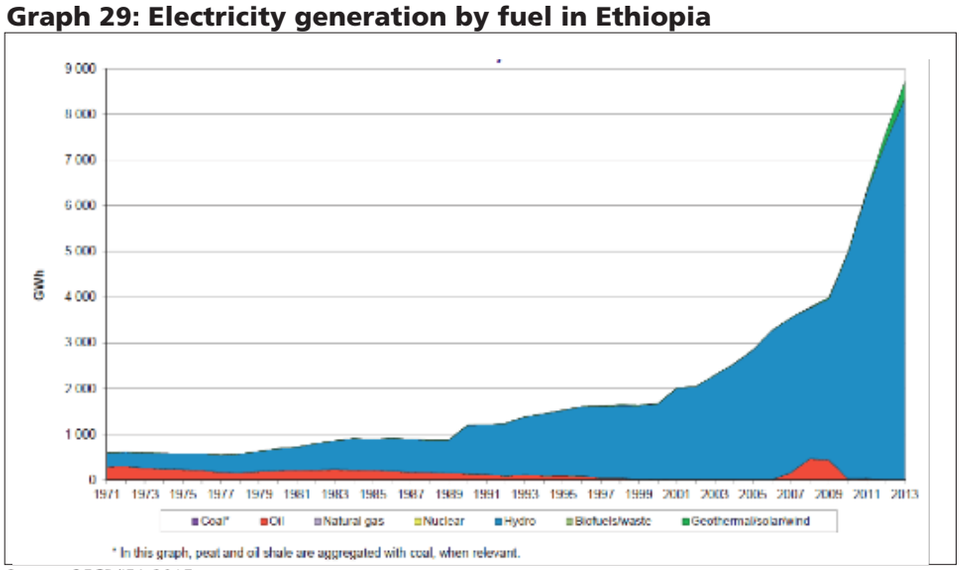
As the county is already using renewable energy sources for power generation, it is important to expand and utilise the diverse energy sources. Though the electricity production from thermal power plants is small these polluting and inefficient air pollution sources need to be phased out and replaced with clean and energy efficient power plants. A time bound roadmap may put in place.

Graph 28: Energy production in Ethiopia



Source: *OECD/IEA 2015*

Graph 29: Electricity generation by fuel in Ethiopia



Source: *OECD/IEA 2015*

Review the global best practices in emissions standards and technology for power plants and adapt it to the roadmap of Ethiopia.

3. Emissions from generator sets for captive power generation in power deficit areas.

There is no information on the use of generator sets for captive power generation in Ethiopia. It is important to reduce dependence on these polluting and harmful gen sets by improving overall access to electricity; by setting tighter emission standards for generator sets and by adopting use of clean fuel gen sets. This problem can grow if power deficit grows. Preventive action is important. There is a scope of cross learning from India. The key approaches that are being adopted in India to address the problem include – energy access; emissions standards for generator sets; and energy efficiency norms for the generator sets. The ultimate solution lies in improving energy access.

Focus on renewables for electricity generation

As a result of electricity generation through hydropower, the power generation sector in Ethiopia accounts for only 3 per cent of the total GHG emissions. Between 2008 and 2012, the power generation improved by 230 per cent with six hydroelectric and wind power projects coming online. These include Tekeze (2009, hydroelectric, 300 MW), Gibe II (2010, hydroelectric, 420 MW), Tana Beles (2010, hydroelectric, 460 MW), Amerti Nesha (2011, hydroelectric, 97 MW), Ashegoda (2012, wind, 30 MW), and Adama I (2012, wind, 51 MW). In addition, four more projects (Gibe III, Ashegoda expansion, Adama II, and the Grand Ethiopian Renaissance Dam) are under construction. The combined output is expected to be nearly 8,150 MW. However, an inadequate power transmission system means that Ethiopia's increased energy supply is not yet being utilized efficiently.

A 2014 study by REEEP highlighted the following concerns

- **Capacity concerns:** The Ethiopian power sector is over dependant on hydropower. There is a need to diversify its energy sector and also other energy sources such as wind, geothermal and solar. There are apprehensions that extreme hydropower dependence may leave the country's power sector vulnerable to drought, an increasingly risky scenario due to climate change.
- **Hydropower:** Despite having enormous potential for hydropower development and total endowment of hydropower estimated to be up to 45,000 MW per annum, only 3 per cent of the country's hydropower potential is being exploited at present.
- **Geothermal:** The estimated geothermal resource potential for power generation is about 5,000 MWe. So far, exploratory drilling has taken place in Aluto-Langano (1982 to 1985) and Tendaho-Dubti (1993 to 1998) geothermal fields. Detailed surface exploration has been completed in four other geothermal prospect areas (Corbetti, Abaya, Dofan Fantale and Tulu Moye).

