Soft Approaches for Achieving Benefits from Black Carbon Emissions Reduction

Summary of a Consultation Workshop

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SUMMARY
Consultation on Soft Approaches for Achieving Co-benefits from Black Carbon Emissions Reductions

March 21-23, 2011 Kathmandu, Nepal

1. Background

Recent findings of international programmes such as the Atmospheric Brown Cloud (ABC) project, United Nations Environment Programme (UNEP), the World Health Organization (WMO), Integrated Assessment of Black Carbon and Tropospheric Ozone and other initiatives have suggested that short lived atmospheric species such as Black Carbon (BC) and ozone have a significant impact on climate change, human health, food security, and water security. Black carbon is emitted from the burning of fossil fuels, crop residues, and traditional bio-fuels such as wood and dung cakes. Black carbon absorbs radiation and warms the atmosphere at regional and global scales. Deposition of black carbon on snow and ice surfaces can contribute to glacier melting as well, as seen in the Hindu-Kush Himalayan (HKH) region and other glaciated and snow-covered regions. In fact, after global warming due to greenhouse gas emissions, black carbon deposition has been found to be the second most important cause of glacier retreat on the Tibetan Plateau. Various studies have identified South Asia as one of the major sources of BC emissions, whose real and potential impacts are particularly alarming, given the population density in this region and the water resources tied up in the Himalayan glacier system, A significant portion of these emissions are linked to traditional ways of cooking and choice of cooking fuels in rural areas.

A decade ago UNEP grew increasingly concerned about the impacts of atmospheric haze and launched a programme called Atmospheric Brown Cloud (ABC) in 2001. Successful efforts of the ABC team developed deeper understanding about the sources and effects of haze and black carbon. Over time, UNEP and others realized that knowledge generated through such programmes ultimately needed to be translated into action to mitigate black carbon emissions. Since the sources of most black carbon emissions are tied to three major sectors i.e. industrial, residential and transport, its mitigation necessitates interaction with local stakeholders and leadership on the part of community stakeholders. In order to help identify unrealized opportunities for action to mitigate BC emissions in South Asia, EPA's Office of International and Tribal Affairs, the International Centre for Integrated Mountain Development (ICIMOD), and UNEP co-hosted a consultation which brought together government representatives, local officials and especially, local and regional NGOs, practitioners and leaders, to discuss activities that could be enhanced, as well as low cost, low tech, yet significant actions that could yet be taken to reduce BC emissions locally and regionally. The emphasis of the consultation was on the use or deployment of low tech innovations coupled with operational behavior changes, that alone or together could bring about considerable reductions in BC emissions at low cost. The consultation was held in Kathmandu, Nepal during 21-23 March 2011.

The workshop started with welcome remarks and Keynote Address delivered by representatives from UNEP, U.S. EPA, ICIMOD, and the Ministry of Environment, Nepal. The internationally renowned climate scientist and Chair of the ABC-International Science Team, Prof. Ramanathan, delivered the Keynote address. In his address, Prof. V. Ramanathan, expressed the need to formulate strategies for reducing black carbon emissions as the present scientific understanding of short-lived pollutants is sufficiently advanced to support appropriate policies and actions. He further mentioned in his address that black carbon emissions carry considerable negative impacts on local air quality and local, regional and global climate. He expressed his concern about the BC emissions scenarios which, along with Greenhouse Gases, may give rise to more than a 2° Celsius temperature increase in the coming 4-5 decades, in the absence of taking immediate actions to reduce BC emissions.

2. Sources and Impacts

2.1 Sources

During the workshop, the three major sectors responsible for most black carbon emissions in the South Asian region were identified as: (1) residential, (2) industrial, and (3) transport. The residential sector which uses wood, agricultural and animal residue as energy sources, has been the biggest contributor of black carbon in this region. In the industrial sector, while not well known, brick kilns are a major source of black carbon emissions locally and regionally in South Asia. In the transport sector, fleets of trucks with diesel engines are the biggest sources of black carbon in the region.

