

## The Multiple Benefits Pathway Framework

### *A framework to maximize multiple climate and clean air benefits on the path to the Paris targets; and its practical application*

#### Methodology Briefing

### Overview

The purpose of this methodology briefing is to help inform technical and nontechnical audiences about the multiple benefits pathway framework, how the process works and the types of results that can be achieved. This is envisioned to be a ‘living’ document which will be refined and further developed by the CCAC SAP.

The sources and impacts of air pollution and climate change are closely interlinked, and many air pollutants have important effects on the climate. Active design and implementation of integrated air quality and climate measures can achieve multiple benefits which enable policy decisions that are more cost effective and coherent. The multiple benefits pathway framework enables policy-makers to quantify the multiple benefits of their actions to reduce air pollutants and greenhouse gas emissions. This provides a solid foundation upon which to build climate, environmental and public health policy.

### Definition of the Multiple Benefits Pathway Framework

The CCAC’s multiple benefits pathway framework is an integrated approach that links strategies to reduce emissions of CO<sub>2</sub>, Short-Lived Climate Pollutants (SLCPs), and other air pollutants. It allows for the identification of mitigation strategies that can maximise health improvements and other key local development priorities, and at the same time significantly reduce the rate or warming in the near-term (next 25 years) and long term (to 2100), contributing to the achievement of the Paris targets. This framework emphasises that the path we take to achieving the Paris temperature targets matters. This has been developed by the SAP and others as a way of highlighting that we need to take action immediately and that there are strategies that can significantly reduce climate and air pollution impacts in the near term – saving lives and reducing health impacts immediately – and every year after action is taken. These actions can be synergistic with strategies that will safeguard the climate over the longer term (end of century).

The multiple benefits pathway framework is an evolution of the messaging of the CCAC that responds to the agreement on the long-term temperature goals in Paris, but in practice it puts additional focus on saving lives and reducing temperature increase across timescales and is not so tied to SLCP mitigation *per se*. For many countries with high methane and BC emission, the largest reductions in near-term temperature is likely to come from implementing SLCP measures, and their reduction in CO<sub>2</sub> will mainly provide long-term climate benefits. However, for other countries, such as Norway, with low SLCP and air pollutant emissions, CO<sub>2</sub> reductions give the largest reduction in both near-term and long-term temperatures. By incorporating both air quality and climate, the framework also provides a clearer look at strategies to protect long-term climate that do not necessarily lead to large near-term climate benefits, such as a transition away from coal use, since it shows their near-term health benefits. Therefore, this framework emphasises the societal goals (local and global) rather than the strategies.

The CCAC has been developing practical applications of the framework that can be applied by practitioners in countries, sub-national regions or cities using different tools. These first estimate baseline emission scenarios, and then different mitigation scenarios covering part or preferably all of this century. These tools can then illustrate the benefits to reducing warming in annual time steps relative to a baseline, and the number of avoided deaths from reduced air pollution and can compare different strategies to identify those that will help to reduce near-term climate change and save lives. These can be compared in a simple way to global temperature goals (e.g. the goal in the SAP paper to reduce the rate of warming over the next 25 years by 50%)<sup>1</sup>, by comparing the percentage reduction in the global warming of the different national strategies.

The framework:

- Encourages countries to evaluate their Nationally Determined Contributions in terms of different pollutants (in mass units) rather than CO<sub>2</sub>e, to allow health and warming trajectories to be calculated.
- Supports countries wanting to undertake the multiple benefits assessment by providing access to tools and training to help them to implement the framework.
- Encourages further integration of efforts at national levels requiring increased interactions between authorities responsible for air quality, climate change and health, and their interactions with ministries responsible for key source sectors;
- Enables assessment of the multiple benefits that result from the climate change strategies, and air quality plans and national development plans.

## Practical Application of the Framework

The multiple benefits pathway framework can be practically applied by a country wishing to model emissions reduction scenarios, concretely demonstrating the emissions reductions possibilities, and calculate the potential near- and long-term temperature reductions for the world, and the social and economic benefits that will accrue from mitigation measures in the country taking action, especially but not only related to reducing air pollution. If desired, the pathway analysis can be performed to assess the multiple impacts of emissions reductions calculated by countries (or organizations) independently (e.g. plans formulated prior to taking on a pathway analysis).

