Executive Summary

Introduction

This report addresses the mitigation of short-lived climate forcers (SLCFs) and its key role in air pollution reduction, climate protection and sustainable development. SLCFs are substances in the atmosphere that contribute to global warming and have relatively short lifetimes in the atmosphere. The focus is on three SLCFs – black carbon, tropospheric ozone and methane – because reducing them will provide significant benefits through improved air quality and a slowing of near-term climate change[1].

The 'win-win' benefits for climate and public health have been overlooked in the wider climate change and air-quality debate. The challenges of improving air quality and mitigating climate change, as well as those of human development, are inextricably linked. Policy paths that integrate air quality, climate change and key development concerns bring mutual payoffs. This report builds on the *Integrated Assessment of Black Carbon and Tropospheric Ozone* (UNEP/WMO, 2011)[2] and describes the considerable benefits that different regions of the world could experience if they were to implement specific emission-reduction measures. By including cost implications and options to promote action at the national, regional and global levels, this report charts a path for the widespread implementation of the identified measures.

Reducing SLCF concentrations now is likely to slow the rate of global warming over the next two to four decades. Near-term warming is pushing natural systems closer to thresholds that may lead to a further acceleration of climate change. For example, the melting of permafrost in the Arctic is releasing additional quantities of methane into the atmosphere, which in turn contribute to additional global warming.

Air pollution is impeding sustainable development because it threatens human health and crop production, especially in developing countries. The World Health Organization (WHO) estimates that 3.1 million people (WHO, 2009), mostly in developing countries, die prematurely each year from indoor and outdoor air pollution. Two SLCFs – black carbon and tropospheric ozone – are important pollutants causing these health impacts. In addition to the direct health impacts, ozone pollution reduces the productivity of crops and natural vegetation. A third SLCF – methane – is not an air pollutant but it contributes to tropospheric ozone pollution and its health and environmental impacts.

Climate change also presents numerous barriers to development in the near term. Current warming is already having many harmful effects, which will have the greatest impact on the world's most vulnerable populations and places. Lakes are building up at the foot of melting glaciers and are threatening to burst and cause floods downstream; warmer temperatures are leading to more frequent heat-waves; the melting of land ice in the Arctic is contributing to sea-level rise throughout the world; and shifting climatic zones of plant and animal life threaten the existence of some species. Slowing down near-term warming would reduce the intensity of these impacts and give society and nature more time to adapt to climate change.

A package of 16 measures for reducing emissions of black carbon and methane has been identified that could provide substantial combined benefits for air quality

1. A subset of hydrofluorocarbons (HFCs) also have short lifetimes and warm the atmosphere, but do not currently have air quality impacts and are not the focus of this report.

