Black Carbon Mitigation and the Role of the Global Environment Facility: A STAP Advisory Document

The primary objective of the United Nations Framework Convention on Climate Change (UNFCCC) is to "avoid dangerous anthropogenic interference with the climate system". To achieve this, the global community will have to use every means available and focus on all climate-changing emissions to the atmosphere. These emissions include short-lived climate pollutants (SLCPs) such as black carbon (BC), methane (CH_4) and other precursors of tropospheric ozone (O_3). Reducing the emissions of SLCPs can help slow the rate of global warming – particularly over the next two to four decades. In so doing, it would increase the probability of staying below the target of a 2°C maximum global temperature rise above pre-industrial levels, as agreed to by the 195 parties to the UNFCCC at the 16th Conference of the Parties at Cancun in 2010 (Figure 1).

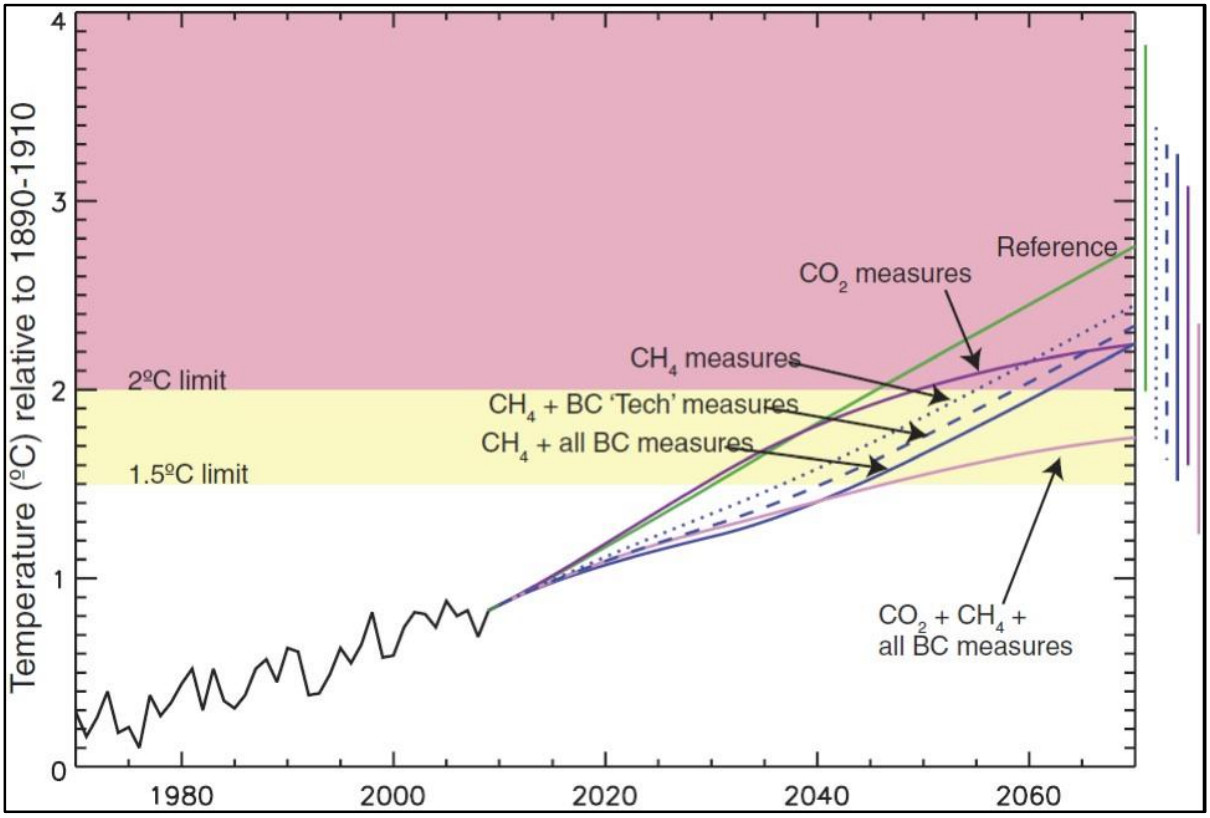

Figure 1 Observed temperatures through 2009 and projected temperatures thereafter under various scenarios, all relative to the 1890–1910 mean. Source: Shindell *et al.*, 2012.

