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The Two Worlds Approach for Mitigating Air Pollution and Climate Change

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For that which is common to the greatest number
has the least care bestowed upon it
Aristotle

Synopsis

There is still time to mitigate unmanageable climate changes, particularly, if we drastically reduce carbon dioxide emissions from fossil fuels and simultaneously reduce emissions of the so-called short-lived climate pollutants. Carbon dioxide, the major greenhouse gas released to the air by fossil fuel combustion is responsible for as much as half to two thirds of the anthropogenic effects on climate change. There is an unexplored synergy between this new hybrid climate mitigation approach and the objectives of sustainable development: *Poverty reduction and meeting the needs of a 'larger but stabilizing population' while sustaining the life support systems of the planet (1).* It is this synergy I explore and illustrate in this paper.

We must, first, recognize that there are two separate but co-dependent worlds: The bottom 3 billion, (B3B), who live in a world with minimal access to fossil fuels while the top 4 billion live in T4B, a world with seemingly inexhaustible supply of affordable fossil fuels. Using emission of climate warming pollutant carbon dioxide as a metric for energy access, the entire B3B world contributes only 6% of fossil CO_2 emissions while about 2.5 billion in T4B contributed as much as 85%. Global efforts such as decarbonization of the economy and reduction of the carbon intensity of energy consumption are essential to slowing down climate change but these policies apply to the life styles of a select 1.1 billion in T4B.

It is my thesis that, to avoid unmanageable climate changes, we must place equal emphasis on three fronts: limiting per capita CO_2 emissions to

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about 10 tons/PP/Year which will affect about 1.1 billion in T4B; reduce drastically emission of short lived climate pollutants by both T4B and B3B; and enable sustainable and clean energy access for the three billion (B3B) living at the base of the energy pyramid. The synergistic part of this two-worlds approach is that it will drastically reduce air pollution which claims about 7 million lives and in addition destroys tens of millions of tons of crops every year; cut by half the deforestation due to firewood harvesting; and most importantly remove one of the major impediments (lack of energy access) for poverty reduction. Currently about a third of food produced for human consumption is wasted. Reduction of food waste by half is another low hanging fruit for such an action will reduce carbon dioxide emissions by about 1.5 billion tons every year.

The approach outlined here requires a combination of top-down approaches of global policies as well as bottom up approaches of interventions in the field at the sub- national and national levels. Examples of actual interventions at the rural level and national level are given to illustrate the two-worlds approach.

Nexus between Energy Access, Human Development and Environment

Access to modern forms of fossil fuel energy is a fundamental necessity for human development and wellbeing (2). The striking feature of the energy access issue is the incomprehensible gap between two groups of population in the world. The gap is so wide that it can best be comprehended and analyzed better if we assume the two groups are living in two different worlds.

About 3 billion (thousand times million or 10^9) people, living mostly in rural areas, depend on solid biomass or solid coal for basic energy needs such as cooking and home heating. Cleaner fossil fuels (gas and electricity) for cooking or heating are either not available reliably (every day) or if available, they are not affordable since the 3 billion live under $2.5 (PPP) a day (Fig. 1).

Most (90%) of the B3B live in rural areas and rely mostly on subsistence farming and the rest (10%) are in urban or the margins of rural to urban areas. About 1.3 billion of this 3 billion lack access to electricity even for lighting. We will be adding at least two more billion people this century and without a concerted global effort, most of the additional two billion will likely inhabit B3B or the lower income groups in T4B.

The costs of relying on solid biomass and solid coal for basic energy needs to the well being of humanity and that of nature are enormous, both locally and regionally. Exposure to the toxic particles and gases inside the smoke filled kitchens are responsible for about 4 million premature deaths, mainly among women and children, annually. The smoke escapes outdoors