The current energy sector policy aimed a five-fold increase in renewable energy production by 2015 end from 2,052 MW (52 MW added from wind in December 2012) to about10,000 MW. The policy also targets to export power to neighbouring countries as power demand in Ethiopia is constrained by limited consumption due to underdevelopment. Inorder to meet the target, the Ethiopian government is aggressively constructing eight wind farms of total capacity of 1116 MW, one geothermal plant with capacity of around 70 MW and a number of hydropower plant projects, including the 1,870 MW Gilgel Gibe III dam on the Omo River, the 2,000 MW Gilgel Gibe IV dam and the 6,000 MW Grand Ethiopian Renaissance Damon the Blue Nile river. Four wind farms are under construction and one wind farm with capacity of 52 MW power had been completed in December 2012. The Ethiopian Electric Power Corporation's long-term plan is to hit a zero carbon emissions target by 2025 with private sector participation.

Source: Anon 2014, Ethiopia 2014, *https://www.reeep.org/ethiopia-2014* as viewed on March 1.

The key elements of emissions regulation for generator sets are as follow:

- Mandatory diesel genset norms for acoustic enclosures and stack height for 6,000 cell phone towers and other captive users needs to be monitored closely
- Generator-set standards for commercial operations that are revised periodically. This may be supported by studies on indoor-air quality.
- Inventorize diesel gensets in commercial areas and lay down stringent rules for their acoustic and emission compliance (stack height)
- Devise mechanisms for effective regulations of the informal market (meeting with Market Traders Associations)
- Devise energy-efficiency measures in buildings to reduce overall demand for electricity
- Regulate location of big diesel gensets to reduce exposure

Thermal power plant norms in India for air pollutant emissions

Developing countries like India are also grappling with pollution from thermal power plants. They are continuously upgrading power plant emissions standards to push the technology to improve. Some snapshots of the initiatives in India are as follow.

1. TPPs (units) installed before 31st December, 2003	2. TPPs (units) installed after 1st January,2003, upto 31st December, 2016	3. TPPs (units) to be installed from 1st January, 2017 (Includes all the TPPs (units) which have been accorded environmental clearance and are under construction)
PM 100 mg/Nm_3 SO_2 – 600 mg/Nm_3 (Units Smaller than 500MW capacity units) – 200 mg/Nm_3 (for units having capacity of 500MW and above) NOx 600 mg/Nm3 Mercury (Hg) 0.03 mg/Nm_3 (for units having capacity of 500MW and above)	PM 50 mg/Nm_3 SO_2 – 600 mg/Nm_3 (Units Smaller than 500MW capacity units) – 200 mg/Nm_3 (for units having capacity of 500MW and above) NOx 300 mg/Nm_3 Mercury (Hg) 0.03 mg/Nm_3	PM 30 mg/Nm_3 SO_2 100 mg/Nm_3 NOx 100 mg/Nm_3 Mercury (Hg) 0.03 mg/Nm_3

Source: *Notification SO 3305 (E) The Gazette of India, Extraordinary, Part II—Section 3—Sub-Section (II), Published By Authority, New Delhi, Tuesday, December 8, 2015/Agrahayana 17, 1937*

- Inventorization of diesel gensets in cities. Introduce a legal framework that will require permission from government for use of diesel gensets
- Energy efficiency measures for buildings. Energy efficiency measures for buildings. Energy security through implementation of energy building codes should be strengthened and monitored for better implementation/ adherence to codes. This will help in demand management for power.
- Incentivise uptake of energy-efficient appliances

Open burning of waste

Open burning of municipal waste as well as horticultural waste leads to emission of toxic gases and compounds. There are two types of open burning - open burning of trash in municipal dump-yards by urban local bodies and small fires that are lit by local residents.

This is a unique problem of developing cities. As there is inadequate waste management practice, burning of the garbage becomes the easiest way to dispose of waste. This causes enormous local pollution and exposure. Ethiopia and Addis Ababa will have to adopt integrated waste management and disposal systems at the early stages to prevent this problem. This is a low hanging fruit that if implemented well can give enormous pollution benefits.