Notes: Bars on right show 2070 ranges due to uncertainty in radiative forcing and climate sensitivity.
BC 'Tech' measures cover reducing emissions from diesel vehicles, biomass stoves, brick kilns and coal ovens.
'all BC measures' include BC Tech measures plus regulations to ban agricultural waste burning, eliminate high BC-emitting vehicles, and provide modern cooking and heating options.

The state of knowledge regarding the impacts of SLCP emissions is rapidly advancing, and the Intergovernmental Panel on Climate Change (IPCC), World Bank, UNEP, and others have recently released a number of pertinent studies in this domain (e.g., UNEP, 2011; UNEP/WMO, 2011; World

Bank/ICCI, 2013; and World Bank, 2015). The increasing recognition of the importance of reducing emissions of SLCPs in achieving short-term climate benefits within the GEF program, while simultaneously continuing efforts to mitigate long-term CO_2 emissions, provides the main impetus for this analysis.

STAP initially drew attention to the role of SLCPs and their mitigation potential for the GEF Partnership in its 2012 report entitled "*Climate Change: A Scientific Assessment for the GEF*". (STAP, 2012). Subsequently, the GEF included SLCP mitigation in the *GEF – 6 Climate Change Mitigation Program* (GEF/R.6/20/Rev.04)[1]. It also sought STAP's assistance in recommending how to embed the mitigation of SLCPs in the GEF project portfolio, as well as to provide guidance to Implementing Agencies on mitigation technologies and measuring protocols and methods. In response to the GEF's request, STAP wrote a report to providing in-depth information and recommendations on one major SLCP – black carbon (Sims *et al.,* 2015).

Black carbon (BC) is formed by the incomplete combustion of fossil fuels and biomass (Figure 2). It is the most strongly light-absorbing component of fine particulate matter ($PM_{2.5}$), a local and regional air pollutant, and the major cause of air pollution-related ill health and premature deaths. It is also a short-lived climate pollutant with a lifetime of a few days to weeks in the atmosphere. During that short period, it can have significant direct and indirect radiative forcing (warming) effects that contribute to anthropogenic climate change at regional and global scales. Black carbon also accelerates the rapid melting of the cryosphere, particularly in the Himalayas and the Arctic, with consequence for sea-level rise, adding urgency to the need to decrease its emission into the atmosphere.

[1] See http://www.thegef.org/documents/gef-6-programming-directions http://www.thegef.org/documents/gef-6-programming-directions