And while the time is ripe for taking actions to reduce BC emissions in South Asia, especially in these three sectors, there is a complementary need to reduce uncertainty present in emission estimates by developing more detailed emissions inventories. Chemical analysis of atmospheric aerosols in the region shows that the fine fraction of air-borne particulates is composed of organic matter (40-50%), sulfate (23%) and elemental carbon (10%). Receptor modeling results indicate that fossil fuel combustion and biomass burning are the major sources in the region which contribute 25-35% of organic carbon and ~100% of black carbon. Some aerosols, such as organic and sulphates rend to be reflective and have a cooling effect. Others, such as black carbon, absorb solar radiation and have a warming effect on the surface-atmosphere system. Hence the proportionality of black carbon to organic carbon and sulfates, determines the whether a regional or an area experiences warming or cooling. In either case however, these emissions result in considerable local and regional impacts.

2.2 Impacts

Black carbon significantly affects climate, agriculture, human health and glaciers, or more generally, water resources. During the workshop, impacts of BC on all the above were discussed.

2.2.1 Impact on climate

Atmospheric aerosol studies in the region highlight that Large Aerosol Optical Depth (AOD) is distributed across Asia having significant impacts on climate. Black carbon, a major fraction of Atmospheric Brown Clouds (ABCs), heats up the atmosphere by absorbing solar radiation and heating up the atmosphere locally and at the same time, cools the surface somewhat due to the blockage of incoming solar radiation. The net effect of this is a warming overall. Black carbon can directly, semi-directly and indirectly impact climate. These impacts can alter the patterns of heating, reflection, radiation, absorption, evaporation and cloud formation resulting in changes in convective activities, monsoon circulation and precipitation frequency, amount and location

2.2.2 Impact on Agriculture

Aerosol loading can also affect crop yields. Research findings show that moderate loadings of aerosols enhance the crop yield of maize and wheat under clear sky conditions. But heavy aerosol loadings result in decreases in yields of maize and wheat. Surface ‘dimming’ can adversely affect photosynthesis and yield by up to 10-15%. Increasing atmospheric temperature due to black carbon affects crops directly. Studies indicate that the increased temperature is not good for crop yield as it enhances the growth rates and shortens the duration of phenological stages thereby reducing yield. Indirect effects of black carbon on agriculture can result in changing monsoon patterns and timing which can adversely affect rain fed agriculture. Under clear sky conditions, high AOD results in higher diffused radiation which can

penetrate deeper into the canopy where it can expose the shaded leaves of C3 plants and enhances the photosynthetic rate.

2.2.3 Impact on Human health

In general, greenhouse gas emissions are not a direct problem for human health in the way that particulate pollutants are when released during incomplete combustion. These include such pollutants as poly-aromatic hydrocarbons (PAH), carbon monoxide and black carbon, all of which can give rise to a host of respiratory-related health problems. Particulate matter (PM) is the most common health damaging material in the air which consists of black carbon and other chemical species of air-borne particulates. $PM_{2.5}$ and smaller particles in particular, have more severe health impacts as these fine and ultra fine particles can penetrate into and beyond the alveoli of lungs. Studies show that as compared to PM_{10} mode, $PM_{2.5}$ mode has a higher fraction of BC suggesting that BC is more commonly found in the finer mode which can be inhaled deep inside and beyond the lungs creating more health problems, particularly cardiovascular diseases. In addition, there is evidence suggesting, smaller particles have also been shown to cause other ailments related to the reproductive system such as premature birth and cervical cancer. According to the World Health Organization (WHO), in 2004 outdoor urban air pollution was responsible for 1 million premature deaths and accounted for 0.5% of the total disease burden. However, the overall impact on health is not decided by size of the particle alone, the chemical composition of particulates and concentration of constituents also play important role. In South Asia, more common health problems are seen associated with indoor air pollution. A large percentage of the population is settled in rural areas where different kinds of solid fuels (wood, dung cake etc) are used for cooking. Groups most affected by indoor emissions from incomplete combustion of these bio-fuels are women and children due to the longer exposure time and closer proximity to the combustion source during daily cooking and heating activities. According to the World Health Organization (WHO), in 2004 approximately 2 million deaths were attributed to household indoor air pollution.

