SEI Stockholm Environment Institute

Air pollution and its impact on human health

An important driver for achieving the 1.5°C goal of the Intergovernmental Panel on Climate Change

SEI policy brief
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Johan Kuylenstierna[1]

Chris Malley[1]

Patrick Büker[2]

Tangmar Marmon[2]

1 SEI
2 GIZ

How the Stockholm Environment Institute's Low Emissions Analysis Platform (LEAP) and Integrated Benefits Calculator can help plan coherent emission reduction strategies with health benefits

Key messages

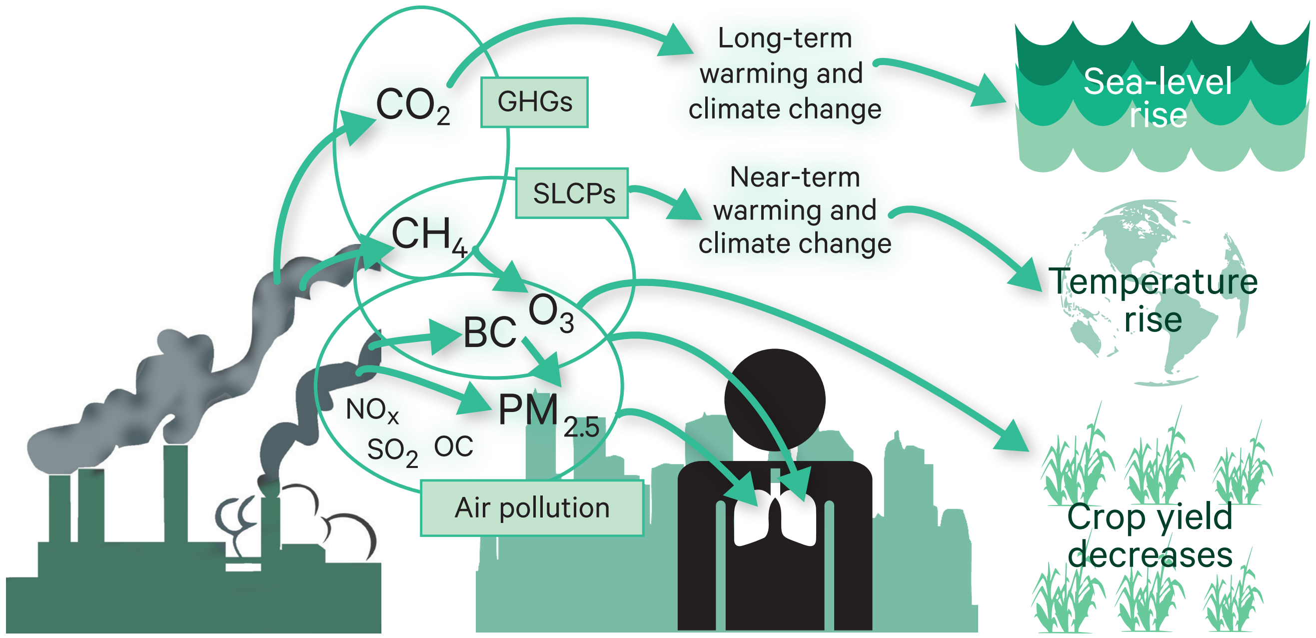
- **Almost all processes that produce air pollutants also impact health and contribute to climate change. Emphasizing the near-term human health benefits of managing air pollutants can act as a major driver for policy change, which in turn, can achieve long-term benefits for reducing climate change.**
- **Fast action to reduce short-lived climate pollutants – especially methane, black carbon and hydrofluorocarbons – is required alongside drastic cuts in carbon dioxide emissions, to stay within the Intergovernmental Panel on Climate Change 1.5°C goal. Immediate coordinated action on reducing short-lived climate pollutants can prevent over 0.5°C of warming by 2050, but can also reduce the health impacts from air pollution, including exposure to small particulate matter and tropospheric ozone.**
- **Stockholm Environment Institute research has highlighted the main impacts of air pollution on health, showing that small particulate matter can be related to millions of asthma-related visits to hospital each year globally, and over two million pre-term births, which can have life-long health implications for survivors. This knowledge can motivate action on air pollutants and in turn reduce greenhouse gases, helping to achieve the Intergovernmental Panel on Climate Change 1.5°C goal. Human health can be an important driver for policy change, as recently highlighted during the coronavirus pandemic.**
- **If this opportunity is to be realized, then countries and cities need to know which air pollution measures and policies at national and urban scales can provide both human health and climate change reduction benefits.**
- **The Low Emissions Analysis Platform (LEAP) and Integrated Benefits Calculator, developed by the Stockholm Environment Institute, enables integrated modelling of emission projections for air pollutants, short-lived climate pollutants and greenhouse gases in countries and cities under different scenarios, charting progress towards the 1.5°C goal. The Integrated Benefits Calculator module of the tool allows users to assess the implications of different climate policies on human health.**