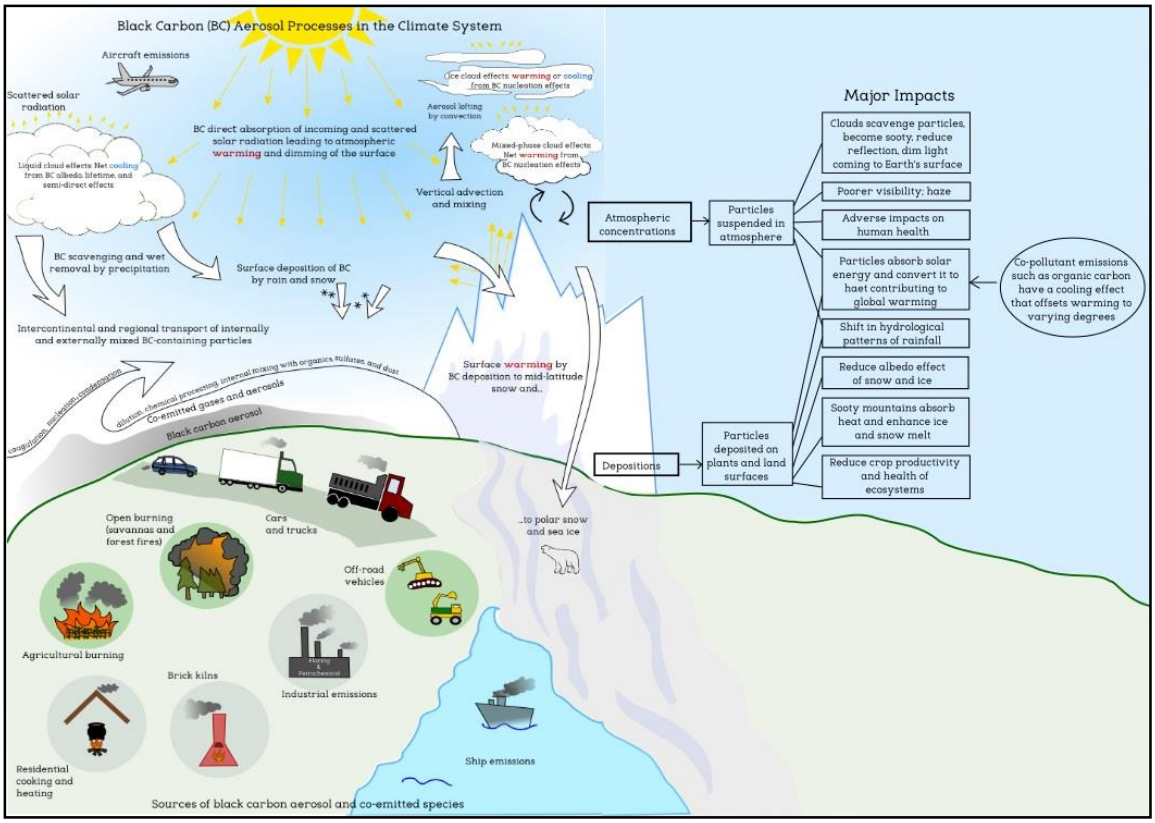

Figure 2 Primary sources of BC emissions and the processes that control the distribution of BC in the atmosphere and its role in the climate system. Source: Based on U.S. EPA, 2012 and Bond *et al.,* 2013.

Unlike long-lived and well-mixed CO_2, BC concentrations in the atmosphere are highly variable across regions, as are their impacts on local populations, climate and ecosystems. The opportunities for abatement also vary; several emission reduction measures[2] targeting black carbon and ozone precursors are already available and in use in some parts of the world. If implemented globally, these measures alone could reduce warming by about 0.2°C by 2050; avoid millions of premature deaths annually from indoor and local outdoor air pollution exposure; reduce millions of workdays lost to illness; and reduce losses of crop yields[3] (Table 1 highlights examples of abatement measures in four main sectors).

[2] A 2011 UNEP/WMO Assessment identified 16 emissions reduction measures for black carbon and methane – a short-lived climate pollutant and a precursor to ozone formation. Since the release of the UNEP/WMO assessment additional measure have also been identified – see for example Stohl et al. (2015).

[3] UNEP/WMO (2011). Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers. United Nations Environment Programme/World Meteorological Organization. http://www.wmo.int/pages/prog/arep/gaw/documents/BlackCarbon_SDM.pdf

Table 1 Selected key abatement measures for BC emissions.