2. Available from: <http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_SDM.pdf>

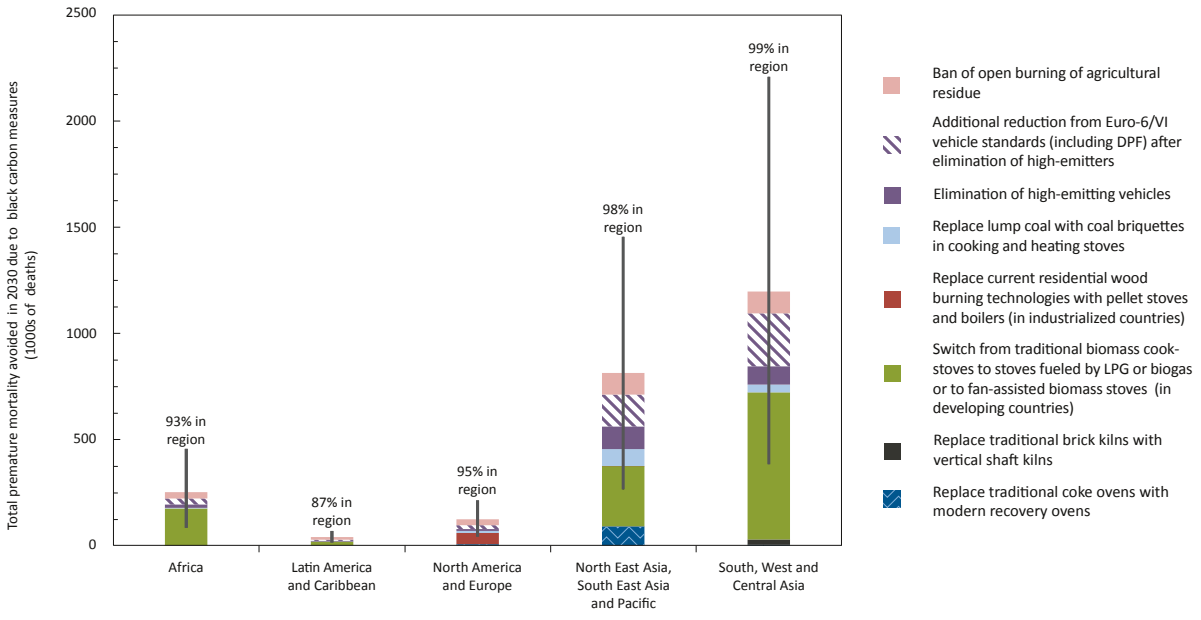
and near-term climate protection. These measures can accomplish about 38 per cent reduction of global methane emissions and around 77 per cent of black carbon emissions, if implemented between now and 2030, relative to a 2030 'reference' emission scenario. The 'reference' scenario is based on a 'business-as-usual' energy demand projection and does not include any new legislation relevant to SLCF emissions beyond that already agreed. These 16 measures form a strong starting point for the reduction of SLCF impacts in all regions, although additional measures may be more appropriate in specific circumstances. The benefits described in the following paragraphs assume that the measures will be fully implemented worldwide by 2030, starting immediately.

The air quality benefits of short-lived climate forcer mitigation

Confidence is high that black carbon measures would provide substantial health benefits. The reduction in outdoor particulate air pollution from having fully implemented the measures by 2030 would avoid an estimated 2.4 million (range 0.7–4.6 million)[3] premature deaths annually. It would also greatly reduce impacts on health from indoor exposures. The health benefits of the measures come from reduced exposure to fine particulate matter ($PM_{2.5}$) resulting from reductions in black carbon and other particle emissions. Because particulate matter is reduced rapidly after the measures have been implemented, the health benefits will also be felt immediately. Due to the very high particulate-matter burden in Asia, the black carbon measures could prevent a greater number of premature deaths in this region than elsewhere (Figure ES-1) with the next highest benefit likely to be achieved in Africa. Health benefits in these two regions are mainly achieved by controlling biomass cookstove and transport emissions.

Confidence is also high that controlling methane emissions and ozone precursor emissions by implementing black carbon measures would reduce ozone concentrations and its impacts on crops. Implementing all 16 measures would avoid annual losses from four major crops of about 32 million tonnes (range of 21-57 million

Figure ES-1: The annual reduction in premature deaths from the implementation of different black carbon measures in each region in 2030. The percentage given above each bar indicates the proportion of avoided deaths from inhalation of outdoor air pollution particles within the region that implements the measures. Vertical grey bars indicate the uncertainty range in the mortality figures based on the uncertainty in the concentration-response relationships