To apply the framework, it is necessary to:

### Develop Integrated Emissions Inventories and Scenarios

- Develop a comprehensive base-year emissions inventory of all particles and gases affecting the climate, PM<sub>2.5</sub> and ozone pollution.
- Ideally specific emitted species would include: CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, BC, HFCs, NO<sub>x</sub>, SO<sub>2</sub>, OC, CO, NMVOCs, NH<sub>3</sub>, and other primary PM<sub>2.5</sub> species.
- All emissions should be calculated in mass units (e.g. tonnes).
- Develop a baseline scenario for all sectors causing these emissions.

<sup>1</sup> UNEP & WMO (2011) *Integrated Assessment of Black Carbon and Tropospheric Ozone*. UNEP: Nairobi.

<ul style="list-style-type: none"> <li>• Evaluate all mitigation plans that exist for the country – e.g. NDC, other climate laws / strategies, air quality management strategies, national development plans etc. and develop emissions mitigation scenarios that characterize those plans</li> <li>• A number of integrated mitigations scenarios should be developed which take into account existing and planned policies.</li> </ul>
<p><b>Calculate Atmospheric Concentrations</b></p>
<ul style="list-style-type: none"> <li>• Use atmospheric transport and chemistry models, or linear coefficients developed from these models, to estimate concentrations of PM<sub>2.5</sub> and ozone, and other pollutants</li> </ul>
<p><b>Quantify Public Health, Agricultural, and Climate Effects</b></p>
<ul style="list-style-type: none"> <li>• Use concentration-response-functions between PM<sub>2.5</sub> and ozone and human health. The most used are those between these pollutants and premature mortality</li> <li>• Use concentration-response-functions between ozone and crop yields and forest growth and link these impacts also to climate change</li> <li>• Use approaches to estimate the impact of all these emissions on global temperature over time – i.e. understand their impact in the near and long term</li> </ul>
<p><b>Assess Policy Options</b></p>
<ul style="list-style-type: none"> <li>• Assess these different policy options to identify those which conflict in terms of attainment of the different air quality and climate goals, and where synergies exist, and assess which packages of measures will be likely to provide the maximum benefit for climate and clean air, in the near and long term.</li> </ul>
<p><b>Implement Measures</b></p>
<ul style="list-style-type: none"> <li>• Incorporate the results into policymaking processes such as Nationally Determined Contribution pledges</li> </ul>

## Recommended Pathway Metrics

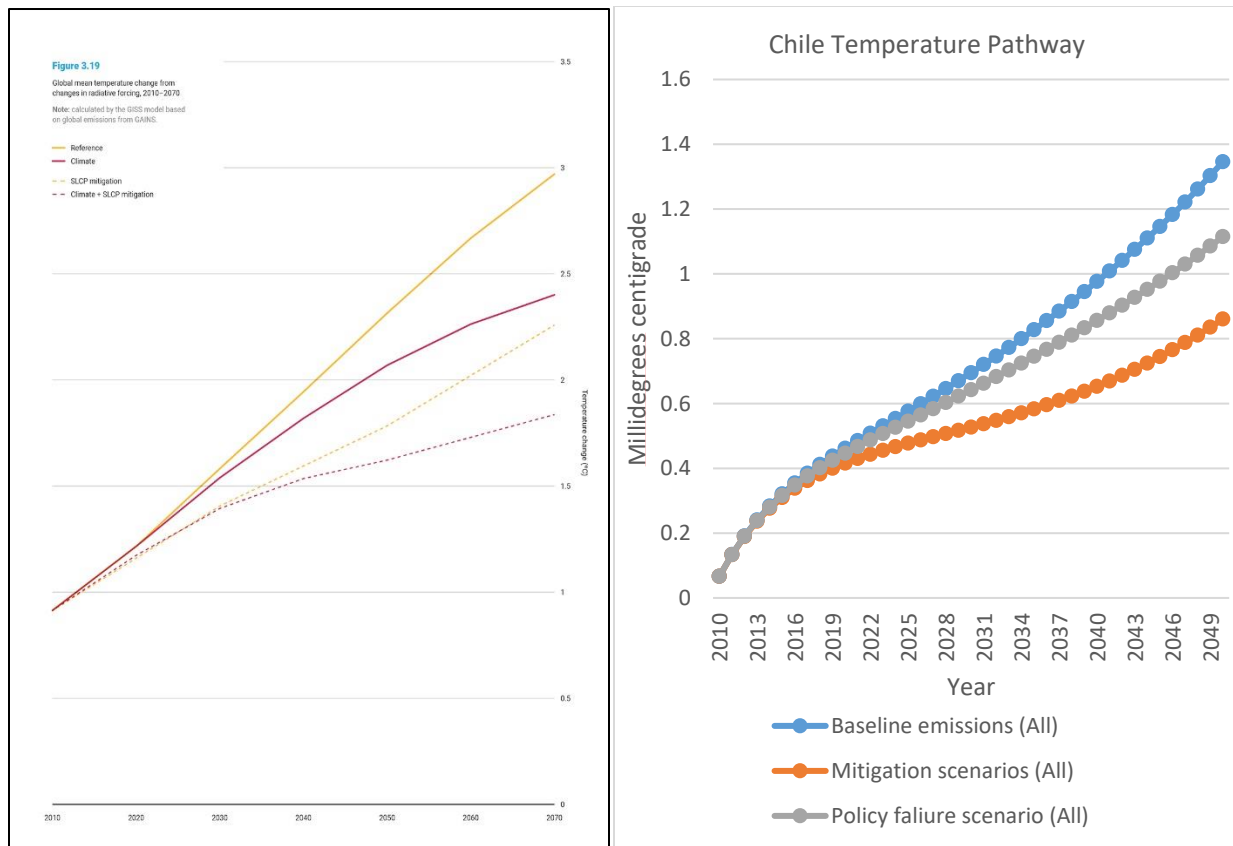
Metrics are needed to quantify the impacts and benefits of the implementation of measures and policies which affect emissions of climate forcing substances and other air pollutants. In March 2017, the CCAC Scientific Advisory Panel convened an expert workshop to evaluate and recommend appropriate climate, health, agriculture, and economic impact/benefit metrics for use by the Coalition.<sup>2</sup> This section is adapted from these recommendations.