Intergovernmental Panel on Climate Change 1.5°C goal

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C (2018) provided a shock to the global community. It showed that to restrict global temperature rise to 1.5°C – in order to avoid dangerous climate change – reductions in all emissions that are warming the planet are needed at an urgent pace. The Report found that fast action to reduce carbon dioxide is essential, but it also emphasized that action on short-lived climate pollutants (SLCPs) – air pollutants that

IMAGE (ABOVE): Power station, Si Ping, Ji Lin, China © ZHUYONGMING / GETTY

Figure 1. Emissions from combustion include greenhouse gases (GHGs), short-lived climate pollutants (SLCPs) and air pollutants. These have a range of impacts on temperature change over different time frames, and impact on human health and agricultural productivity.



also warm the climate – is needed, to stay within the 1.5°C goal[1]. A key implication from the IPCC Report is the need for about a 35% reduction in methane and black carbon emissions by 2030, and about a 70-80% reduction in hydrofluorocarbons.

Immediate, widespread, coordinated action on reducing these SLCPs can prevent over 0.5°C of warming by 2050. According to the United Nations Environment Programme and World Meteorological Organization (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone (a derivative of methane), the global implementation of 16 actions that target emission reductions in the major SLCP source sectors, can deliver this. In comparison, CO_2 has a longer lifespan and hence longer warming effect in the atmosphere. So, reducing SLCPs is something like a pain killer cure: effective in bringing down the pain in the short-term and as such, highly welcome, but you still have to work on the causes of the pain in the long-term to solve the problem.

While the IPCC Report gave a global focus on the issue of climate change, it also highlighted the need to address closely related sustainable development issues, including air pollution and its impacts on human health. Almost all processes that contribute to climate change, also produce air pollutants. And almost all air pollutants from these processes, can cause health impacts. Emphasizing the human health benefits of managing these pollutants can act as a major driver for policy change, which in turn, can help reduce greenhouse gas (GHG) emissions and achieve the IPCC 1.5°C goal. How influential human health can be in driving policy change has been clearly indicated by the worldwide lock-downs in response to the coronavirus (COVID-19) pandemic.

The close linkages between air pollution, health and climate change

Combustion processes, transport and agriculture are the main sources of both GHGs and air pollutants. In the case of combustion, as shown in Figure 1, CO_2 emissions are the cause of long-term climate change; however, the combustion process also emits air pollutants, some of which are SLCPs. While CO_2 has a longer-term impact on climate

1 Read the Climate and Clean Air Coalition summary of the IPCC report here: Reducing Short-Lived Climate Pollutants necessary to achieve 1.5°C climate goal.

warming, mitigating SLCPs has a significantly larger impact on reducing warming in the near term, and this mitigation will also benefit human health and crop yields, due to reduced air pollution impacts.