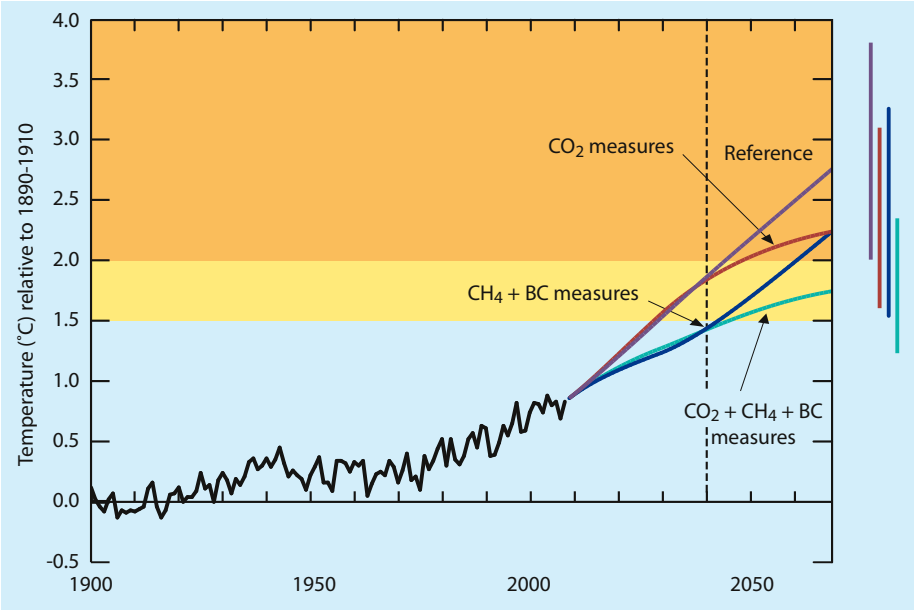
3. The ranges for health and crops reflect the uncertainty in the concentration-response relationships alone and not uncertainties in the estimation of concentrations.

tonnes) each year after 2030 when all the measures have been implemented (note that the UNEP/WMO Assessment gave a higher central value of 52 million tonnes, reflecting differences between global models). Half of these benefits result from implementing the methane mitigation measures and the other half from black carbon measures. The greatest crop benefit from the methane measures comes from reducing emissions from coal mines, especially in North East Asia, South East Asia and the Pacific; from oil and gas production in all regions; and from long-distance natural gas transmission pipelines in North America and Europe. The crop benefits from action on black carbon emissions largely come from the implementation of measures in the transport sector, especially the wider implementation of Euro-6/VI standards.

The near-term climate benefits of reducing short-lived climate forcer concentrations

Reducing the three short-lived climate forcers offers a realistic opportunity to significantly reduce the rate of global warming over the next two to four decades. If fully implemented by 2030, the 16 measures are estimated to reduce global warming between 2010 and 2050 by about 0.4°C (this study)[4] to 0.5°C (from the *Integrated Assessment of Black Carbon and Tropospheric Ozone,* UNEP/WMO, 2011). From here on we make reference to the 0.4°C global decrease from this study. While maximum benefits will be reached by 2050, the bulk of the benefits will already be realised by 2040, as indicated by the dotted line in Figure ES-2. This is compared to the temperature

Figure ES-2: Observed deviation of temperature to 2009 and projections under various scenarios from the *Integrated Assessment of Black Carbon and Tropospheric Ozone* (UNEP/WMO, 2011). Implementation of the identified black carbon (BC) and methane (CH_4) measures between 2010 and 2030, together with measures to reduce carbon dioxide (CO_2) emissions, would greatly improve the chances of keeping the Earth's temperature increase to less than 2˚C relative to pre-industrial levels. The uncertainty of the temperature projections in 2070 is shown by the lines on the right hand side[5]