<sup>2</sup> CCAC (2017) CCAC Scientific Advisory Panel Expert Workshop on Metrics and Inventory Development. <http://ccacoalition.org/en/resources/climate-clean-air-coalition-scientific-advisory-panel-expert-workshop-metrics-and>

### Recommended Climate Metrics

The SAP recommends the use of Absolute Global Temperature Potential (AGTP) to assess the impact of different substances (including long-lived and short-lived substances) on global warming as well as the effectiveness of emissions reduction in mitigating the rate of warming in the near term. This recommendation is also based on the IPCC fifth assessment report (AR5).<sup>3</sup> AGTP can provide estimates of the temperature change for a given year for a given emission profile. These metrics incorporate the radiative efficiency and lifetime of emitted substances (or climate drivers produced from those substances) and the time-dependent response of the climate system to estimate the surface temperature response to a tonne of emission over time.

Temperature impacts can be expressed as a progression of temperature change, i.e. a temperature pathway, in annual time steps and thus compare the influence of difference emissions scenarios on global temperature change over a short or long time period. The SAP has developed a tool using AGTPs that readily provides temperature evolutions for any input set of emissions over time.

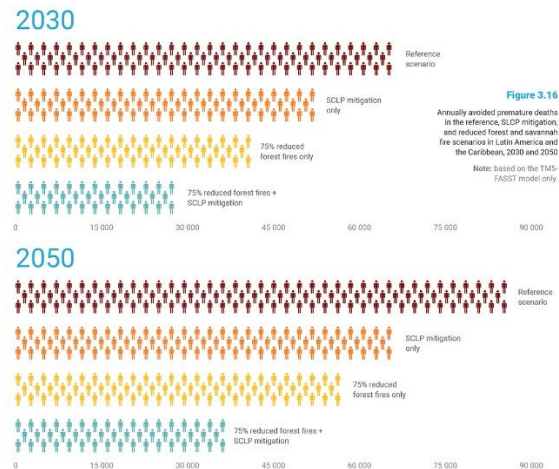
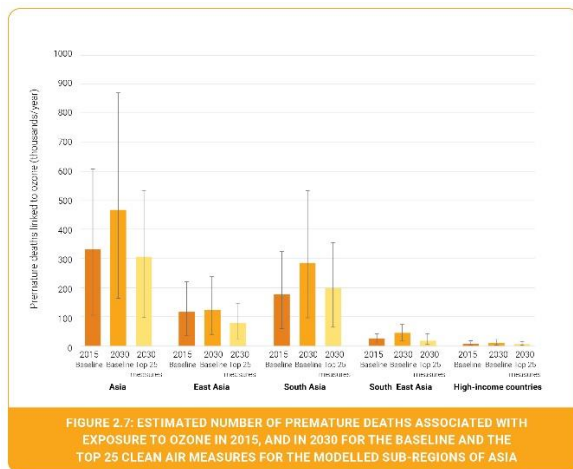


**Figure 1** - (left) Latin America and Caribbean Assessment (2018); (right) Chile’s temperature pathway for residential sector scenarios. The mitigation scenario includes home insulation and replacement of wood-burning stoves. The Policy Failure Scenario contemplates 50% of wood burning stoves remaining by 2049. Analysis conducted as part of 2018 Pathway Task Team practical test of the SAP Pathway Tool.