Measures	Sector
1. Standards for the reduction of pollutants from diesel vehicles (including adding particle filters to exhausts), equivalent to those included in Euro-6/VI standards, for on- and off-road vehicles.	Transport
2. Elimination of high-emitting vehicles in on- and off-road applications.	
3. Replacing lump coal with coal briquettes in cooking and heating stoves.	Residential
4. Replacing traditional fuelwood combustion technologies in the residential sector in industrialized countries with wood pellet stoves that use dry fuel produced from recycled wood waste or sawdust.	
5. Substitution of traditional biomass cook-stoves with stoves using clean-burning fuels such as bio-ethanol gel, liquefied petroleum gas (LPG) or biogas.[1, 2]	
6. Replacing traditional brick kilns with vertical shaft brick kilns.[3]	Industry
7. Replacing traditional coke ovens with modern recovery designs.	
8. Banning open burning of agricultural and forest wastes in the fields.[1]	Agriculture

1. Motivated in part by the effect on health and regional climate, including impacts on areas of ice and snow, but noting the potential CO_2 impacts depending on the source of biomass and biogas.
2. For cook-stoves, given their importance for BC emissions, two alternative measures are included.
3. Zig-zag brick kilns would achieve comparable emission reductions to vertical-shaft brick kilns.

Sources: UNEP, 2011; UNEP/WMO, 2011; World Bank and ICCI, 2013.

Ideally, all SLCPs should be considered since each component has highly complex impacts on the local and global atmosphere, and demands specific options for emissions control and measurement techniques. However, the STAP advisory document guidance concentrates solely on black carbon in order to provide a more in-depth review of this particularly important SLCP, which has relevance across a number of focal areas in the GEF program. Moreover, controlling BC emissions through carefully selected measures could support sustainable development while simultaneously improving air quality, human health, and food and water security, particularly for local communities.

As mentioned, the GEF – 6 Strategy (2014 – 2018) specifically highlights the need to incorporate BC, as well as other SLCPs including methane, hydrofluorocarbons (HFCs) and tropospheric ozone (O_3) into climate change mitigation projects[4]. Since the GEF provides support for partner countries to address global environmental issues, it is well-positioned to support BC mitigation measures across all relevant sectors. However, the GEF Strategy does not provide direction on how to accomplish BC-related benefits in practice. In this regard, the Climate and Clean Air Coalition (CCAC) has prepared a guidance note for countries wishing to include BC in their Intended Nationally Determined Contribution (INDC) to the

[4] This is also supported by the CCAC/World Bank Black Carbon Finance Study Group report (World Bank, 2015).

UNFCCC[5] and some countries have already begun considering measures to reduce BC emissions. For example, Mexico has included a 51% reduction by 2030 of its current BC emissions[6] in its INDC.

The STAP advisory document entitled "Black Carbon Mitigation and the Role of the Global Environment Facility" provides an overview of BC emissions, their sources, impacts, and potential mitigation approaches. It summarizes the state of current knowledge; provides specific recommendations to the GEF Partnership about BC mitigation options; identifies the multiple benefits from reducing BC emissions, including improved human health and reduced crop losses; and highlights various ways in which GEF investments can catalyze future action and realize these multiple benefits.

A methodology for incorporating all GHG and SLCP emissions into a single climate impact assessment has yet to be developed. Meanwhile, the methods for reducing BC emissions as outlined in the STAP report will enable the GEF to consider the implications of mitigation for its project portfolio.

Key messages of the STAP Advisory Report on Black Carbon:

1. BC is the most strongly absorbing component of fine particulate matter ($PM_{2.5}$) and contributes to regional and global climate change in the near-term (over months to a few decades). Reducing BC emissions can help slow the rate of climate change, reduce local air pollution, improve human health and security of food and water supplies, and support achieving the Sustainable Development Goals (SDGs).

2. Moderating the pace and magnitude of global climate change will require aggressive efforts to reduce CO_2 emissions (mainly through lowering energy demand and decarbonizing energy systems) which will affect the climate system over centuries, as well as reduce BC and other SLCPs, which would have a more immediate climate effect. These two actions are complementary and must be undertaken together to increase the possibility of meeting the 2°C target.