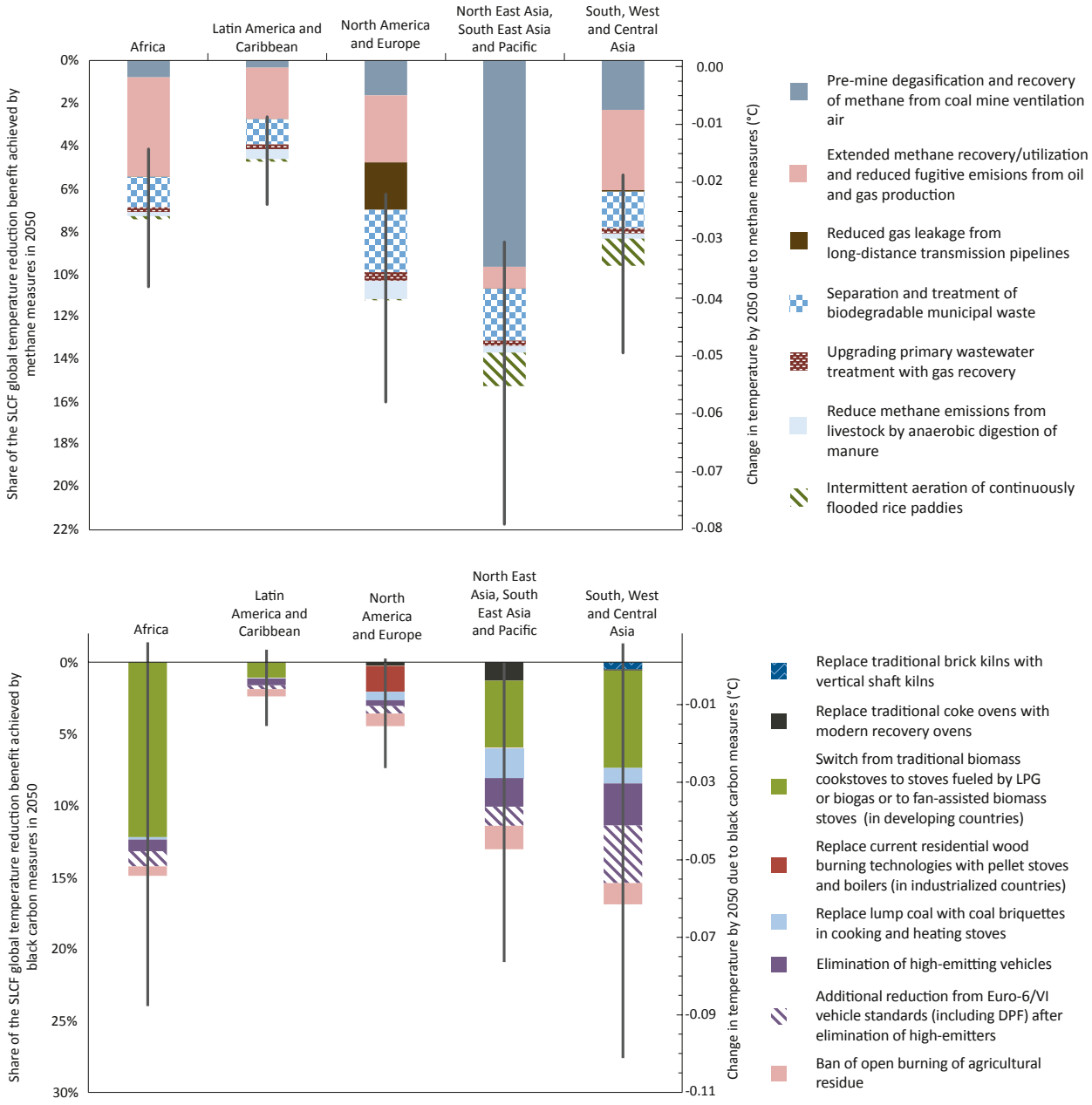


Source: UNEP/WMO (2011) using an average of two global composition-climate models (GCMs) that estimate pollutant concentrations, radiative forcing and global climate

4. The TM5-FASST model was used to disaggregate the influence of the different measures on temperature. This model estimated total temperature change to be closer to 0.4°C than 0.5°C as estimated in the Assessment by the NASA-GISS and ECHAM models (UNEP/WMO, 2011), but this will not affect the proportional contribution of the measures to the reduced warming.

5. The uncertainty for black carbon on global temperature is greater than for methane, whose impact is relatively well known. It is possible that the impact of black carbon on warming could be around zero, but current knowledge suggests that it is more likely that removing black carbon would provide a net global climate benefit.

Figure ES-3: The estimated impact of methane (top) and black carbon (bottom) measures on global temperature expressed as their percentage share of the global temperature benefit delivered by the sum of all 16 measures in 2050 (left-hand axis) and in terms of absolute temperature change (right-hand axis). The absolute temperature benefit sums to 0.4°C (using TM5-FASST). When added together, the bars for both methane and black carbon add up to 100 per cent of the temperature reduction. Vertical grey bars indicate the uncertainty range in absolute temperature change due to the likely range of the radiative forcing of methane and black carbon (and co-emitted substances)



*Note: For biomass cookstoves, only the effect of substitution with LPG and biogas stoves is shown in the black carbon graph for clarity. With 100 per cent substitution by fan-assisted biomass stoves, the reductions would be slightly lower (i.e. the lengths of green bars would be 6 per cent shorter)

increase projected in the 'reference' scenario (Figure ES-2) and represents nearly a halving of the pace of global warming between 2010 and 2040. This 0.4°C benefit (range 0.1-0.6°C) might be maintained into the future, but the contribution of these measures to long-term climate protection is difficult to assess as it is hard to predict the development of SLCF emissions from different sectors in the reference scenario into the more distant future.