<sup>3</sup> Myhre et al. 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, et al (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

### Recommended Health Metrics

For health impacts, metrics would ideally align with those used in the analysis of the Global Burden of Disease (GBD), and those suggested by the World Health Organization (WHO).<sup>4</sup> These include Equivalent Attributable Deaths, Years of Life Lost (YLL), Years Lived with Disability (YLD), and Disability Adjusted Life Years (DALYs).



**Figure 2** – (left) Asia Pacific Solutions Report; (right) LAC Assessment

Health impacts can also be expressed in terms of changes in population exposure to concentrations of air pollutants, such as PM<sub>2.5</sub>. For example, the CCAC Asia Pacific Science-Based Solutions Report calculated the population-weighted exposure to PM<sub>2.5</sub> between 2015 and 2030 for different packages of mitigation measures compared to WHO air quality standards.

<sup>4</sup> See for example: [http://www.who.int/phe/health\\_topics/outdoorair/databases/AAP\\_BoD\\_methods\\_March2014.pdf](http://www.who.int/phe/health_topics/outdoorair/databases/AAP_BoD_methods_March2014.pdf)

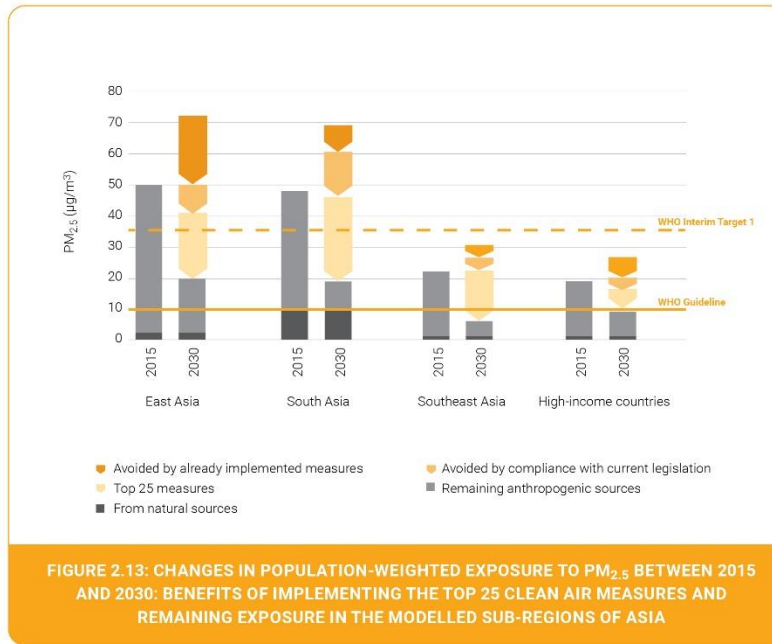


Figure 3 – Asia Pacific Solutions Report

### Agricultural and Vegetation Metrics

For agricultural impacts, the SAP recommends, the relative yield loss, expressed either as a percentage of expected yield (relative loss) or as a total amount of yield loss in tonnes. More work is needed to increase the number of crops covered in this analysis beyond the four staple crops currently available.