There is an example from India. India's Union Ministry of Environment and Forest and Climate Change is redrafting the rules and Draft Waste Management Rules 2015 are available in the ministry's website concerning bio-medical waste, solid waste, plastic waste; and e-waste. These rules give specific guidelines and provisions for enforcement so that burning can be systematically tackled along with proper scientific management and disposal of wastes of different kinds[47] *(see Box: Action taken on open burning in Delhi).*

Emissions norms for diesel generator sets in India

Emissions from new diesel engines used in generator sets have been regulated by the Ministry of Environment and Forests, Government of India. The regulations impose type approval testing, production conformity testing and labeling requirements. The regulations also include a list of authorized agencies for type approval testing. Engines up to 800 kW. Emission limits for new diesel engines ≤ 800 kW used in genset applications were set in 2002 and strengthened in 2013. The regulations also set noise limits for diesel generator sets up to 1000 kVA.)

Table: Standards applicable with effect from 2004/2005 for diesel engines ≤ 800 kW

Engine Power (P)	Date	CO g/kWh	HC 1/m	NOx	PM	Smoke
		g/kWh				1/m
P ≤ 19 kW	2004.01	5.0	1.3	9.2	0.6	0.7
	2005.07	3.5	1.3	9.2	0.3	0.7
19 kW < P ≤ 50 kW	2004.01	5.0	1.3	9.2	0.5	0.7
	2004.07	3.5	1.3	9.2	0.3	0.7
50 kW < P ≤ 176 kW	2004.01	3.5	1.3	9.2	0.3	0.7
176 kW < P ≤ 800 kW	2004.11	3.5	1.3	9.2	0.3	0.7

Table: Emission standards for diesel engines ≤ 800 kW for generator sets (2014) This table lists the strengthened limits applicable from April 2014.

Engine Power (P)	Date	CO	NOx+HC	PM	Smoke
		g/kWh			1/m
P ≤ 19 kW	2014.04	3.5	7.5	0.3	0.7
19 kW < P ≤ 75 kW	2014.04	3.5	4.7	0.3	0.7
75 kW < P ≤ 800 kW	2014.04	3.5	4.0	0.2	0.7

Emission standards in India – Generator sets, https://dieselnet.com/standards/in/genset.php as viewed on March 1.

Engines are tested over the 5-mode ISO 8178 D2 test cycle. Smoke opacity must not exceed the limits at full load (for Diesel Engines ≤ 800 kW w.e.f. 2004/2005)) or at any load point of the test cycle (for Diesel Engines ≤ 800 kW w.e.f. 2014)). The same limits are applicable for type approval and for conformity of production (COP) testing.

Engines above 800 kW. Emission standards for new diesel engines above 800 kW used in genset applications were phased-in between 2003 and 2005

Table: Emission limits for diesel engines > 800 kW for generator sets

Date	CO	NMHC	NOx	PM
	mg/Nm_3	$mg\ C/Nm_3$	ppm(v)	mg/Nm_3
Until 2003.06	150	150	1100	75b
2003.07 - 2005.06	150	100	970 (710a)	75c
2005.07	150	100	710 (360a)	75c

a For engines in plants of total power rating above 75/150 MW located in urban/rural areas, respectively.
b 150 mg/Nm_3 for engines fueled with furnace oil.
c 100 mg/Nm_3 for engines fueled with furnace oil.

Concentrations are corrected to dry exhaust conditions at 15% residual O_2.

Norms for other fuelled engines are available in the CPCB website. System and procedure for compliance with noise limits are also detailed out. CPCB has published a list of manufacturers who have obtained conformity of production verification certificates.[19]

Installation of gensets: Gensets be installed with stand alone or isolated foundation with proper anti-vibration packing/pad, etc. Smoke of gensets be channelized/emitted in a manner that it is not a nuisance in the neighbourhood. Genset be installed in the basement, roof top, ground floor, front/back offset of the premises/building, in order of priority. However, due care be taken so that it is not a nuisance in the neighbourhood. The developer for new market/malls, high rise building or a gated green field colony shall necessarily install a source of standby power back up and installation of genset by individuals be prohibited. Developer shall necessarily install a system to harvest solar or wind energy, as applicable as a source of electricity apart from solar geysers.

Phasing out old generator sets: Phasing out of old generators as per following schedule may be enforced by concerned SPCB/PCC, area SDM and Police. Any generator set having engines not engraved with manufacturer's name and date of manufacturing not to be allowed to operate on or after 01.06.2015; Any diesel generator set without certified acoustic enclosure as per GSR 371(E), dated May 17, 2002 not to be allowed to operate on or after June 1, 2015. Generator sets manufactured on or after May 17, 2002 be scrapped and dismantled after its useful life, that is 15 years from the date of manufacturing or 50,000 hours of operation, which ever earlier.