About half of the 0.4°C climate benefit in 2050 comes from implementing the black carbon measures, mainly in Asia and Africa, and the other half comes from implementing the methane measures, mainly in Asia, Europe and North America. Figure ES-3 shows the contribution of the different measures in the different regions to the global warming reduction of 0.4°C in 2050. The higher uncertainty of the black carbon measures on climate compared with the methane measures is shown.

The role of short-lived climate forcers in achieving longer-term climate goals and contributing to closing the 'emissions gap'

Although reductions of SLCFs would substantially slow the rate of climate change over the next few decades, they are likely to make only a modest contribution to longer-term climate goals and help narrow but not close a greenhouse gas 'emissions gap' in 2020[6]. Therefore, reducing SLCFs must be viewed as a strategy that complements but does not replace carbon dioxide emission reductions. Because SLCFs have a relatively short atmospheric lifetime, their concentrations decline fairly quickly in the atmosphere if their precursor emissions are drawn down. Hence, reducing methane and black carbon emissions can be an effective way to slow global warming over the next two to four decades. However, because SLCFs have a short atmospheric lifetime, their removal also has a relatively small effect on long-term global warming. As an example, assuming that all the SLCF measures were implemented in 2020, the influence of the emission reductions achieved in that year on global temperature over a 100 year time horizon would be about 1.1 Gt CO_2e (range: 0.4-1.7 Gt CO_2 e)[7]. This amount would help narrow but not close the 6-11 Gt CO_2e emissions gap[8] in 2020, i.e. the gap between expected emissions if countries comply with their reduction pledges, and emissions consistent with keeping global warming below a 2°C increase for a hundred years or more. Hence, while reducing SLCFs helps slow global warming and avoid exceeding the 2°C target, immediate reductions of CO_2 and other long-lived greenhouse gases are needed to meet the target over the long run.

Regional variation in benefits from implementing the SLCF measures

In Asia, about 1.9 million premature deaths from outdoor air pollution could be prevented each year, by 2030, by implementing black carbon measures addressing the transport and residential sectors and open agricultural biomass burning. Methane measures in Asia would provide about the same global climate benefit as black carbon measures. Most of the climate benefit from methane emission reductions derives from coal mine methane recovery, especially in North East Asia, and reducing emissions from oil and gas production in South, West and Central Asia, as well as through better management of municipal waste. For black carbon, measures in Asia addressing emissions from traditional biomass cookstoves and transport would provide the largest climate benefit.

In North America and Europe, the largest climate benefit would be realized by implementing measures to reduce methane emissions from coal mining, oil and gas production and better management of municipal waste. These same measures, together with measures in the transport sector, would also bring large crop-yield benefits. Further action on black carbon emissions to replace current domestic wood-burning technologies with pellet stoves/boilers, and banning the outdoor burning of agricultural residues in countries where this practice continues, would provide climate benefits, especially for the Arctic. Shipping activity near the Arctic, which is a source of black carbon emissions, is a growing black carbon concern.