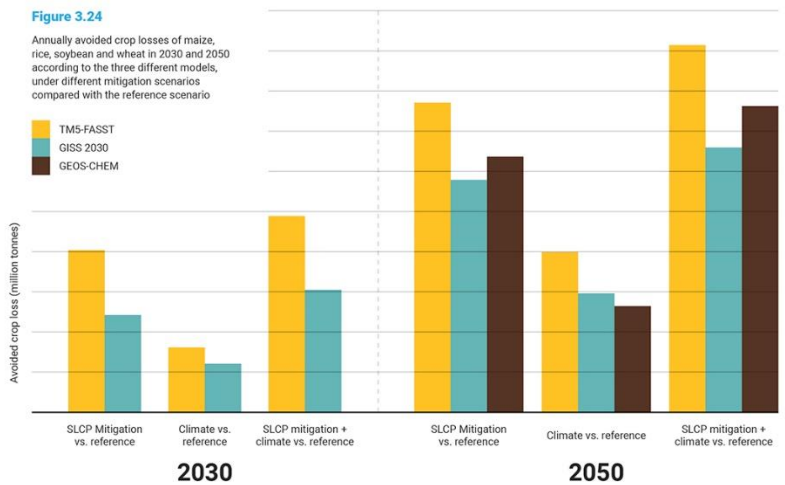


Figure 4 – LAC Assessment

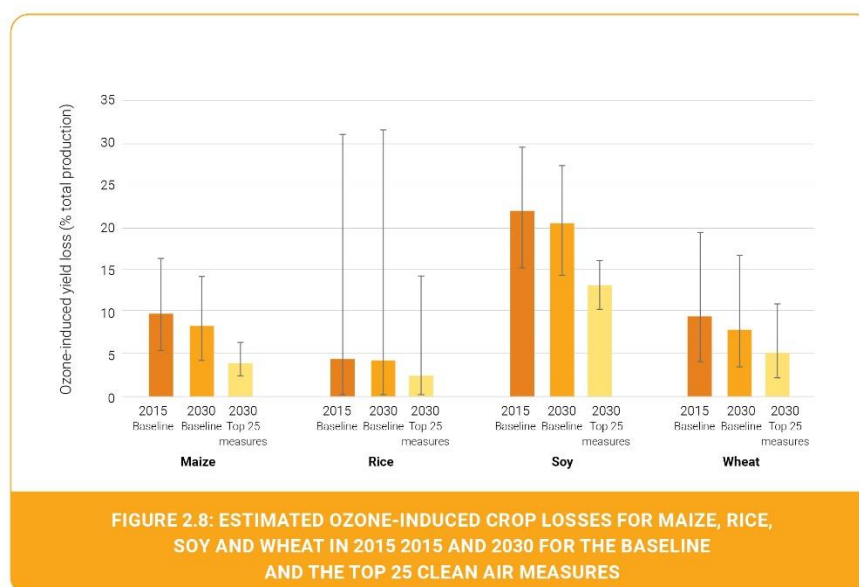


Figure 5 – Asia-Pacific Solutions Report

### Economic Valuation of Impacts/Metrics for Financing

The “social cost of emissions” is recommended as a method for assessing monetary value of the climate and air quality impacts of emissions as it attempts to incorporate monetized market and non-market impacts over time. The “cost of illness”, “willingness to pay”, “value of a statistical life” and “forgone output” (which are already incorporated into social costs) are among the metrics that can be used for the economic valuation of health impacts/benefits, but it is important to take into consideration what is acceptable and the local context in different countries. Further work is needed to describe the robustness of calculations through the impact pathway from emission to impact and value: this needs to stress ‘certainty’ as well as ‘uncertainty’.

### Practical application of the multiple benefits pathway framework to national strategies: Relevance to Global Progress