Phasing out age old diesel gensets for agricultural applications Gensets being operated for agricultural applications are away from habitation. The phasing out of diesel gensets may be undertaking as per the following: i. Any genset being used for agriculture purpose, having engines not engraved with manufacturer's name and date of manufacturing not to be allowed to operate after June 1, 2016.

Any diesel genset without certified acoustic enclosure as per GSR 371(E), dated May 17, 2002 not to be allowed to operate on or after June 1, 2016 and All gensets manufactured on or after May 17, 2002 be discarded after its useful life that is 16 years from the date of manufacturing or 60,000 hours of operation, whichever earlier.

Maintenance of diesel gensets. It is the responsibility of genset owner to maintain the genset. Proper maintenance as per following can reduce the pollution level and increase the genset life.

Source: Anon undated, Generator sets, Central Pollution Control Board, http://cpcb.nic.in/Generator.php as viewed on March 1.
National Green Tribunal India order March 11, 2015, http://cpcb.nic.in/Guidelines-for-UsedGeneratorSets.pdf as viewed on February 20.

Action agenda to control emissions from waste burning

Open burning is quite common in Addis Ababa. The measures may include the following:

- An outright ban/absolute curb on open burning anywhere within the city limits. Fires should be permitted only for legitimate reasons after scrutiny of the need for the same.
- Development and implementation of clear composting rules and decentralized strategies for organic waste. Composting of organic waste should be promoted as a disposal mechanism instead of incineration.
- Segregation of waste at source, during transportation and final disposal, is necessary, so that the waste can be processed efficiently, recycled and reused.
- Leverage informal mechanisms of waste collection, recycling and re-use which already exist.
- Regular meetings of departments dealing with horticulture and sanitation at the regional level to prepare strategies to stop open burning of both horticultural and municipal waste.
- Build public awareness and public health consequences.

Action taken on open burning in Delhi

Delhi has already banned open burning of biomass in Delhi. Enforcement of this policy decision remains a challenge. Stringent enforcement, public awareness as well as innovative methods of waste disposal are needed to minimize this problem.

Priority action

- Enforcing the ban on open burning—with clear composting rules and strategies for vegetative waste of municipalities. Municipal zonal office to be responsible for controlling the burning of leaves and garbage on roads and in parks. This should be monitored.
- Building awareness campaign through RWAs, eco clubs and municipal authorities
- All horticulture agencies should have compost pits in parks
- Meeting of horticulture and sanitation departments at chief secretary level to prepare strategies to stop leaf-burning
- Slums and low-income neighbourhoods, as well as roadside eateries etc. use biomass and coal to a large degree. A rapid increase in use of LPG is needed to counter this.

- Improve access to clean energy to prevent polluting bio-mass burning for heating and cooking.

Building construction and road dust

With building construction boom urban areas have become increasingly vulnerable to the problem of dust pollution. In a growing city like Addis Ababa construction activities are expected to increase rapidly. This investment will have to be linked with mandatory compliance with dust control measures. Concrete and cement dust is harmful. To this is added the problem of road dust due to unpaved or badly constructed roads. This requires strategies to contain it. Construction and demolition (C&D) waste is enormous in urban areas. Strategies are needed for proper disposal and recycling.

Action agenda for construction and demolition waste and road dust

Formally adopt dust-control regulations and techniques for construction activities and roads.

Control dust from (C&D): The following measures need to be taken for C&D waste:

- Special procedure to be developed and implemented for demolition activities, dismantling should be preferred over demolition.
- Adopt dust control measures like water-sprinkling and other dust-suppressing techniques to stabilise surfaces and loose soil during and after construction activities. Greening of such surfaces should be undertaken as long term measure.
- Tighter dust control measures to be adopted for ready-mix concrete batching.
- Making it obligatory for developers to provide evidence of proper covered storage and disposal of debris from construction and demolition activities on site and ultimately at designated disposal sites.
- Regulations should ensure a certain percentage of recycled C&D waste is brought back to be reused in construction.
- Transportation of building material and debris should be done via covered vehicles to avoid fugitive dust immersions. All building materials and debris which have soil or dust component should be adequately watered to cut dust while transportation.
- Promoting on-site recycling of C&D waste for large building and

infrastructure projects.
- Setting up proper disposal sites for C&D waste and decentralized recycling facilities for small projects.
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Road dust: For road dust control, develop and implement street-design guidelines for footpaths and cycle tracks with adequate vegetative barriers. Limit vehicular speed to reduce dust on non-arterial roads. Proper procedure for road digging and filling should be developed and implemented.