2.2.4 Impacts on glaciers

According to mountaineer Dawa Steven Sherpa, the leader of Eco Everest Expedition in 2008, the snow on the peak of Mountain Everest has melted significantly as observed between 2005 and 2008. Unlike the Alps where successive photographs taken during past 50 years provided the evidence of glacier retreat, the Hindu-Kush Himalayan (HKH) region lacks such evidences due to the remoteness of the setting. However, ICIMOD findings reveal that most glaciers in the Nepal Himalayas are retreating. The rate of Himalayan glacier retreat has been estimated from 10 to 60 meters in length every year. The Trakarding glacier which is associated with Tso Rolpa Glacier Lake has been retreating at the rate of 66 meter per year from 1957 to 2000. Imja and Lhotse Sar glaciers which are associated with Imja Glacier Lake have been retreating at the rate of 41 meter per year from 1962 to 2001. Surprisingly, an alarming retreat (74 meter per year) of these glaciers has been noted between 2001 and 2006.

In the Hindu-Kush Himalaya, black carbon deposition is significantly enhancing glacier melting. But very little is known about the process of just how black carbon impacts Himalayan glaciers. Hence, there is a great need to generate knowledge about the process of black carbon deposition on snow and its role in snow and ice melt due to absorption of heat by the BC particles deposited on the surfaces of snow and ice. The ABC Regional Assessment in 2008 notes that deposition of black carbon is a major driver of glacial retreat in the H-KH and Tibetan regions. According to the report, 26-68 µg black carbon per kg of snow was estimated at Nepal Climate Observatory at Pyramid (NCO-P observatory) during the pre-monsoon season which contributed to 2-5.2% snow albedo reduction and 70-204 mm w.e (millimeter water equivalent) increase in runoff from a typical Tibetan glacier. This runoff equals 24% of the seasonal runoff.

3. Co-benefits and Soft Approaches

The consultative workshop discussed the co-benefits of deploying low tech innovations and instituting operational behavioral changes to achieve significant BC reductions at low cost, within the three sectors or sub-sectors discussed previously. The importance of these approaches as complementing more well-known but more costly high technology approaches such as the use of diesel particulate filters and the use of low sulfur fuel, were discussed. In general, the consultation viewed the more traditional approaches to mitigation as referring to more resource-intensive methodologies and technologies such as regulation, the transfer of high tech and infrastructural change. Less traditional and less resource intensive approaches discussed at length at the workshop include changes in operational behavior through training and outreach, coupled with the use of low-cost, low tech innovations. During the workshop, the conversation was focused on cook stoves in the residential sector, brick kilns in the industrial sector and fleet management in the transport sector, all of which represented unfulfilled yet potentially significant low-cost opportunities to reduce BC emissions in South Asia.

3.1 Residential sector

About three billion people in the world rely on traditional cooking stoves for cooking and heating which involve direct inefficient burning of biomass. There are different types of improved cook stove models like the Parishad model, the Philips 4012 forced draft model, the Oorja plus model, the Philips 4008 natural draft model, the Environfit G-3300 model, the Environfit B-1200 model and the Arti sarai model. Several projects aiming to promote improved cooking stoves have been implemented in South Asia (Box 1).

Experience from the past and ongoing initiatives shows that adoption of improved cook stoves is difficult as it pertains to changes in attitude and behavior given the complex social, cultural, and gender interaction as well as the affordability issues typically associated with alternative technologies. Involving the users up front, or lack thereof, in cookstove

Box 1: Improved cook stoves offer environmental and health benefits

Traditional stove no longer in use

Improved stove

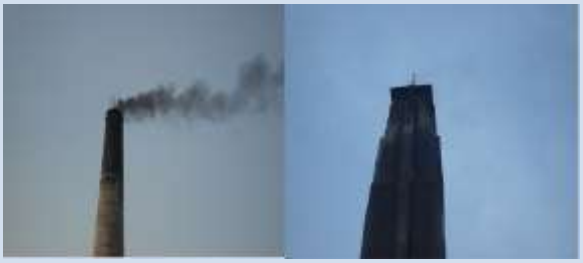
Development and testing of locally fabricated cook stoves by Project Surya shows significant socio-economic and environmental benefits of improved cook stoves:

- **Contribution to climatic benefits**- Locally fabricated cook stove will reduces BC emission by 70% to 80% compared to the traditional mud-stoves.
- **Improved health and living conditions for women and children**- Introduction of improved stoves resulted in three immediate benefits to the families: (1) significantly improved kitchen air quality, (2) reduced drudgery in collecting biomass fuel like wood chips as the improved stoves require 50% less biomass fuel than the traditional stoves, and (3) reduction in cooking time.
- Established **sustainability and culturally appropriate or sensitive business model** for the new technology by addressing the poverty and .cultural issues associated with successful stove adoption- Customization and local fabrication reduced cost and increased usage of the stoves and reduced spending on purchasing biomass.

design etc., was demonstrated to play a major role in the appeal, adoption and continued use of improved cook stoves.

To mitigate black carbon in the residential sector, particularly in the case of indoor air pollution, those present felt that there had to be technological interventions, coupled with operational behavioral changes and changes in local customs and attitudes, to bring about significant reductions in BC emissions. New technologies could be introduced that are culturally acceptable and desirable, and affordable with efficient options that meet the emission standards sought, For cook stoves in particular, there have been huge improvements in the technology but a great deal more needs to be done in terms of addressing local customs and norms and development of protocols, standards and benchmarks. These are all important from climate, health and sociological perspectives. From the climate perspective, there is a need to push for recognition of black carbon mitigation in carbon trading, and the setting up of financial mechanisms to support cook stove initiatives.

Box 2: Improved brick kilns offer economic and environmental benefits



Traditional Bull's Trench Kiln (BTK) | Zig-Zag Kiln

Modification of traditional Bull's Trench Kilns (BTK) to natural draught zig-zag firing offers attractive cost benefits with annual increase in revenue and quick payback period of less than a year. Significant environmental and economic benefits:

- Reduced energy need- Coal consumption reduced by 15-25%
- Improved product quality-percentage of Class I bricks increased from 50-60% to >85%
- Reduced emissions- Emissions of particulate matter, soot, CO, and CO2 reduced.

Source: Compiled from the presentation of O.P. Badlani and Sameer Maithel.

3.2 Industrial sector

In the industrial sector, the brick kiln industry is a major source of black carbon emissions in South Asia. There are different types of technologies available for brick making that include: Hoffmann kilns, Bull's Trench Kiln (BTK), clamp, Zig-Zag, VSBK, and Habla, all of which represent a spectrum of fuel efficiencies and emissions of BC.

Most of the kilns in developing countries use inefficient technologies such as the BTK and clamp kilns which produce high black carbon emissions due to inefficient combustion.

In the past, there have been attempts to promote fuel efficient and less polluting methods such as VSBK, Habla, and Zig-Zang kilns (Box 2). As was made evident at the consultation, a combination of low-cost, low tech improvements coupled with operational behavioral changes can easily result in cost savings, reduced emissions of BC and cleaner brick production. Such changes could take the form of enforcement of existing environmental regulations for brick kilns, building codes and regulations favoring the use of hollow bricks, operator training and education of brick makers and brick buyers, developing a cadre of local technology providers for technology provisioning and trouble shooting, and

manufacturers of machinery and material handling systems, training of workers, owners and managers and provision of financing.

3.3 Transport sector

In the transport sector diesel engines are major sources of black carbon emissions. Studies suggest diesel engine particulate emissions have significant warming impacts due to large amounts of black carbon. Diesel vehicle engines have been growing in numbers all over the Asia. The percentage of diesel in the transport fuel mix has also been growing rapidly in Asian countries. Diesel vehicles, including trucks, also have relatively higher emissions rates. As a result, diesel emissions are expected to grow steadily over the coming years.