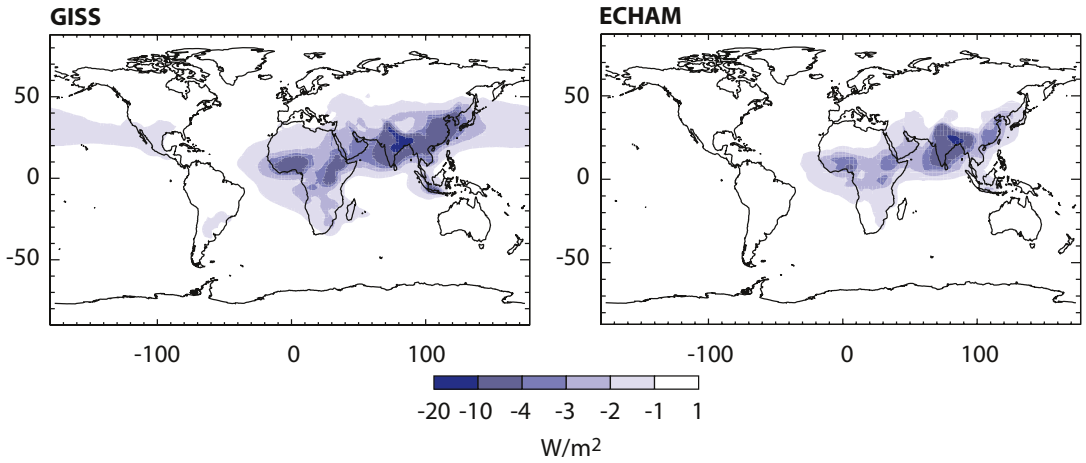
In Africa, action on black carbon, especially from biomass cookstoves, would potentially provide the largest near-term climate benefit, although the impact of black carbon mitigation on climate is subject to a higher uncertainty than

6. UNEP, 2011b.

7. Converting black carbon and methane emission reductions to CO_2 equivalents using their Global Temperature Potentials for a 100 year time horizon.

8. UNEP, 2011b.

Figure ES-4: Change in atmospheric forcing in the year 2030 relative to the reference scenario in the two general circulation models (GISS and ECHAM) of the *Integrated Assessment of Black Carbon and Tropospheric Ozone* (UNEP/WMO, 2011). The greatest benefit for regional climate would be expected where there is the greatest change in atmospheric forcing (shown by the darker areas in the two maps). Here the benefit is expected to result from reduced disruption of rainfall patterns. The results of two models using the same input data are shown and they demonstrate similar results, despite having very different treatment of aerosols in the models



methane mitigation. The biomass cookstoves measures also provide large benefits to health protection and would prevent about 200,000 premature deaths from outdoor air pollution each year by 2030. The methane measures that bring about the largest benefit for crops and near-term climate are mainly those in the oil and gas production industries, better management of municipal waste and reducing the release of methane from coal mines.

In Latin America and the Caribbean, methane measures would provide a larger climate benefit compared to black carbon measures, mainly by recovering methane from oil and gas production and better management of municipal waste. Black carbon measures deliver more modest climate and health benefits in this region, but a relatively large benefit for crop yields, all from addressing diesel-vehicle emissions.

The package of 16 black carbon and methane reduction measures would also have a major positive impact on regional climate protection:

- A reduction in SLCFs would slow the projected warming in the Arctic by about 0.7°C in 2040, about two-thirds slower than the pace of warming under the reference scenario described above. This is very significant in light of the rapid rate at which Arctic land- and sea-ice is now melting.
- Current levels of black carbon and other particles in the atmosphere have disrupted regional weather patterns including the South Asian monsoon. Because the emission reduction measures would noticeably reduce the impact of SLCFs on the atmosphere in this region (Figure ES-4), it is possible that weather patterns could return to a less disturbed state.
- Reducing black carbon emissions would reduce the amount of these dark black carbon particles being deposited on snow and ice surfaces in the Himalayas and other mountainous areas. The deposition of black carbon is suspected of contributing to the accelerated melting of glaciers.

Taking action to reduce methane and black carbon emissions represents a 'no-regrets' policy because there is high confidence that the sum of the 16 measures would greatly reduce air pollution and its impact, thereby lowering barriers to sustainable development. Furthermore, there is high confidence that methane emission reductions would reduce global warming and that black-carbon emission reductions would result in regional climate benefits. There is still some uncertainty about the magnitude of global-warming benefits of black carbon emission measures, but the measures are expected to have a net positive global climate benefit.