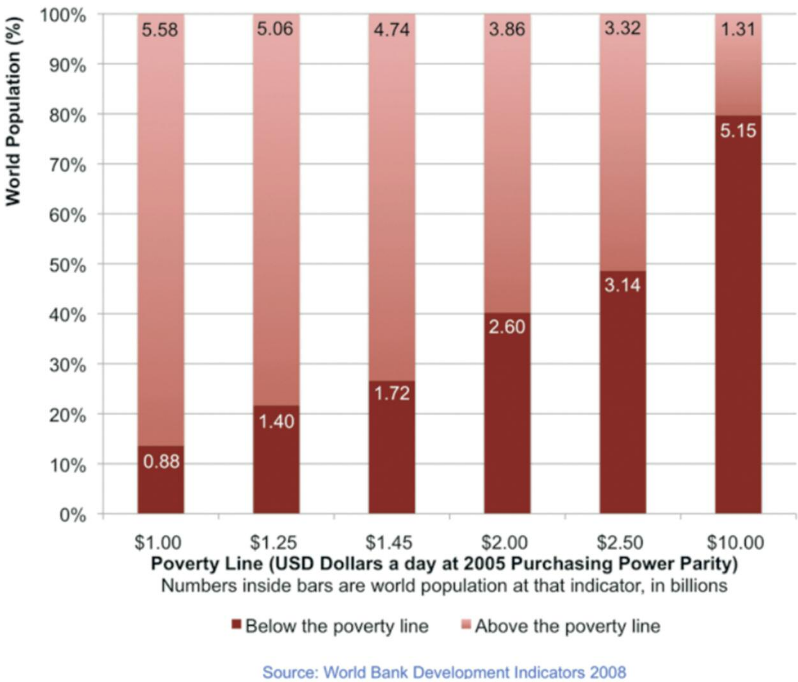

Figure 1. Percent of people in the world at different poverty levels, 2005.

and in a matter of days, becomes widespread brown clouds over thousands of kilometers (3) and causes a million more deaths (4, 5).

The black carbon (also known as soot) from the smoke settles on glaciers and contributes to melting. This problem is particularly severe over the Himalaya/Tibetan region, which provides the head, waters for the major Asian river systems. The particles in the smoke intercepts sunlight, which affects regional climate and disrupts monsoon rain fall patterns. The changes in climate and the gases in the brown clouds damages crops and reduces agriculture yield (6, 7). A detailed review of the brown clouds problem can be found in Ramanathan and Carmichael (8) and UNEP-WMO (9). Consumption of solid biomass fuels also leads to deforestation of about a billion tons of firewood, every year.

The bottom three billion people are a world apart from the rest of the 4 billion population, even if they are living side by side in the same rural area or in the same city. The 4 billion in T4B have almost unlimited access to modern forms of fossil fuel energy. Even among this 4 billion, there are huge disparities in energy access. One reliable metric of access is the amount of CO_2 emitted to the atmosphere by fossil energy consumption. In 2003, roughly 1 billion emitted as much as 50% of the total fossil CO_2; the next 1.5 billion emitted about 35% and the last 1.5 billion in T4B emitted only 10% (10). About 0.9 billion of this 1.5 billion are in urban slums (11). The 3 billion in B3B emit just 5%. The climate change resulting from emissions of CO_2 is one of the biggest threats to sustainability facing society (12). In addition, the added CO_2 increases the acidity of the surface waters of the oceans with major implications for the marine ecosystems and food chain.

It is convenient to sub-divide the T4B, some what arbitrarily, into low income (1.5 billion), middle income (1.4 billion) and high income (1.1 billion high emitters). The CO_2 emission from these three groups correspond reasonably well to their income as follows (inferred from Chakravarty *et al.*, 10): 2.6 giga tons for T4B_low income; 8.9 giga tons for T4B_middle income; and 13 giga tons for the T4B_high income. The per capita emissions are respectively: 1.5 ton/PP, 6.4 tons/PP, and 12 tons/PP. The emission and per capita emission for the 3 billion in B3B are respectively 1.5 giga tons and 0.5 tons/PP. If business as usual continues, the per capita emission is projected to nearly double for the T4B by 2030. The challenge for climate mitigation actions is to maintain the emission by the high and middle income at current levels while allowing much more energy access for B3B and the 1 billion slum dwellers in T4B.