Domestic fuel in Ethiopia: Source of high exposure

According to the UNEP, wood which is used by the poor for cooking accounts for 94 per cent of the energy mix in Ethiopia. It is estimated that solid fuel combustion causes an estimated 72,400 premature deaths every year. Even in urban areas, half the households rely on traditional biomass (wood, dung and agricultural residues) for cooking, and in rural areas, virtually all do (except for 0.2 per cent who use kerosene, and 1.2 per cent charcoal). Indoor air pollution also contributes to outdoor air pollution. In India this share is as high as 25 per cent.

Example from Delhi: Guidance on measures to be adopted to control dust emissions from construction activities larger than 20,000 sqm of built-up area

S. No.	Task
1	Whether continuous dust/wind breaking walls of appropriate height* have been provided around the periphery of the construction site? *Three meter (3 mt) or one tenth of plot length whichever is higher
2	Whether tarpaulin or green-net on scaffolding around the area under-construction and the building is provided?
3	Whether all vehicles including carrying construction material and construction debris of any kind cleaned and wheels washed before leaving the construction site?
4	Whether all vehicles carrying construction material and construction debris are fully covered and protected so as to ensure dust from construction material or debris does not become air-borne in transportation?
5	Whether all construction debris and construction material of any kind is stored on the site (not dumped on roads or pavements) and is fully covered in all respect? Ideally in a warehouse.
6	Whether wet-jet being used in grinding and stone cutting?
7	Whether unpaved surfaces and areas with loose soil are adequately sprinkled with water to suppress dust? Ideally site to be fitted with fine water spraying nozzle system.
8	Whether construction and demolition waste is recycled on-site or transported to authorised recycling facility and due record of the same is maintained?
9	Whether every worker working on construction site and involved in loading, unloading and carriage of construction material and construction debris are provided with dust-mask to prevent inhalation of dust particles?
10	Whether arrangement provided for medical help, investigation and treatment to workers involved in the construction of building and carry of construction material and debris relatable to dust emission?
11	Whether green belt or green air barriers created around the construction site? Note: This method is usually not possible in under-construction site and should not be insisted upon if all high and medium significance requirements are fulfilled.
12	Any additional measures taken to control dust pollution.

Action agenda for pollution from solid fuel in households

Clean fuel/energy should be made available to all to reduce exposure and pollution. The energy transition requires changeover to cleaner sources with support from the government. This will require a roadmap to make clean fuel like LPG available to all households at affordable prices. Fiscal strategy is needed to help poor households to move up the energy ladder. The government can adopt differential taxation policy in which dirtier fuel is taxed higher than cleaner fuel to cross subsidise the clean fuel.

Set up institutional process for clean air action

Clean air action plan involves mitigation strategies for all pollution sources to meet the air quality standards in a time bound manner. This also requires mapping of pollution sources in micro environments and neighbourhoods to reduce toxic exposure to pollution. Vehicles, one of the rapidly growing source of pollution in cities and a complex problem to deal with has been discussed in detail in this guidance document. Other key sources of pollution and action strategy have also been discussed.

An institutional mechanism and process for clean air action plan will have to be put in place to guide the action planning process. Departmental coordination and multi-stakeholder platform will be needed under the Federal Ministry of Environment and Forests and Climate Change to guide and monitor the process. This will require indicators to assess if all cross-sector action are delivering on clean air and energy efficiency; action agenda with time line; the ministry/ department that are responsible for implementation; inter-departmental task force for oversight; periodic review to further refine and upgrade the plan. This will require strong legal framework for implementation and compliance.

Annexure

Multi-stakeholder forum under the Federal Ministry of Environment and Forests and Climate Change to inform clean air action plan

A Stakeholder consultation Workshop on urban air quality and roadmap for Addis Ababa and other cities of Ethiopia was organised by the Ministry of Environment, Forest and Climate Change (MEFCC), Federal Republic of Ethiopia in collaboration with the Centre for Science and Environment (CSE) India on March 18-19, 2016 in Addis Ababa. This workshop is part of the initiative to build experience sharing and knowledge building platform to inform and support the process of developing and implementing action plan to achieve clean air in Addis Ababa and other key urban centres of Ethiopia. This workshop was a follow up of the inception workshop that was held on September 8, 2015 in Addis Ababa. In the inception workshop it was agreed that the MEFCC and based on consultation with CSE and all other key stakeholders would help to prepare a guidance framework for urban air quality management and action in Ethiopia for the MEFCC based on the local imperatives and global best practices.