[5] *Guidance Note on Short-Lived Climate Pollutants for Intended Nationally Determined Contributions*, Ver. 09-03-2015. Prepared by the *Supporting National Planning for Action on SLCPs (SNAP) Initiative Lead Partners* in consultation with members of the Scientific Advisory Panel (SAP), Climate and Clean Air Coalition. www.ccacoalition.org.

[6] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Mexico/1/MEXICO%20INDC%2003.30.2015.pdf

3. The scientific knowledge and understanding of BC emissions and atmospheric concentrations, their measurement, impacts and mitigation options, continue to advance rapidly. Emissions from solid-fueled cook-stoves and from the combustion of diesel and other transport fuels, as well as from the flaring of natural gas, burning of crop residues and forests, and heating of brick kilns, can be reduced by appropriate interventions.

4. The most promising mitigation opportunities in a given region depend on local circumstances, such as the major sources of BC emissions and the feasibility of each individual technological and social mitigation strategy and policy. The main emitting sectors of BC in developing countries are open biomass burning and residential solid fuel combustion for cooking, whereas in developed countries transport dominates BC emissions. In East Asia, most emissions stem from industrial use of coal.

5. Where the presence of BC indicates inefficient combustion, more efficient cook-stove or heating appliance designs will reduce emissions and lower fuel costs. This, in turn, contributes to family well-being, improved human health, poverty alleviation and other benefits. Also, reduced fuel consumption in more efficient residential cook-stoves can lead to a decrease in fuelwood demand, resulting in improved ecosystem health and enhanced carbon storage.

6. The emission of 1 tonne of BC can have different impacts on health and climate depending on the source, location and the extent of co-pollutants, especially those that result in climate-cooling. Therefore, the avoidance of 1t of BC emissions cannot always be a common metric when used across various interventions. So, unlike having a common approach for GHG emission abatement, financing BC abatement needs to be customized to match the specific circumstances.

7. The *Black Carbon Finance Study Group Report 2015* of the CCAC and World Bank[7] concluded that unlocking funding requires the development of BC performance standards and metrics. This will allow financiers to understand the impact of mitigation actions on health and climate benefits when evaluating and screening potential interventions.

8. Direct emissions of BC from a single point source (such as a diesel vehicle exhaust pipe or a biomass plant chimney flue) can be measured with a reasonable degree of accuracy. However, any changes

[7] See World Bank, (2015) and http://www.unep.org/ccac/Publications/Publications/BlackCarbonFinanceStudyGroupReport2015/tabid/1060194/Default.aspx

in atmospheric loadings from reducing BC emissions as part of a typical, accredited mitigation project are usually too small to measure. These can only be evaluated by modeling techniques.

9. Atmospheric BC loadings can be measured, or estimated using widely proven and innovative methods at multiple scales[8]. Several tools are under development to quantify changes in climate, health and agricultural impacts resulting from reducing BC and other related pollutant emissions.

Key recommendations:

The GEF strives to utilize its resources and network to introduce innovation in the design of programs and policies in a manner that encourages early adoption and scaling up to support the stewardship of the global environmental commons[9]. As such, the GEF is well positioned to channel financial and technical resources to help address near-term climate warming by operationalizing BC mitigation as a complementary strategy to its climate change mitigation program and the Integrated Approach pilots (IAPs)[10]. Based on the current state of knowledge concerning BC emissions and related climate impacts, STAP recommends the GEF Partnership take the four following areas of actions:

1. Mainstream BC mitigation measures into the GEF project portfolio, including the Integrated Approach Pilots (IAPs).

- *Include interventions to reduce BC emissions[11] and support methods for measuring, monitoring and impact evaluation to more fully characterize the co-benefits.*

The GEF finances numerous projects aimed at reducing CO_2 emissions across the residential, transport, industrial, forestry and agricultural sectors. Many of the projects, including the IAPs on food security and sustainable cities, support measures such as clean and efficient design solutions for cook-stoves, more efficient brick kilns and low-carbon transport modes. In addition to reducing emissions of long-lived CO_2, these projects could also reduce amounts of BC and other co-emitted short-lived climate pollutants (SLCPs) released into the atmosphere. Information on the extent to which a project or program will have an expected impact on BC emissions could be included at the early concept stage, for example, in the Project Information Form (PIF) or the Program Framework Document (PFD).