Climate Change: Causes and Effects

Power generation, agriculture, industry, transportation and other sectors of the economy have increased the concentration of carbon dioxide and other greenhouse gases to the atmosphere. Until 1975, scientists assumed that CO_2 was the main anthropogenic or manmade greenhouse gas (13). This picture changed drastically when it was discovered that Chlorofluorocarbons, on a per molecule basis, could be up to ten thousand times stronger than the CO_2 greenhouse effect (14). Chlorofluorocarbons (a banned substance now), belonging to the chemical family of halocarbons, were used as refrigerants and propellants in deodorizers and drug delivery pumps. The other potent greenhouse gases that were added to the list include methane, nitrous oxide, ozone and others. These gases trap the heat (infrared energy) radiated by the earth and the atmosphere and lead to warming. In addition, certain sources such as diesel used in transportation and biomass for cooking and heating emit black carbon (soot) particles, which trap incoming sunlight and lead to additional warming. Carbon dioxide contributes about 55% of the heat trapping and 45% from the other climate warming pollutants. The sectors, which emit these pollutants, also emit other particles that reflect sunlight (back to space) and offset (or mask the warming) some of the warming effect of the heat trapping pollutants. There is quite a bit of uncertainty in this masking effect with estimates ranging from 30% to 60%.

We have already added enough greenhouse gases to warm the planet by more than 2°C (Figure 2 below from Reference 15) during this century.

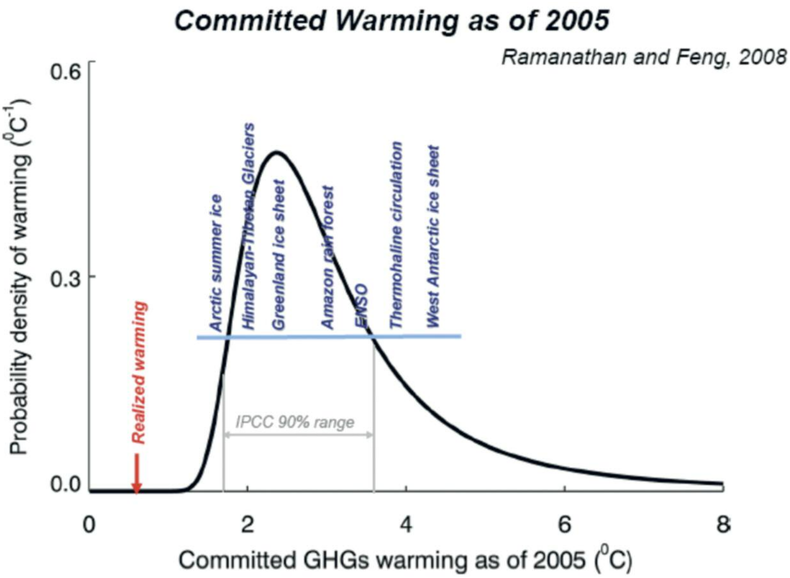

Figure 2. The probability distribution of warming that would ultimately (this century) result from the greenhouse gases that are already in the atmosphere. The various components of the climate system that could tip over are shown as a function of the warming.

Furthermore, the emission of certain climate warming gases, particularly that of CO_2, is continuing unabated. If the trend continues, we can witness unprecedented warming of 2°C by 2050 and 3°C to 4°C by end of this century (Figure 2; also see Reference 12). The worse consequences of such a large warming are yet to be unraveled but the impacts will likely include severe events such as intense droughts, cyclones, heat waves, rapid melting of sea ice and glaciers that provide head waters for major rivers and rising levels threatening the existence of islands, deltas and low-lying coastal areas.

Climate Change Mitigation: Near Term and Long Term

There are two separate but linked problems that have to be dealt with. First, in the near-term (by mid century), the warming (from pre-industrial times) in the absence of any mitigation actions can exceed 2°C. The second problem is that by end of century, the warming can exceed 4°C. The Copenhagen accord recognized 2°C warming as a potential threshold for dangerous interference with the climate system. The lifetime of a CO_2 molecule in the atmosphere is very long. About 45% of the CO_2 emitted today can remain in the atmosphere for a century and about 20% remain longer than few centuries. The warming due to CO_2 that we experience today is a result of accumulated emissions over the last 200+ years. As a result of the long life-time, emission reductions today will take several decades to mitigate the warming and will not reduce much the probability of the warming exceeding 2°C in the near term, i.e., by 2050. However, without mitigation of CO_2 emissions beginning now, we have no hope of keeping the longer-term (end of century) warming below 2°C.