Box 3: Ahmadabad Municipal Corporation Initiative

Ahmadabad Municipal Corporation (AMC) has taken some initiatives to reduce fuel consumption and carbon emissions. These include training drivers and private operators regarding proper usage of municipal buses , no idling, no overloading, timely clutching and declutching, no unwanted accelerating and limiting vehicle speed. In addition, maintenance staffs have been trained for proper tuning of the engines, keeping the fuel compressor as per the requirement for the proper combustion and full combustion, and keeping tire pressure to the optimum standards. These steps were proven to be very effective in saving fuel and reducing carbon emissions. This has also reduced the air pollution levels in Ahmadabad. AMC has also converted all its petrol driven vehicles into CNG vehicles. It has also started replacement of all its older vehicles which are Euro 1 compliant, to Euro 3 and Euro 4 compliant vehicles.

Some of the long-standing broad-based challenges that this sector faces are: limited policies for trucks with a large number of government agencies' involved in one way or another; truck fleets being highly fragmented with a majority being owner-driven trucks; much of the fleets consist of old trucks having poor maintenance practices while hauling practices typically result in a high percentage of empty hauls and overloaded hauls as well as o overloading. An additional challenge is limited proven technologies that are available in and applicable to Asia, combined with fragmented supplier networks.

In terms of BC emissions reductions, some of the more sweeping recommendations discussed related to standards and technologies. For example, it was suggested that sulfur levels should be maintained at 50 ppm or lower in petrol and diesel fuels; at least Euro 4 vehicle emission standards should be adopted; and fuel economy standards should be set for all vehicle types. With regard to technologies, diesel particulate filters and other emissions control technologies that improve fuel efficiency could be promoted as well as technologies that improve fuel efficiency.

Again, considering opportunities on a broader scale, many in attendance identified the need for a modal shift away from private vehicles to public transportation, and appropriate implementing tools, such as the Business To Rails (BTR) project currently under development in Ahmadabad.

Recommendations that complement the broad seeping, resource intensive actions described above, that were more consistent, scale-wise and resource-wise, with the specific approach adopted by this consultative process of identifying low cost, low tech ways of reducing BC emissions, including operational behavioral modification featured actions such as eco-driver training combined with regular inspection and maintenance programs and improved fleet management, logistics and modernization. For example, building the capacity of drivers to operate vehicles more fuel-efficiently through driver training programs has been shown to lead to significant gains in fuel efficiency and emissions reductions (Box 3).

4. Recommendations

This important and unique consultation provided a platform to discuss the latest black carbon science and its implications, low-cost yet effective intervention technologies and low-cost but effective techniques for altering operational behavior, and broad policies for achieving greater, region or country-wide BC reductions in the residential, industrial and transportation sectors in particular. Recognizing the impacts of black carbon in the South Asian region, the workshop made the following recommendations.

4.1. Science

- Scientific understanding of climate – aerosol interactions and health impacts of aerosols are now sufficiently advanced to support the development and implementation of effective, innovative and in some cases, underutilized mitigation strategies
- There is a need, however, to continue the monitoring and assessment of black carbon and other aerosols under an integrated framework that includes capacity building in developing countries and regions most threatened by the impacts of black carbon emissions.
- Capacity building as well as better understanding of science is needed to implement the most successful and effective mitigation measures, many of which are not cost-intensive either. Some of the activities that could be included would be:
    - Provision of operational training and the use of low tech equipment or improvements
    - Continued monitoring and evaluation of sources of black carbon and the status and effectiveness of emissions reductions efforts.
    - Periodic updates on black carbon science especially as it relates to the appropriateness and effectiveness of mitigation strategies

Knowledge to Action: There is an urgent need to translate science into action for mitigating climate and health impacts. The Surya project, a science-driven, community-led cookstove intervention project, is a good example of how UNEP's Atmospheric Brown Clouds project led to the development of Surya in rural India and Kenya, and the involvement of local communities in the gathering and use of critical data.