The cost implications of the emission reduction measures

About half of the emission reductions of both methane and black carbon could be achieved by measures that would deliver financial cost savings (as a global average) over the lifetime of the measures. This estimate of

cost savings does not account for the economic gains associated with reduced health, climate, crop yield and ecosystem impacts. These same measures account for about half of the temperature benefit that could be achieved. However, these measures may be considered less profitable by private-sector investors who expect a fast return on their investments. As a result, it is unlikely that these SLCF measures would be implemented by market forces alone under current conditions. Nevertheless, the cost saving is an important feature that could encourage the development of financing schemes for these measures. The remaining temperature reduction could be achieved through measures that would be competitive in the global carbon market, and also by measures that have already been widely implemented by developed countries.

Options for short-lived climate forcer policy development and implementation

It is essential to link SLCF benefits and measures to wider policies and processes addressing air quality management, sustainable development and climate action. Existing processes and institutions at the national, regional and global scale could be the starting points for raising awareness, implementing measures and mainstreaming the issues into these policy arenas.

National-level policy options

The current state of knowledge is sufficiently robust to justify immediate action to reduce emissions at the national level. Countries can be confident that multiple benefits will be achieved if they were to begin the implementation of SLCF reduction measures. There are good reasons for giving special priority for actions at the national level. Firstly, the greatest public health benefits of black carbon emission reductions are expected to occur close to where the reductions take place. Secondly, each country has its own unique combination of emission sources, therefore requiring an individualized national strategy for reducing emissions. Thirdly, acting at the national level allows a country to incorporate the reduction of SLCFs into its air quality, climate change and development policy and regulatory frameworks, as well as into relevant sectoral policies according to its national priorities.

An integrated approach across national agencies and policies is required to address SLCFs. Such an approach could be established in the context of national development planning based on an inter-agency structure and integrated with national priorities.

Developing national action plans for reducing SLCFs would be an effective way to consolidate mitigation activities on the national scale. Such plans could build on existing institutions and policies, including those for air quality management, development and climate change and could include:

- characterizing sources and opportunities for emission reductions;
- assessing the relative costs and benefits of action;
- determining the political feasibility of implementation;
- undertaking an inventory of current policy, legislation and institutions that could be used to implement or strengthen relevant measures;
- identifying further policies, where there are gaps, to make more rapid progress; and
- taking cost-effective action on SLCF sources.

Key actions that may be suitable for inclusion in a national action plan would depend on the specific national SLCF sources and national priorities. The actions could include:

- strengthening national regulations for coal, oil and gas industries to implement methane mitigation measures;
- strengthening support measures for recovery of methane from coal mining operations;
- strengthening support measures for recovery of methane from landfill, including separation of waste streams;
- creating and enforcing regulations to ban the open burning of agricultural wastes;
- strengthening support measures for alternative uses for agricultural wastes;
- introducing support measures to test, select and encourage widespread acceptance and use of improved cookstoves;
- establishing and strengthening inspection and maintenance of vehicles; and
- creating and implementing regulations to establish or tighten emission standards for all vehicle categories, including non-road vehicles, and stationary sources.

For many developing countries, national policies for reducing SLCFs need to take into account the lack of established systems for managing air pollution. Therefore, policies for controlling SLCFs might be more successful if they were incorporated within sustainable development frameworks and existing practices. It is also likely that financial incentives will be needed.

Regional-level policy options

Regional coordination has an important role in enhancing action taken at the national level. Existing and emerging regional air pollution management initiatives

and inter-governmental agreements could be used as an effective way of building awareness, promoting the implementation of SLCF measures and enhancing capacity. National action could be supported by regional banks and other financial institutions and by pooling scientific expertise and sharing policy experience across a region.