The two-day workshop on March 18-19, 2016 brought together large number of diverse group of concerned stakeholders representing the concerned Ministries, multilateral agencies and academic departments dealing with issues related to air quality, vehicle technology, fuel quality and mobility strategies to deliberate on the proposed Guidance Framework for Air Quality Management in Ethiopia and recommend ways to strengthen this further. Prominent members of academia, experts and media were present. As many as 80 participants actively participated in the deliberations.

The event was graced by H. E. Mr. Ato Kare Chawicha, Hon'ble minister of Environment, Forests and Climate Change. The event was conducted under the guidance of Mr. Mehari Wondmagegn, Director, Compliance Monitoring and Control Directorate, MEFCC. The key organizations that were present include -- Officials of MEFCC, United Nations Environment Programme (UNEP). Ethiopian Roads Authority (ERA), Ethiopian Environment and Forest Research Institute (EEFRI), Ministry of Water, Irrigation and Energy of Ethiopia (MoWIE), Solid Waste Recycling and Disposal Project Office, The Ethiopian Food, Medicine and Health Care Administration and Control Authority, Chemical and Construction Inputs Industry Development Institute, Ministry of Transport (MoT), Federal Ministry of Health, National Meteorology Agency (NMA), Addis Ababa University-School of Public Health, Addis Ababa Science and Technology University, World Health Organization, Ministry of Industry (MoI), Ethiopian Petroleum Supply Enterprise (EPSE), Addis Ababa Health Bureau, Lifan Motor, Ethiopian Institute of Architecture, Building Construction and City Development (EiABC), Addis Ababa Environmental Protection Agency, Ministry of Industry and Trade (MoIT), African Development Bank (AfDB), Ethiopian Revenues and Customs Authority (ERCA), representatives of Centre for Science and Environment among others.

The stakeholder forum recommended the following:

Set up institutional process for clean air action plan: The MEFCC will adopt clean air action plan for Addis Ababa and other cities to guide regulatory action to control air pollution for all key pollution sources in the city and meet clean air target. An institutional process will be set up to facilitate adoption

and implementation of source wise action plan to meet the clean air standards within a time frame. Develop indicators to assess if all cross sector action are delivering on clean air and energy efficiency. List action with time line and attribute it to the ministry/department responsible for implementation. Harmonise action across departments. Take stock periodically to further refine and upgrade the plan. Adopt strong legal framework for implementation and compliance

Set up inter-departmental task force to monitor implementation: The MEFCC to set up a Task Force with representation from the key concerned departments and other stakeholders to monitor implementation of source-wise clean air action plan in a time bound manner to meet clean air target.

A steering committee: A Steering Committee will be formed which will include decision makers as well as the technical team. Next step would be to define implementation modalities for policy level, operational level and lower (woreda and kebele) levels. An inter-ministerial committee will be formed with lead ministries including the MEFCC, Ministry of Mines, Petroleum and Natural Gas, MoWIE, MoT, MoH, MoI, MoUD, Ministry of Construction, MoST and ERCA. The Steering committee will be set with political representatives, experts and other stakeholders to oversee and guide the process. Leading ministries have been identified to steer the implementation process.

Develop time bound implementation strategy for short, medium and long term measures, adopt appropriate policies, regulations, standards and appropriate schemes or priority implementation

It was proposed that the Task Force will include representations from the key stakeholders including: –

- Ministry of Environment and Forests and Climate Change
- Ministry of Health (have rules and regulations to control air pollution and works with MEFCC),
- Ministry of Transport (have project on cycling, share the road and other non-motorised forms of transport and have LRT projects and mass transport system and also trans regional railways),
- National Meteorology Agency (compile meteorological data, set up air quality monitoring stations, air quality monitoring station is installed at Adama and will be inaugurated in the coming week. Another station will be set up in Hawassa. Thus NMA will provide important data for the roadmap),
- Addis Ababa Health Bureau (air pollution induced health problems), Addis Ababa Institute of Technology (member of the technical committee on the roadmap),
- Ministry of Communication and Information Technology (deals with e-waste management),
- EiABC (various departments can play roles involving the different areas of city construction including architecture, planning, urban design, landscape architecture and construction),
- Addis Ababa University and Addis Ababa Science and Technology University (participate on energy sector roadmap and now will provide technical support of this roadmap),
- EEFRI (conducts research on air quality policies), Ministry of Industry (have project on how greenhouse gas emissions is reduced from industries that used coal, biomass etc and change the importation of materials),