Methane released from the extraction of fossil fuels, for example, in addition to being the second most important GHG after CO_2, is also a SLCP. This means that methane is relatively short lived (with a lifetime of about 12 years in the atmosphere) and so reducing methane emissions can achieve rapid reductions in temperature. Importantly, methane is also a precursor giving rise to the formation of tropospheric ozone, which is an air pollutant that affects human health and crop yields. Reducing methane emissions can therefore have a triple benefit, for climate change, health and agriculture.

Black carbon is another SLCP, produced in the combustion of fossil fuels and biomass, and warms the atmosphere, causing global and regional climate changes. It also forms part of the small particulate matter ($PM_{2.5}$) that causes ill health. Reducing black carbon emissions can therefore benefit both climate change and human health. This is particularly effective at reducing health impacts, since tackling black carbon emissions also reduces other air pollutants that form $PM_{2.5}$, such as nitrogen oxides, sulphur dioxide and organic carbon.

The impact of air pollution on human health

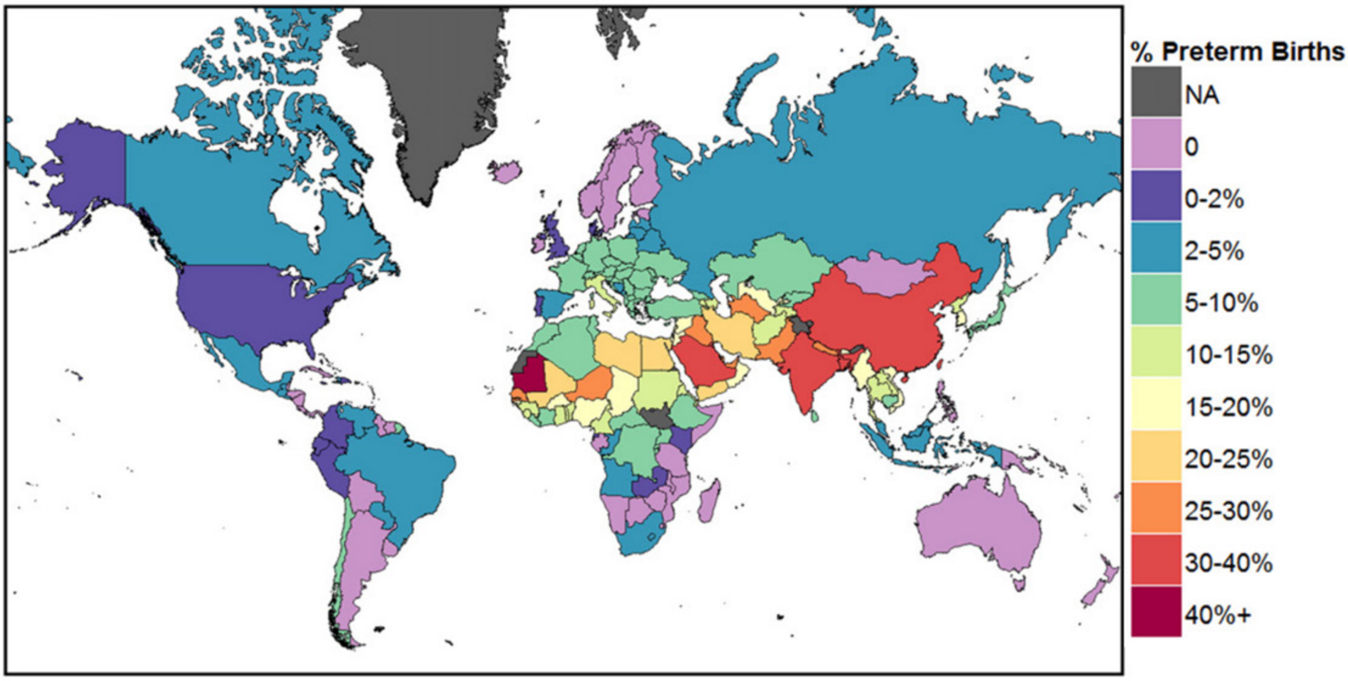
Air pollutants are having drastic impacts on human health. Both household and ambient (outdoor) pollution, for example, from cookstoves and vehicle emissions, contribute to these impacts. Air pollution has the greatest impact on human health of any environmental health risk. It harms health and kills in much the same way as smoking: by increasing the risk of developing cardiovascular and respiratory diseases, and lung cancer. Estimates of the overall health burden from air pollution vary; the Global Burden of Disease project estimates that 4.9 million premature deaths were attributable to air pollution exposure in 2017, while the World Health Organization estimates 7 million premature deaths in 2016. In addition to premature mortality, air pollution exposure contributes to many other health impacts, such as low birth weight, pre-term births, severe asthma attacks, childhood pneumonia, heart attacks and strokes (Malley, Kuylenstierna et al. 2017; Anenberg et al. 2018).