Regional initiatives and inter-governmental networks for air pollution management are in different stages of development, but they have the potential to provide a basis for cooperative action as well as enhancing and supporting national activity. The many different institutions covering air pollution management at a regional scale could be clustered into three main categories, each requiring a different approach for including SLCF policies:

i) Legally binding regional agreements such as the Convention on Long-Range Transboundary Air Pollution (CLRTAP) covering the region of the United Nations Economic Commission for Europe (UNECE) and the ASEAN Haze Agreement. These institutions could be, and in some cases already are, platforms for policy action on controlling SLCFs.

ii) Intergovernmental initiatives such as the Malé Declaration addressing air pollution in South Asia and the Acid Deposition Monitoring Network in East Asia (EANET) covering North East and South East Asia, which have established structures and a focus on monitoring and scientific research. These institutions could be platforms for developing the scientific information, awareness raising and capacity building on SLCFs needed for policy action.

iii) Agreements or initiatives based on declarations of goals with no existing structures for pursuing knowledge or policies. These include the Southern African Development Community (SADC) Regional Policy Framework on Air Pollution (known as the Lusaka Agreement) and the Inter-governmental Network on Air Pollution in Latin America and the Caribbean. These institutions could become forums for awareness raising and capacity building with regard to SLCFs. If further developed they could also become platforms for developing scientific information and policy action regarding SLCFs.

Coordinated regional action is important to effectively address certain key impacts, for instance on the Arctic, Himalayas and South Asian Monsoon. Short-lived climate forcers cross national borders and impact neighbouring countries. Securing early progress in collaborative efforts to mitigate black carbon in the Arctic is particularly important because of increasingly obvious climate impacts in this region. This is a priority issue for the Arctic Council, which has already acted to move SLCF issues forward for that region. The Arctic Council's approach could provide a model for needed action in other regions where the effects of climate change and black carbon concentration and deposition are particularly important, such as the Himalayas and Andes, and the monsoon regions of South Asia. Existing regional institutions covering these sensitive regions could embrace the issue and work toward region-based solutions.

Global-level policy options

There are three main approaches to acting on SLCFs at the global level:

i) **Building on existing legal instruments for the purpose of abating SLCFs.** Some examples include: taking further action on methane in the context of the UN Framework Convention on Climate Change (UN FCCC); exchanging information about SLCF measures and policies within the subsidiary bodies of the UNFCCC; and working with the International Convention for the Prevention of Marine Pollution from Ships (MARPOL) to develop SLCF mitigation policies. Meanwhile, the Intergovernmental Panel on Climate Change, UNEP and other organizations can be encouraged to continue to assess the scientific knowledge about SLCFs for policymakers.

ii) **Promoting further efforts to control SLCFs by United Nations agencies and other international organizations, and by various partnerships and other cooperative mechanisms.** These "further efforts" could include:
- convening stakeholders around a shared vision and global strategy to mitigate SLCFs;
- developing common standards and guidelines for emissions and ambient levels of SLCFs;
- promoting the coherent integration of SLCFs into different policy streams such as development, public health, climate change and air pollution;
- encouraging joint action amongst and between the private sector, civil society, and governments on various activities for SLCF abatement. These could include the adoption of best practices in industry and improvement of polluting technology.

iii) **Putting enabling mechanisms in place at the global scale to facilitate national implementation of SLCF measures.** A few of the many possible global steps for enabling action at the national level would be:
- sponsoring activities such as workshops, conferences, and the production of publications

that raise awareness and generate and share knowledge about SLCFs;
- providing technical assistance and facilitating technology transfer to upgrade and retrofit technology to reduce emissions;
- helping to build capacity for controlling SLCFs, including assistance in setting up necessary monitoring and observation networks and incorporate SLCFs in air quality management plans;
- facilitating the financing of SLCF abatement. Options include the expansion of existing SLCF-specific funds (or establishing new such funds); building on existing climate-related funds and funding mechanisms (Global Environmental Facility, Clean Development Mechanism, Green Climate Fund, and others), and/or integrating SLCF abatement into funding for sustainable development.

Action on SLCFs can also be supported at the global level through a voluntary partnership of committed governments and other interested stakeholders. This initiative could be led by a small steering committee of country champions working together with a small secretariat which could be hosted by UNEP. Such an initiative could:

- identify opportunities for enhanced international coordination and outreach;
- identify knowledge gaps, human and financial resource requirements;
- raise public awareness of the problems and opportunities and discuss common approaches to taking new action, or to promoting and reinforcing action in other organizations; and
- promote the development of national or regional action plans, tracking progress of programmes and commitments and mobilizing funding for SLCF mitigation.