[8] See for example, http://www.unep.org/NewsCentre/default.aspx?DocumentID=26840&ArticleID=35403
[9] See the Vision Statement of the GEF CEO at http://www.thegef.org/publications/time-transformational-change.
[10] See http://www.thegef.org/topics/integrated-approach-pilots for more information on the Integrated Approach Pilots (IAPs).
[11] Based on a suite of nine control measures that reduce BC as proposed in the UNEP (2011) Synthesis Report.

- *Give priority to GEF climate change mitigation projects that reduce both long-term and short-term climate forcers and provide other socioeconomic benefits.*

Given the large climate change mitigation potential of using cleaner and more efficient cook-stoves, which also provide co-benefits such as reduced demand for fuelwood and improved local air quality and public health, the GEF should scale up financial support for clean cook-stove design initiatives. Ongoing GEF support for sustainable low-carbon urban development and transport could also be expanded to include specific BC control measures. Examples of such measures include improving the quality of diesel fuel and the installation, and regular maintenance, of diesel particulate filters for both on- and off-road vehicles.

2. Support programs and stand-alone projects that focus on the reduction of BC emissions.

Projects could emphasize the importance of financing integrated BC-reducing solutions that consist of monitoring and assessment, technology transfer, policy and regulatory support, capacity building and awareness raising among countries and cities that are major BC emitters.

The selection and design of specific control measures for BC emissions could be based on the assessment of multiple benefits among different project objectives (e.g. climate mitigation potential, air pollution control, public health benefits). These, in turn, are driven by the enabling environment, including technologies, policies, measures and regulations, and the financial and geographical conditions of the region and country where mitigation measures are planned.

3. Measure, account for and report on the amount of BC emissions avoided or reduced as a result of GEF-funded projects.

The GEF should begin to introduce reporting on near-term climate change mitigation impacts from BC emissions into GEF–6 projects. A project proposal could consider the amount of BC emission reductions expected to be achieved (taking into account co-emitted species, if any) as a co-benefit of climate mitigation financing. Project-specific interventions and emission reductions could be consolidated into the GEF's reporting activities on its programming to the UNFCCC and other relevant entities.

Measurement and monitoring methods continue to be developed to quantify BC emissions, as well as changes to atmospheric concentrations. The GEF should be aware of, and actively participate in, discussions regarding methods and tools available and under development for measuring and monitoring BC and any co-emitted pollutants. It could support financially the development of an indicator (or indicators) and methodologies for measuring BC emission reductions. Therefore, the GEF should liaise closely with the Climate and Clean Air Coalition (CCAC),[12] World Bank, UNEP and others to assess the practicality of future measuring systems as they are developed and improved.
An additional area for GEF support is the development and use of BC performance standards (such as the emerging ISO standards for cook-stoves or fine particulate matter emission standards for clean transport). This would help direct capital towards BC mitigation technologies.

GEF tracking tools developed for climate change mitigation projects, such as the New Guidelines on Greenhouse Gas Emission Accounting and Reporting for GEF Projects (GEF/C.48/Inf.09)[13], could be updated. New versions could include additional emission reductions of BC as a co-benefit (together with any co-emitted pollutant emission reductions where feasible and applicable). This should be completed by the time GEF's methodology for BC accounting (as described above) becomes available.
Monitoring and reporting on BC emissions in GEF projects should be done separately from reporting on GHG emissions. Any approach to estimate the associated net climate impacts designed to address BC requires using modeling approaches. These should also include co-emitted SLCPs that lead to cooling, such as organic carbon (OC) and sulfur dioxide (SO_2), as well as those that lead to additional warming, such as brown carbon (BrC) and methane (CH_4). Measuring and monitoring the performance of mitigation measures for BC, either as emissions, concentrations, or exposure to impacts, can theoretically be undertaken at various points along the "impact chain".