Because of the importance of health as a driver of policy, the Stockholm Environment Institute (SEI) has invested in studies on the different health impacts of air pollution. A global assessment of the number of pre-term births associated with outdoor exposure to $PM_{2.5}$ in 2010 found that globally, 2.7 million pre-term births, or 18% of all pre-term births, can be associated with $PM_{2.5}$ (Malley, Kuylenstierna et al. 2017). Being born pre-term is associated with neonatal and infant mortality and can have life-long health consequences for survivors.

Figure 2 shows the percentage of all pre-term births in 2010 that were estimated to be associated with maternal exposure to outdoor $PM_{2.5}$. The largest numbers of pre-term births associated with maternal $PM_{2.5}$ exposure occurred in China and India, while the largest percentage of pre-term births associated with maternal $PM_{2.5}$ exposure were found in Africa and West Asia, partly associated with high levels of desert dust in this region.

SEI have also assessed the link between premature mortality and exposure to tropospheric ozone. This research estimated that more people might be dying prematurely from tropospheric ozone exposure than previously thought, due to updated epidemiological analysis providing an updated, and more robust relationship between ozone exposure and respiratory deaths (Malley, Henze et al. 2017).

Figure 2. Percentage of total pre-term births associated with maternal exposure to outdoor $PM_{2.5}$ in 2010.



Source: Malley, Kuylenstierna et al. 2017.

Another health outcome looked into was the relationship between exposure to human-induced $PM_{2.5}$ and tropospheric ozone, and the prevalence of severe asthma attacks (Anenberg et al. 2018). The research estimated that, in 2015, $PM_{2.5}$ was attributable for 3.7- 7.3 million asthma-related emergency room visits globally, while tropospheric ozone was attributable for 3.3- 8.5 million visits. This represents 3-7% of global emergency room visits for asthma, annually.

Air pollution has a large health impact and reducing it is a priority, with growing public demand around the world for better air quality. Not only are insurance companies and health services becoming more sensitive to air pollution issues, but citizens too are relating poor air quality to their health and the health of their families.

This increased demand for action partly comes from greater awareness, driven by better knowledge of the severity of the air pollution problem, especially its effect on health. The current impacts of air pollution in Asia are particularly large, while air pollution in Africa is also increasing. Even in Europe, where air pollution has been reduced considerably during the last decades, it is still having an impact on human health.

During the current pandemic, those patients who have underlying or pre-existing cardiovascular or respiratory diseases are more likely to experience severe COVID-19 symptoms (Mai et al. 2020; Nishiga et al. 2020; WHO 2020). This acts as a timely reminder of the importance of addressing air quality, due to its impact on respiratory and cardiovascular diseases.

The current focus on health offers an opportunity to reduce air pollution for health benefits and in turn, reduce emissions causing climate change. If this opportunity is to be realized, then countries and cities need to understand the importance of integrated planning, for identifying which measures and policies at urban and national scales can provide this double benefit.

Integrated planning for air quality, climate and health

There are strategies that reduce both air pollutants and GHGs, which include energy efficiency, renewable energy, electric vehicles (ideally running on renewable energy), and a modal shift to public transport, walking and cycling.