4.2 Residential Sector (Cookstoves and Heating)

- Understanding what provokes people to take action and modify their behavior is critical: : People take action for a variety of reasons such as concerns regarding environmental quality, health, development and equity, in varying degrees and for a variety of reasons. Understanding what people are concerned about and what motivates people to act are critical to the ultimate adoption and effectiveness of BC mitigation actions.
- Bundling: There is a need to bundle together where appropriate, clean energy solutions such as the use of solar energy and gas and solid fuels, coupled with behavioral changes, as in the case of cookstove replacement coupled with solar house lighting.
- Integration and dovetailing: It is desirable to have an integrated approach to reducing BC emissions so as to avoid undesirable and perverse outcomes, and an effective, functional and practical network of existing institutions and leading stakeholders, and especially practitioners
- Finance: There is a need to raise awareness and share experiences on the use, affordability and availability of innovative finance mechanisms such as micro-finance loans which may offer more flexible and less costly terms locally.

4.3 Industrial Sector (Brick Kilns)

- Locally, there is a need to showcase best operating practices and the use of new and existing low-cost technologies, as well as the production and use of alternative products such as perforated bricks, among policy makers and brick kiln owners and operators primarily, and secondarily among consumers such as architects, builders, government bodies and end users.
- As a part of the capacity building initiative, trainings should be given to the brick kiln owners and kiln operators, by owners and operators, on best operating practices coupled with the use of improved, more efficient technologies as embodied in the panoply of kiln types (e.g., zigzag kiln, Hoffman kiln, tunnel kiln and Habla kiln), and on the effectiveness of mixing internal fuels.
- As a part of a national action plan, it would be important to inventory the number and type of operating kilns, quantity and type of fuel used, total emissions of SPM and black carbon, and emission factors for different fuels and technologies.
- Some consideration was given to the appropriateness of an institutional mechanism for developing and introducing brick sector specific policies, guidelines, best practices, technology upgrades, substitutions and demonstrations, as well as capacity building of stakeholders.
- Some consideration is warranted on how to better enforce and implement existing rules and regulations that would facilitate more rapid and widespread improvements in kilns and kiln operations resulting in black carbon emissions reductions.

4.4 Transportation Sector (Fleets)

Local Actions:

- Eco-driving should be promoted to minimize the fuel use by training diesel vehicle drivers on driving techniques. Since transportation is a fragmented sector, there is a need for trainers and training systems to reach the drivers.
- There should be regular inspection and maintenance of the vehicles. This is one of the most cost-effective options to improve fuel efficiency and reduce black carbon emissions.
- The infrastructure for public transportation systems (e.g., designated bus stops, walkable and safe walkways, adherence to schedules and reliable vehicles) should also be improved as it results in broad based reductions in fuel use and emissions through more efficient operation of vehicles, the use of less polluting more efficient fuels and reductions in the use of private vehicles
- New and improved fuel-efficient technologies such as low rolling-resistance tires, air pressure gauges, and improved aerodynamics should also be adopted.

'Empty hauls' i.e. truck trips without loads on the return trip, are one of the key unresolved issues in developing Asian countries.

National Actions:

- All local actions should ideally be coordinated with national actions and policies. This includes striving for a standard of 50 ppm sulphur in petrol and diesels, Euro 4 vehicle emission standards, and setting up fuel economy standards for all vehicles.
- Diesel particulate filters and other emission control technologies should be promoted, as well as appropriate financing mechanisms.
- Call for the development of national programs for trucks, buses, and other diesel fleets and vehicles, on the use and availability of new and improved technologies and the use of innovative financing mechanisms, to make available and facilitate technology adoption. National programs might also facilitate knowledge sharing and capacity building, and the

building of partnerships and networks for knowledge sharing and coordination amongst the private sector, government and other stakeholders and practitioners.

4.5 Beyond Sectors

- 4 “A” measures
    - Awareness: Promote awareness of available mitigation measures
    - Availability: Improve availability of mitigation technologies with local fabrication
    - Affordability: Enhance affordability through micro-finance and other community based organizations or private institutions
    - Assessment: Assess the economic, environmental and social benefits of mitigation measures, as well as their effectiveness.
- Generic guidelines: Sector specific guidelines to assist development and implementation of strategies and policies
- Knowledge sharing: The knowledge base on black carbon mitigation measures needs to be enhanced through compilation and sharing of mitigation related knowledge, good practices, tools, and successes.