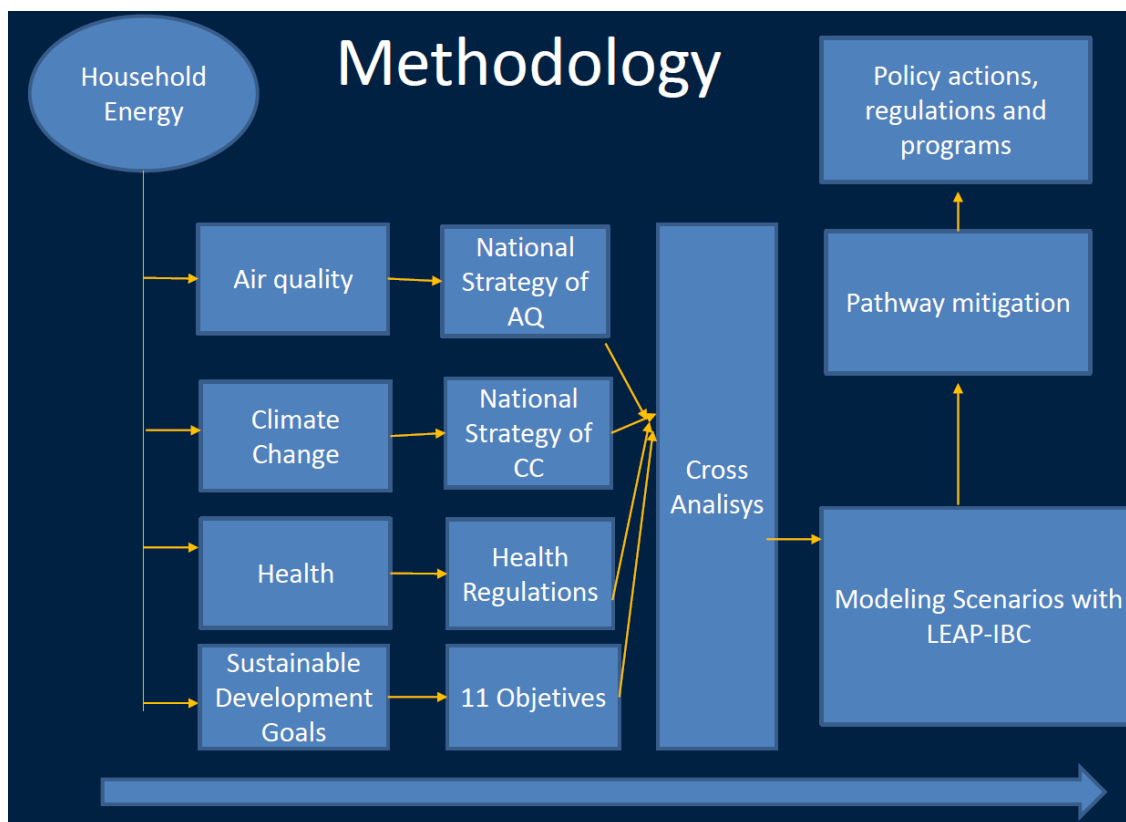
A pathway analysis is useful for assessing how planned or proposed mitigation actions can support achievement of a low temperature increase in the near-term, achievement of the Paris temperature targets, and highlight the air pollution benefits of the emission reductions. The CCAC and its partners have developed and applied tools, such as the SAP Pathway Tool and LEAP-IBC, that can be used to estimate the impact of emission scenarios on global temperature.

The SAP Pathway Tool needs the input of all relevant emissions affecting temperature and then calculates the change in temperature in annual timesteps for the globe and for four latitudinal bands. It also shows the degree of influence of different warming and cooling substances over time. It uses globally averaged coefficients to calculate the temperature changes. For policies primarily affecting

methane emissions alone (e.g. capture of fugitive methane or waste sector controls), the tool also provides values for public health and agricultural benefits (avoided deaths, yield losses, and their valuations).

LEAP-IBC can be used to calculate emission scenarios – both baseline and mitigation scenarios from different sectors. It then uses the same calculations as the SAP Pathway Tool to calculate temperature responses. The difference is that the LEAP-IBC tool more fully takes into account the location of emission in relation to the impact on temperature in different latitudinal bands and hence the globe. It similarly shows the influence of different pollutants and GHGs on temperature in annual time steps. Further to that LEAP-IBC also can calculate the impact of emissions on national population weighted PM<sub>2.5</sub> concentrations using linear coefficients derived from the GEOS-Chem Adjoint model. These are used with concentration-response functions to estimate changes to national premature mortality. There are also linear coefficients relating ozone precursors to ozone concentrations which are linked to concentration-response functions for human health (premature mortality again) and the change in yield of four staple agricultural crops (rice, wheat, maize, soybean). As ozone formation is non-linear in relation to the relative concentration of ozone precursors (especially local NO<sub>x</sub> and NMVOCs) this calculation is only valid for limited changes in emissions.

The CCAC SNAP Initiative has used the LEAP-IBC tool to estimate the particulate and ozone pollution changes related to emissions from a number of countries and calculated the health and crop yield impacts due to those changes. One country, Mexico, is applying the framework and the processes being used is described in Figure 6 for their examination of household energy alternative strategies. They first considered all the regulations affecting household energy, developed mitigation scenarios taking these into account, used LEAP-IBC to examine the different strategies in relation to the outcomes for temperature and health over the following decades and this then would feed into their decision-making process in Mexico.



**Figure 6** - Example of the approach developed by INECC in Mexico to examine the Pathway Framework in relation to household energy strategies

### Real World Example of the Multiple Benefits Pathway Framework

Ghana has been heavily engaged in the SNAP initiative and has produced a National SLCP plan that considers the implications of different national strategies for the pathway to the Paris targets. Using LEAP-IBC they estimated the change in emissions according to a baseline scenario, compared to different mitigation strategies with different levels of ambition until 2040 (outlined in Table 1). LEAP-IBC gives emissions of 10 major emissions affecting climate and air pollution. One example is given in Figure 8 for black carbon and in Figure 9 for methane. The baseline chosen is the scenario where emissions change according to major drivers, and that the legislation already agreed is not implemented.