There are however, strategies to address air pollution that don't address climate change. For instance, end-of-pipe measures can remove nitrogen oxides or sulphur dioxide from fossil fuel combustion, but leave the CO_2 emissions that cause climate change. Using end-of-pipe measures for fossil fuel exhausts alone, therefore, is not a climate-friendly solution. Similarly, a shift to diesel vehicles, which was promoted as a climate measure in Europe, has left the continent with a continued problem of elevated nitrogen dioxide and particulate levels.

Generally, however, the technologies and strategies that decarbonize society through the removal of GHGs, will also lead to reduced air pollution. For example, an integrated approach, moving towards electric mobility, powered by renewable energy, has the potential to reduce both air pollution and CO_2. Such strategies can also provide many other positive benefits including reductions in energy prices, noise and traffic congestion, all of which will increase our quality of life. The promotion of a modal shift to walking and cycling will remove emissions and lead to a healthier population.

Despite the availability of effective and, in many cases, cost-effective solutions, the ambition of national governments to achieve the IPCC 1.5°C goal and goal of the Paris Agreement, are not sufficient to put us on the path down to either 1.5°C or even 2°C warming. However, there are opportunities to increase ambition at sub-national scales, and especially in cities, where many of the emission sources are located. According to UN-Habitat (2011), 60-70% of GHG emissions globally, come from cities. At the same time, the majority of health impacts caused by outdoor air pollution, affect people living in cities. While air pollution and climate change can be addressed together, the planning to address these issues often happens in silos, and integrated strategies are not apparent or considered.

Part of the problem can be resolved by increasing the capacity of planners at national, regional and urban scales, to use tools that show the benefits of integrated planning, and identify policies to solve air pollution and climate change simultaneously. The Low Emissions Analysis Platform (LEAP) and Integrated Benefits Calculator (IBC), developed by SEI, is being used for this purpose and it is now being applied at an urban scale.

The LEAP-IBC model

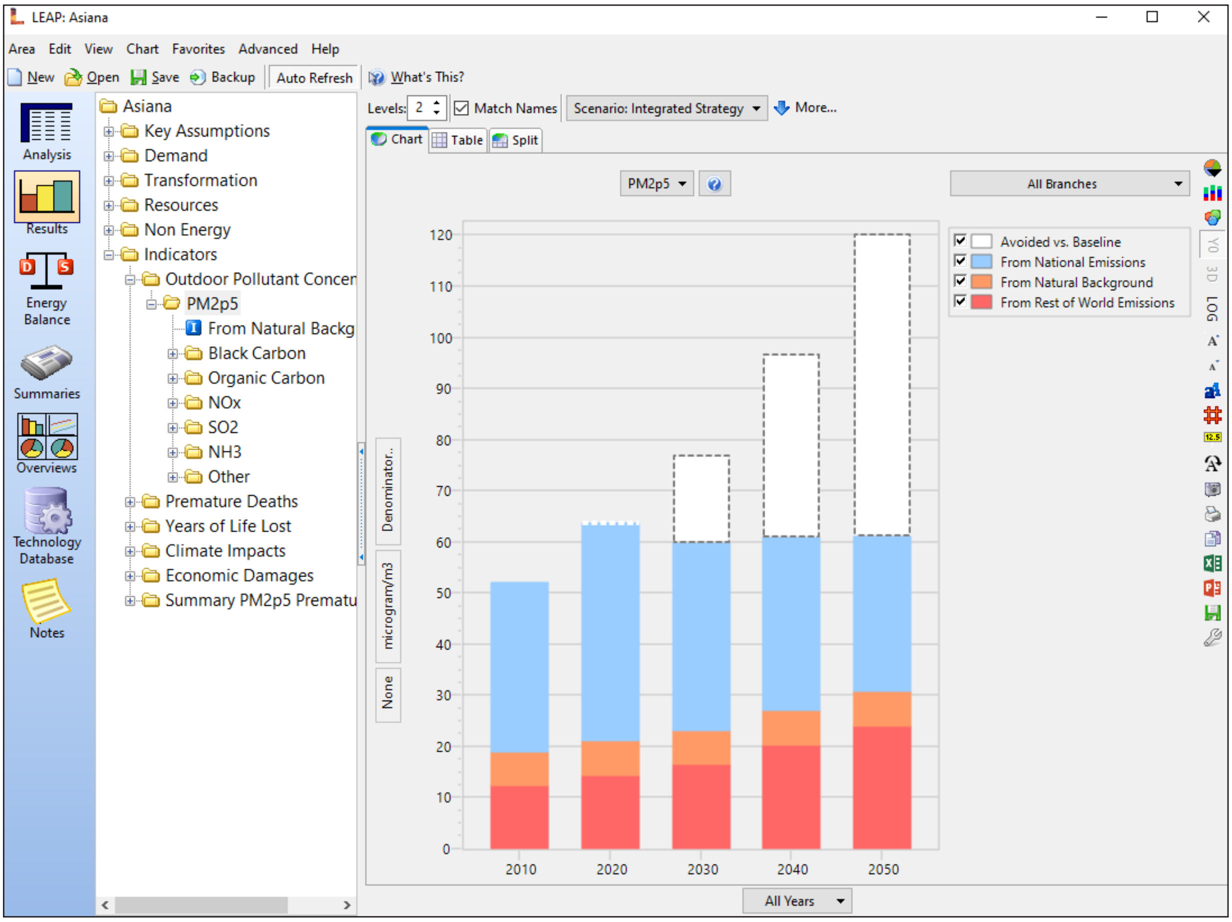
Model-based tools can help policymakers and technical advisors take decisions on how to most effectively reduce air pollution and GHG emissions. This can be done through quantitative modelling and/or assessments of the associated costs and impacts of different measures. These tools also help countries assess the extent to which they are contributing to limiting global temperature rise to 1.5°C.