There is currently no general consensus as to the most appropriate climate impact metric to use for BC, OC and other such aerosols. If a GEF project, other than reporting on GHG emissions, is only monitoring BC, then it should be understood that BC emissions alone will not indicate either the direction or the magnitude of the climate impact resulting from the project. Therefore, a project should also assess emission reductions from any co-emitted pollutant. Where feasible and applicable to do so, project

[12] For example, the CCAC is assisting countries such as Bangladesh, Mexico, Colombia and Ghana to develop national plans through the use of a toolkit on emissions and scenarios that estimates changes in all co-emitted species.
[13] See http://www.thegef.org/council-meeting-documents/guideline-greenhouse-gas-emission-accounting-and-reporting-gef-projects

proponents should assess at least BC and OC baseline emissions (since OC is the main counter-acting, co-emitted, pollutant). Alternative scenario emissions (in terms of tonnes of BC and OC reductions) could be undertaken at the ex-ante, mid-term and terminal evaluation stages using the methods outlined in this advisory document, or more appropriate alternatives as they become available.

4. Increase awareness and engage with stakeholders involved in national, regional and international efforts to address BC mitigation.

The GEF Secretariat, agencies and recipient countries are advised to collaborate with organizations such as the CCAC and Global Alliance for Clean Cook-stoves to coordinate GEF activities relating to BC more effectively with ongoing international efforts. Resulting benefits could include exchanging information and lessons learned, leveraging other related activities and financial resources, including identifying bankable projects and improving future project design. Several GEF Agencies are members of the CCAC and already prioritize SLCP mitigation in their activities.[14] [15]

The GEF could also consider analyzing the broad landscape of development finance used by its Implementing Agencies to assess whether a portion could be channeled to BC abatement through financing strategies identified in the CCAC/World Bank Black Carbon Finance Study Group report (World Bank, 2015).

The GEF Independent Evaluation Office, in collaboration with GEF partners including STAP, should support knowledge management efforts to evaluate the environmental, health and economic impacts of a select set of GEF projects that result in reduced BC emissions. These would include, for example, "soot-free" alternatives to high BC-emitting diesel engines to better understand the full costs and benefits of supporting these types of projects.

BC-reducing activities should be scaled up in the GEF portfolio by raising awareness of the multiple benefits of BC mitigation among GEF partners. The GEF Secretariat could consider developing incentive mechanisms for BC emission reduction projects to provide the necessary impetus for action. The

[14] GEF Agencies participating in the CCAC include the following: World Bank, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), Food and Agriculture Organization of the United Nations (FAO) and the Inter-American Development Bank (IADB).

[15] Some organizations such as the UN Environment Programme (UNEP) have made air pollution a priority and are using near-real time data to capture and display global data flows on air quality through UNEP Live (www.uneplive.unep.org).

Country Support Program and various communication activities could be used to increase awareness among the GEF's recipient countries and stakeholders.

The GEF is already funding climate change mitigation projects that simultaneously reduce BC. It should therefore incorporate BC into its programming as an additional basis for selecting projects for funding. As noted throughout this report, black carbon can also negatively impact on ecosystems, food security and human health, thereby interacting across sectors in several GEF focal areas and cross-cutting themes. Therefore, when assessing mitigation opportunities in this domain, the GEF should look well beyond its climate change mitigation portfolio, particularly to sectors addressing land use, to implement innovative measures and seek out new partnerships that will have positive impacts across multiple sectors.

Successfully constraining the rise of mean annual global temperature to below 2^{o}C will depend not only on reducing the emission of long-lived greenhouse gases, but also on reducing SLCP emissions. Doing so will also help to position mitigation efforts more squarely within the context of sustainable development by positively contributing to enhanced human health and improved food security.

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