As can be seen, if Ghana implements already agreed measures, the BC emissions reduce significantly, but this is not the case for methane. Implementing agreed NDC measures will make additional reductions for BC but large reductions for methane. Additional SLCP measures will help reduce emissions a bit further. Similar graphs for the other emissions can also be seen in Ghana's LEAP-IBC application.

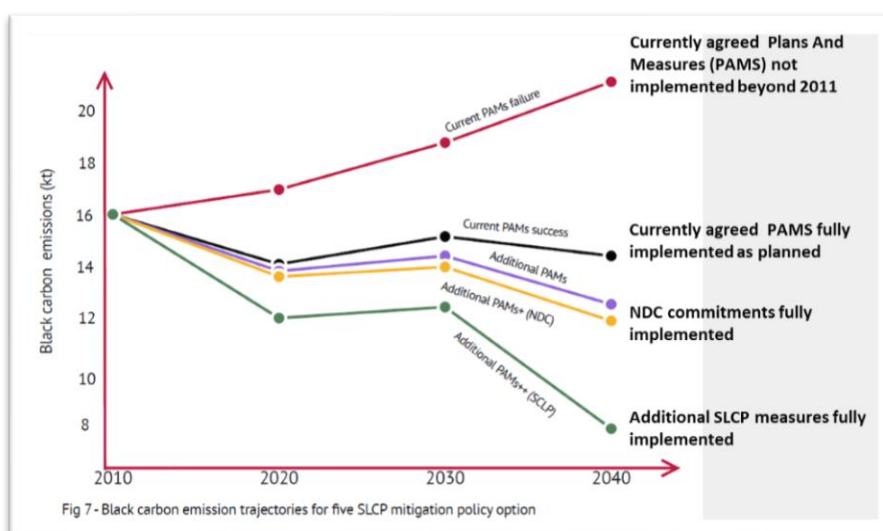
In Figure 9 it can be seen that these strategies have the potential to significantly reduce Ghana's contribution to global warming, and at the same time would reduce the number of premature deaths caused in Ghana by anthropogenic emissions in Ghana by about 30%. The number of deaths increases dramatically, partly due to the increasing and aging population but also because of an anticipated large

increase in the PM<sub>2.5</sub> imported from other countries due to long-range transport, according to the emission estimates from the IIASA GAINS ECLIPSE model runs, which is used as a default emission inventory for all other countries which are not the focus of the country application, and according to the GEOS-Chem adjoint model.

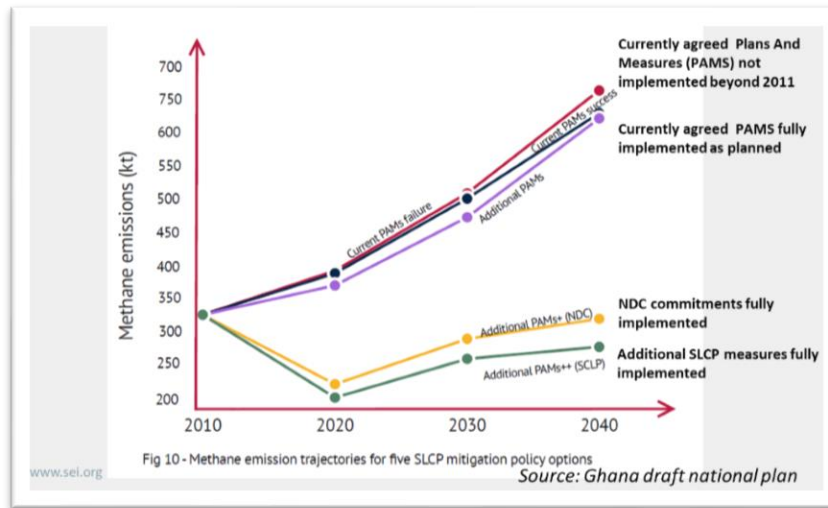
This then represents a Pathway framework analysis by Ghana, looking at different strategies and understanding how they can A. solve some of their national air pollution problems, and B. contribute to reducing global warming.