One such tool is LEAP-IBC[2]. The tool enables practitioners to develop their own national models of emission projections, under different assumptions of future development. It also allows the impacts of different measures on air pollutants and GHG emissions to be quantified.

SEI has been using LEAP-IBC to support decision-makers and technical personnel in low, middle- and high-income countries. It has enabled them to plan cost-effective

2 Visit the LEAP-IBC webpage: https://leap.sei.org/default.asp?action=IBC

Figure 3: A screenshot showing health impacts attributable to $PM_{2.5}$ exposure in LEAP tool (Sample Results).



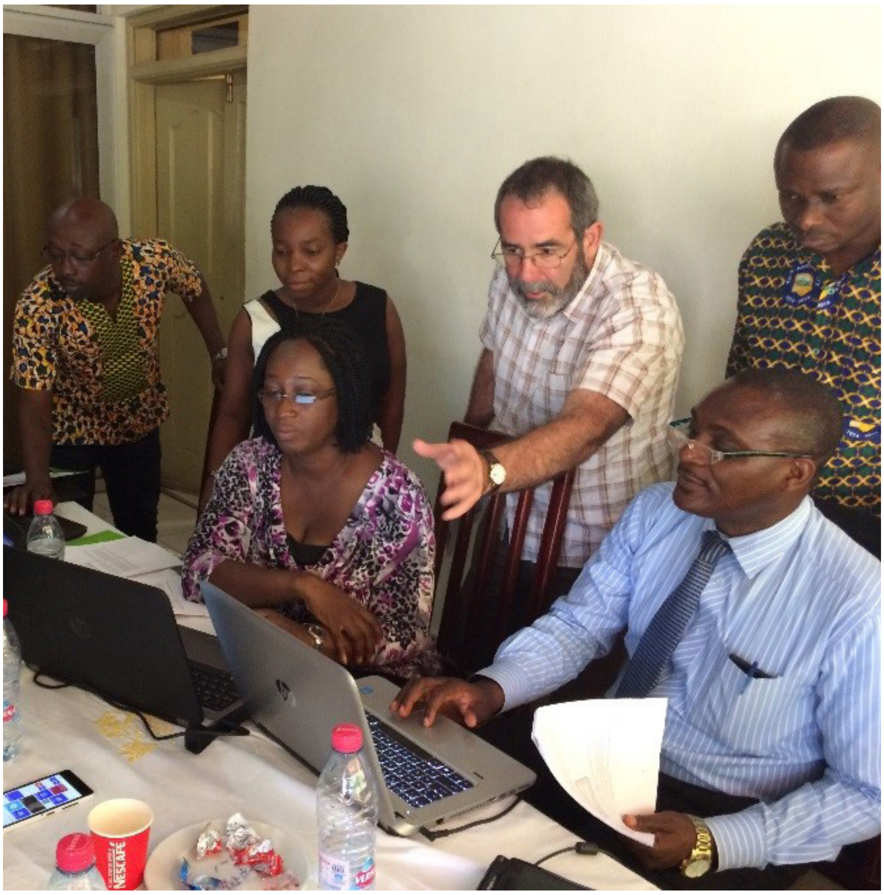
reductions in GHGs and air pollutants, simultaneously. Much of this work, developed under the Climate and Clean Air Coalition's Supporting National Action & Planning on SLCP mitigation (SNAP) initiative, has focused on developing strategies to limit emissions of SLCPs, and slow warming in the near term.