- Somali EPA (replication of Addis Ababa experience to Jigiga),
- Ethiopian Roads Authority (road network expansion and is responsible to manage environmental issues related to pollution and will help MEFCC to ensure safeguard issues are addressed in the construction to reduce noise and air pollution),
- EPSE (standard development and policy implementation),
- Tigray EPA (take the roadmap to the cities and coordinate and conduct preliminary assessment), consulting firms and solid waste recycling agency (have projects on air quality as the main urban problems are emissions from solid waste, collect flaring methane gases and waste to energy projects) and UNEP.

References

1. Dula Shanko 2015, Deputy Director General, National Meteorological Agency, Addis Ababa, personal communication.
2. Elisaveta P. Petkova et al 2013, Particulate matter pollution in African cities, Air Quality, Atmosphere and Health, Vol 6, p 610.
3. G. Gebre et al, 2010, Mass concentrations and elemental composition of urban atmospheric aerosols in Addis Ababa, Ethiopia, Bulletin of the Chemical Society of Ethiopia, Chemical Society of Ethiopia, Vol 24, No 3.
4. Zerihun Abate 2015, Impact of vehicle emission on air pollution in Addis Ababa, Paper presented at the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for Clean Air Action Plan, Ministry of Environment and Forest, The Federal Democratic Republic of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.
5. A Kume et al 2010, Magnitude and variation of traffic air pollution as measured by CO in the City of Addis Ababa, Ethiopia, Ethiopian Journal of Health Development, Vol 24, No 3.
6. Awoke Taddesse Hailu et al 2013, Investigation of traffic air pollution in Addis Ababa city around selected bus stations using instrumental neuron activation technique, International Journal of Basics and Applied Sciences.
7. Duc Hoai Do et al 2013, Volatile organic compounds in an urban environment: a comparison among Belgium, Vietnam and Ethiopia, International Journal of Environmental Analytical Chemistry, Vol 93, Vol 3.
8. Anon 2010, GBP Profile: Ethiopia, Institute for Health Metrics and Evaluation, Seattle, p 3.
9. Anon 2009, Ethiopia: Country profile of Environmental Burden of Disease, World Health Organization, Geneva.
10. Michelle A Williams 2012, Why Non-communicable Diseases? Why now?, Paper presented in Addis Continental Institute of Public Health, Addis Ababa, November 8, mimeo.
11. Worku Tefera 2015, Air Pollution and Health in Ethiopia: Review of Literature, Paper presented in the Stakeholder Workshop on Air quality and transportation challenges in Ethiopia and agenda for action, Ministry of Environment and Forest, Government of Ethiopia and Centre for Science and Environment, Addis Ababa, September 8, mimeo.
12. Alok Tiwari 2011, Urban air pollution caused by automobiles in Addis Ababa, Ethiopia and its health consequences, IUP Journal of Environmental Sciences, Vol 5, No 3.
13. Venn A et al 2005, Proximity of the home to roads and the risk of wheeze in an Ethiopian population, Occupational and Environmental Medicine, Vol 62, No 6.
14. Anon 2009, Monitoring ambient air quality for health impact assessment, World Health Organization , WHO Regional Office for Europe, Copenhagen.
15. Anon 2014, Improving Air Quality Monitoring in Asia: A Good Practice Guidance, Asian Development Bank, Mandaluyong City.
16. Anon 2014, Improving Air Quality Monitoring in Asia: A Good Practice Guidance, Asian Development Bank, Mandaluyong City.
17. Anon 2014, Improving Air Quality Monitoring in Asia: A Good Practice Guidance, Asian Development Bank, Mandaluyong City.
18. Anon undated, Ambient air pollution monitoring, http://nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Environmental%20Air%20Pollution/air%20pollution%20(Civil)/Module-2/1.htm as viewed on March 5.
19. Anon 2014, Improving Air Quality Monitoring in Asia: A Good Practice Guidance, Asian Development Bank, Mandaluyong City.
20. Anon 2003, Guidelines for Ambient Air Quality Monitoring, National Ambient Air Quality Monitoring, Central Pollution Control Board, Ministry of Environment