Fortunately, the other climate warming pollutants can come to our rescue for mitigating near term warming. My studies (8, 15, 16) suggest that 1/3 of the warming is caused by four other pollutants: 1) methane, which leaks out of waste dumps, natural gas, fires, paddy fields and cattle; 2) black carbon, which is a particle and is the dark stuff that comes out of diesel trucks, biomass cook stoves, brick kilns and open fires; 3) ozone produced in the lower atmosphere by air pollutant gases such as carbon monoxide, methane, nitrogen oxides; 4) Hydrofluorocarbons (HFCs) used as refrigerants. Black Carbon is the second largest warming agent (8); next to CO_2 and methane is the second largest greenhouse gas warmer next to CO_2. Collectively these 4 warming pollutants are referred to as Short Lived Climate Pollutants (SLCPs), because their lifetime in the atmosphere is short compared with the century or longer lifetime of CO_2. The air pollution from sources that emit the SLCPs also causes deaths in millions, destruction of crops in millions of tons, melts snow packs and glaciers worldwide. The good news is there are technologies to cut their emissions rapidly so we can slow down the warming caused by the other 1/3 of the warming agents within our life times.

We basically have two knobs: one knob is for dialing down the carbon dioxide emissions and that is largely a Top 4 Billion problem. The other knob is the SLCP knob to dial down emissions of the short-lived pollutants. The SLCPs are anywhere between 25 to 4000 times more potent (per ton of emission) than carbon dioxide and they don't live long. The life times of these pollutants are short and vary from a week (black carbon) to a decade (methane) or two (HFCs). As a result, actions taken today to reduce them drastically, will lead to reduction in the warming trends within few decades and thus address the near-term problem. UNEP has formed the Climate and Clean Air Coalition with over 30 member nations to target mitigation of SLCPs (http://www.unep.org/ccac/).

Technologies exist to drastically cut the emissions of these SLCPs. For example, California reduced emissions of black carbon from diesel combustion by 50% since the 1980s using combinations of improved fuels and soot filters (Ramanathan *et al.*, 2013). The state also cut its emissions of ozone precursor gases by about 80%.

Reducing SLCPs in parallel with carbon dioxide reductions can keep global warming below 2°C though this century and reduce end of century (2100) sea level rise by as much as 30% and thus significantly increase the probability of limiting sea level rise below one meter until 2100 (16,17). The required reductions (also see IPCC (12)) are in the range of: about 30% reductions in CO_2 by 2030 to 50% by 2050 and to zero emissions by

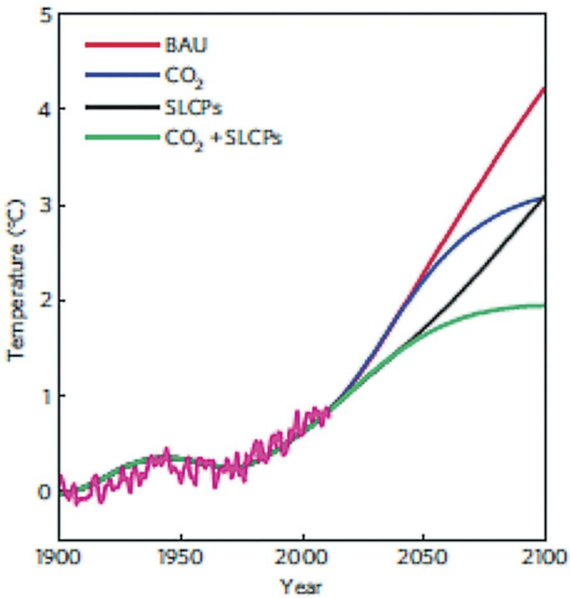

Figure 3. Simulated temperature change for various scenarios. The observed temperatures are shown by the magenta graph. The BAU line shows simulated temperature for the business-as-usual assumption. The CO_2-line includes mitigation of just the CO_2 emissions; the SLCPs-line includes just mitigation of short lived climate pollutants and the green line allows for mitigation of CO_2 as well as SLCPs. Reproduced from Ramanathan and Xu (16).