In addition, one module of the tool, the IBC, attempts to show how emission changes affect $PM_{2.5}$ concentrations in a country or city. This allows the users to assess the implications of their climate policies on human health and agriculture. The IBC also quantifies how the changes in emissions affect a country or city's contribution to global temperature change, relative to a baseline/reference scenario.

Linking the reduction of air pollution with the reduction of GHGs, yields near-term and long-term benefits for the climate, local air quality and human health. Where modelling is applied, the end result is enhanced liveability of the locations. Projecting the monetary and social costs of implementing these combined air pollution/GHG mitigation measures, versus the incurred gains, shows the positive impacts on the local economy, and people's health, income and wellbeing.

In partnership with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), SEI is further developing LEAP-IBC, to apply it on a city-scale. There are opportunities for fast action at urban scales - to improve people's lives in cities, and contribute to the 1.5°C goal. SEI is currently working with authorities in Johannesburg and Tshwane (South Africa) and Accra (Ghana) to build this capacity, and identify actions that address both

Figure 4: A regional training on the LEAP tool for air pollution and climate change mitigation assessment held in Accra, Ghana in May 2016.



air pollutants and GHGs. SEI is also working with universities in West Africa, to apply the tool in Abidjan (Côte d'Ivoire), Kumasi (Ghana) and Lomé (Togo), while also considering novel monitoring approaches in a project being funded by UK Research and Innovation.

Concluding remarks

The global community needs to heed the messages of the IPCC 1.5°C report, and take action to limit emissions sufficiently to achieve this goal. It will require a concerted effort and ambitious action at all scales.

Part of the effort will be to motivate policy decisions. The political will to address environmental issues is often greater if the positive effects of action can be seen quickly, and at a local scale. Measures to address air pollution usually create more tangible, immediate and local benefits, than measures to address climate change. This is especially the case for benefits to human health as it is a very strong driver of policy change – so emphasizing the health benefits of reducing air pollution can prove powerful.

Improved air quality can be achieved by simultaneously addressing emissions that cause climate change, but only if carefully chosen measures are implemented. By using appropriate modelling, such as the LEAP-IBC tool, the right measures can be identified. Facilitating integrated strategy design in this way, allows the benefits felt at a local and national level, to ultimately lead to global benefits.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Stockholm Environment Institute

Published by
Stockholm Environment Institute
Linnégatan 87D, Box 24218
104 51 Stockholm, Sweden
Tel: +46 8 30 80 44

Author contact
johan.kuylenstierna@sei.org

Media contact
frances.dixon@sei.org

Visit us: sei.org
Twitter: @SEIresearch
@SEIclimate

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