Sector	SLCP abatement measures	Rank	SLCP policy package	Measure outlook
Energy	LPG for cooking (LPGC)	High	Additional PAMs	Low hanging fruits
Energy	Solar systems (SS)	High	Additional PAMs	
Forest	Reduced forest burning (RFB)	Low	Additional PAMs+	NDC measures
Waste & energy	Institutional Biogas (IB)	Low	Additional PAMs+	
Transport	Promote CNG Buses (CNG)	High	Additional PAMs+	
Waste	Stop open-burning (SOB)	Medium	Additional PAMs+	
Waste	Landfill gas management (LFM)	High	Additional PAMs+	
Energy	Improved cookstoves (ICS)	High	Additional PAMs+	
Energy	Natural Gas for electricity (NGE)	High	Additional PAMs+	
Energy	Eco-friendly electricity (EFE)	Medium	Additional PAMs+	
Energy & forest	Efficient charcoal kilns (ECK)	High	Additional PAMs+	
Agriculture	Quality livestock feeding (QLF)	Low	Additional PAMs++	
Transport	Vehicle testing standards (VTS)	Medium	Additional PAMs++	SLCP measures
Energy	Cutting-edge stoves (CES)	Medium	Additional PAMs++	
Industry	Gas in plastic industry (GPI)	Low	Additional PAMs++	

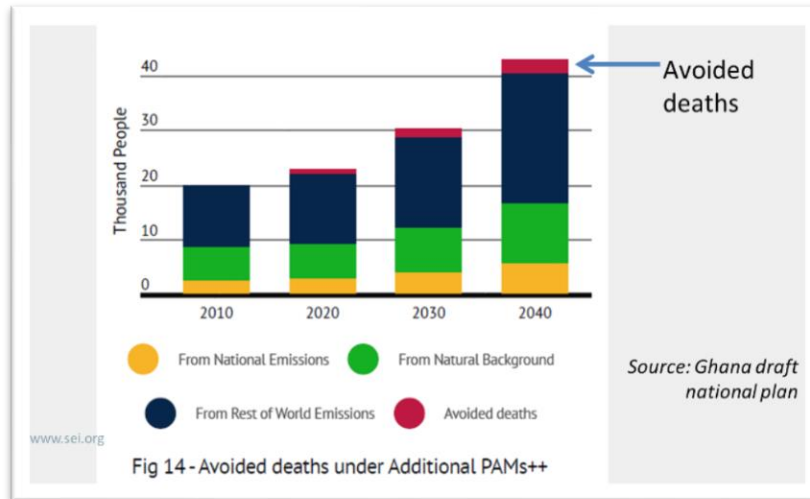
**Table 1.** Strategies investigated in the Ghana National SLCP plan



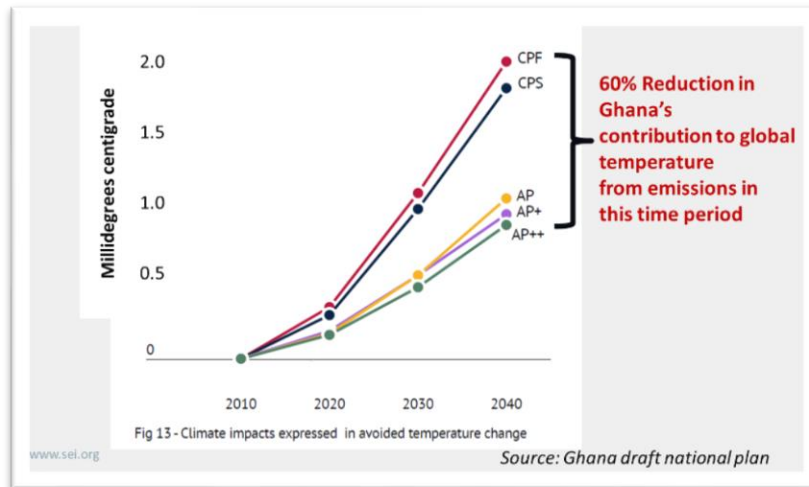
**Figure 8.** The impact of the different strategies on BC emissions in Ghana as calculated by the Ghana EPA using LEAP-IBC



**Figure 9.** The emissions of methane from Ghana according to the different strategies in the national SLCP plan calculated by Ghana EPA using LEAP-IBC



**Figure 10.** The impact of the full package of measures contemplated in the national SLCP plan in Ghana on premature mortality in Ghana caused by PM<sub>2.5</sub> as calculated by the Ghana EPA using LEAP-IBC



**Figure 11.** The impact of the different strategies included in Ghana’s SLCP plan on global temperature until 2040 showing that if all measures considered are fully implemented, then the contribution of Ghana to global temperature could be reduced by about 60% compared to the baseline scenario.