2070. For the SLCPs the required reductions range from 40% for methane, 80% for black carbon and elimination of HFCs emissions by 2030. These reductions, while drastic, are practical and achievable. For example, replacement compounds are already available for HFCs. With respect to black carbon, California has reduced its black carbon emissions by 90% from 1960s to 2000. The reductions in SLCPs would cut the projected warming trends from now to 2050 by nearly half (9,17). Mitigation of SLCPs also help save over 3.5 million lives lost to air pollution every year and save as much as hundred million tons of cop damages and significantly slowing down retreat of Himalayan glaciers.

The Two-World Approach for Mitigation

While all of human population will be impacted by climate change, the lack of access to energy will make B3B especially vulnerable to extreme events with devastating consequences. This is problematic since the B3B world had the least role in the build-up of the heat-trapping greenhouse gases in the atmosphere. We have to find an equitable way to apportion the responsibility for mitigating the harmful emissions.

We will first discuss the mitigation issue from the T4B perspective. There is rancorous exchange between developing and developed nations about who is responsible for global warming. The developing nations point out that about 70% of the CO_2 and other greenhouse gases in the atmosphere was dumped by about 30% of the global population in developed nations. The developed nations respond, in turn, that as the developing nations industrialize using fossil fuels, their emissions in the coming decades will far exceed levels that can trigger dangerous climate changes and mass extinction of species. To justify their case, the developed nations point out how China is now the top emitting nation of CO_2, even more than that of US'. The two worlds approach moves the debate away from such national conflicts.

Increases in consumption and population are two of the major issues with respect to increase in fossil fuel use. Other confounding issues are the rapid urbanization and the increase in the "middle class' work force (19, 20). Fossil fuel combustion released about 25 Giga (billion) tons of CO_2 in 2000 and it is now (Year 2010) 32 giga tons (12). The 7 giga tons increase was contributed by: Population increase (3 giga tons); economic growth (6.5 giga tons); while decarbonization and reduction in carbon intensity offset 2.5 giga tons of the 9.5 giga tons increase. The other major demographic trend is urbanization (Figure 4).

While the rural population stabilizes around 3.3 billion, the urban population increases from the current 3.7 billion to excess of 5 billion by 2050.

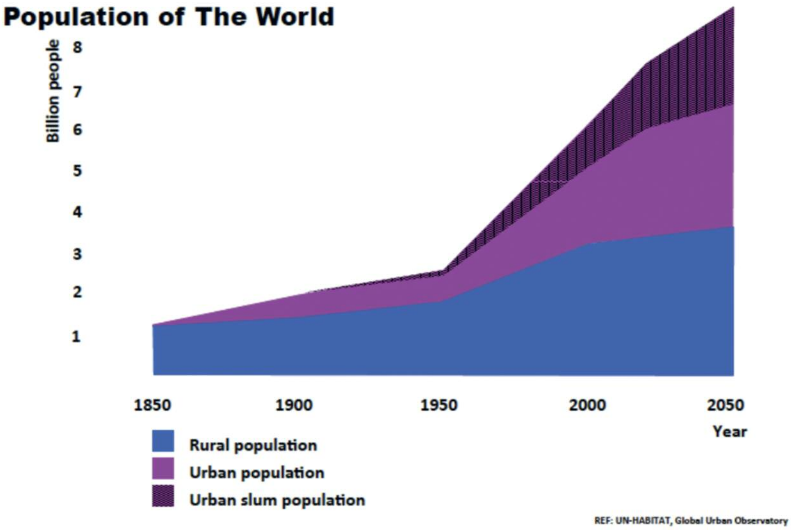

Figure 4. Trends in rural and urban population. Reproduced from UN_Habitat- Global Urban Observatory.

However, most of the increase is due to increase in slum dwellers, who are projected to double from 1 now to about 2 billion in 2050 (UN habitat; also see 19).