and Forests, Government of India.
21. Anon 2009, Monitoring ambient air quality for health impact assessment, World Health Organization , WHO Regional Office for Europe, Copenhagen.
22. Anon 2009, Monitoring ambient air quality for health impact assessment, World Health Organization , WHO Regional Office for Europe, Copenhagen.
23. Anon 2009, Monitoring ambient air quality for health impact assessment, World Health Organization , WHO Regional Office for Europe, Copenhagen.
24. Zerihun Getachew 2014 Ethiopia: Nation Saves U.S.$38.9 Million Through Blended Gasoline, http://allafrica.com/stories/201409082277.html
25. Anon undated, Provision for Non - Motorised Transport in Addis Ababa and recommendations for improvements, UNHabitat
26. Anon 2014, Note of Proposed World Bank Engagement on Urban and Metropolitan Transport and Land-use for Inclusive Green Growth in Addis Ababa, The World Bank, p 6.
27. Anon 2015, Policies for Sustainable Accessibility and Mobility in Urban Areas of Africa, The International Bank for Reconstruction and Development / The World Bank Group, Washington, p17.
28. Anon 2015, Policies for Sustainable Accessibility and Mobility in Urban Areas of Africa, The International Bank for Reconstruction and Development / The World Bank Group, Washington, p 17.
29. Anon 2012, Transportation challenges in a booming city, Background paper for CODATU XV, Addis Ababa City government, October 22-26.
30. Anon 2011, Transport policy of Addis Ababa, Ministry of Transport, The Federal Democratic Republic of Ethiopia, Addis Ababa, August.
31. Dipti Ranjan Mohapatra 2015, Feasibility of non-motorised transport facilities in Addis Ababa city of Ethiopia: An economic analysis, European Academic Research, Vol 11, No 10, January.
32. Binyam Bedelu et al 2008, Simplified travel demand modelling for developing cities: The case of Addis Ababa, World Transport Policy and Practice, Eco-Logica Limited, Lancaste, Vol 14, No 2.
33. Dipti Ranjan Mohapatra 2015, Feasibility of non-motorised transport facilities in Addis Ababa city of Ethiopia: An economic analysis, European Academic Research, Vol 11, No 10, January.
34. Binyam Bedelu et al 2008, Simplified travel demand modelling for developing cities: The case of Addis Ababa, World Transport Policy and Practice, Eco-Logica Limited, Lancaste, Vol 14, No 2.
35. Anon undated, Provision for Non - Motorised Transport in Addis Ababa and recommendations for improvements, UNHabitat
36. Anon 2015, Policies for Sustainable Accessibility and Mobility in Urban Areas of Africa, The International Bank for Reconstruction and Development / The World Bank Group, Washington, p 19.
37. Anon 2013, Transport and Environment in Sub-Saharan Africa, Stockholm Environment Institute, Stockholm
38. Anon 2013, Road safety in the WHO African Region: The facts 2013, World Health Organization.
39. Getu S Tulua et al 2013, Characteristics of police reported road traffic crashes in Ethiopia over a six year perios, Paper presented in the Australasian Road Safety Research, Policing and Education Conference, Queensland, August 29 to 30.
40. Brook Abdou 2014, Ethiopia among worst in traffic safety, Fortune, Addis Ababa.
41. Anon undated, Road traffic accidents increase in Ethiopia, http://www.zegabi.com/articles/6547 as viewed on February 20.
42. Anon 2009, Case study: Road safety in Ethiopia, United Nations Economic Commission for Africa.

43. Dipti Ranjan Mohapatra 2015, Feasibility of non-motorised transport facilities in Addis Ababa city of Ethiopia: An economic analysis, European Academic Research, Vol 11, No 10, January.
44. Guyu Ferede Daie 2013, Identifying major urban road traffic accident blackspots (RTABSs): A Subcity based analysis of evidences from the city of Addis Ababa, Ethiopia, Journal of Sustainable Development in Africa, Vol 15, No 2.
45. Dipti Ranjan Mohapatra 2015, Feasibility of non-motorised transport facilities in Addis Ababa city of Ethiopia: An economic analysis, European Academic Research, Vol 11, No 10, January.
46. Anon 2014, Note of Proposed World Bank Engagement on Urban and Metropolitan Transport and Land-use for Inclusive Green Growth in Addis Ababa, The World Bank, p 8.
47. Draft Waste Management Rules 2015, Ministry of Environment, Forest and Climate Change, http://envfor.nic.in/content/draft-waste-management-rules-2015-comments.

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