If fossil fuel continues to increase at the rate witnessed during the 2000 to 2010 decade, CO_2 emission from fossil fuels can grow to 43 Giga tons by 2030, when the population is projected to reach about 8.1 billion (10). To keep the warming below 2°C, we need to maintain the 2030 emission at or below 30 giga tons, i.e., below the 2010 emission of 32 giga tons. The per-capita emission of CO_2 by the B3B is about 0.5 tons/year, while within the upper 1.1 billion of T4B the per capita emission ranges 10 tons/year to as high as 50 tons/yr. (10). It has been estimated that capping the per capita emission at about 11 tons/year will reduce the projected emission from T4B by 13 giga tons/year, achieving the target emission of 30 giga tons/year. Such a cap will affect only the upper 1.1 billion in T4B (10, 18). As discussed elsewhere (2, 12), the 1.1 billion in T4B can achieve this by decarbonization of the economy and reduction in carbon intensity of energy consumption. The specific steps include: Switching to renewables; carbon capture and storage; improvements in energy use efficiency; drastic reduction in wastage of energy in buildings and clean transportation systems; among many others (2, 12).

On the opposite extreme, we hope that the B3B can catch up with the average living standards of, at least the lower income within the T4B. The compass is pointing in the right direction for this to happen during this century. For example "middle class" wage earners (earning more than $4/day PPP) increased from 332 million workers in 1991 to 1100 million in 2011 and projected to increase to 1700 million by 2017 (20). But if B3B achieves this by relying on fossil fuels with per-capita CO_2 emission of about 4 tons/year, the emissions of the B3B will increase from the current 1.5 billion tons to 12 billion tons per year. For T4B to still meet the goal of limiting global CO_2 emission to 30 giga tons/yr. by 2030, T4B has to reduce its emission by another 12 giga tons: a reduction of 60% in 15 years! Clearly, it is to T4B's own advantage to enable B3B climb on the cleaner renewable ladder instead of the fossil ladder. Global population is projected to reach about 9 billion during this century, which further exacerbates the challenges faced by T4B in reducing CO_2 emissions.

The basic energy needs for the B3B are: cooking, lighting, heating and pumping water for home use and for irrigation. Such energy and water access is crucial to lift the 3 billion out of energy poverty as well as monetary poverty. It is for this reason that the United Nations initiated the Sustainable Energy Access for All Program (http://www.se4all.org). Technologies are available off-the-shelf to provide access to clean, renewable energy without increasing their CO_2 emissions. The cost for providing this access can be as high as $90 billion per year (2) but it pales compared with the $1100 billion cost (2) for decarbonizing T4B sufficiently to mitigate 13 billion tons/year of CO_2 emission by 2030 (2). More importantly, steps for providing energy access to B3B can be initiated by bottom-up sub-national and bi-national efforts with philanthropists and entrepreneurs playing a major role (21). The main motivation is that such steps can also substantially contribute to climate mitigation. Three examples are given below.

1) Advanced Cook Stoves and Solar Lighting for B3B. The woody biomass used for cooking leads to deforestation of about 1 billion tons of woody biomass which is equivalent to 1.5 billion tons of CO_2 emissions; and another 2 billion tons of CO_2-equivalent through emissions of the short lived climate pollutants: black carbon, methane, and ozone. The smoke from the cooking kills over 4 million annually. It is the second- to third-largest source of outdoor air pollution in south Asia; as mentioned earlier, the pollutants destroy millions of tons of crops; exacerbates the melting of Himalayan/Tibetan glaciers; weakens the monsoon. Deforestation combined with monsoon disruption depletes water availability; and worse, women have to walk about 1 to 5 hours per day

to collect firewood. Recognizing the importance of enabling clean cooking to rural areas of the world, the United Nations has formed an alliance called: Global Alliance for Clean Cook Stoves (http://www.cleancookstoves.org). I will report below a bottom-up multi institutional approach to the cook stove problem that was incubated under UNEP.

Project Surya (see www.projectsurya.org) started in 2007, demonstrated that improved forced-draft biomass cooking stoves could drastically reduce emissions of black carbon, CO_2, and other pollutants (Kar *et al.*, 2012). But there are several problems related to the adoption of the new technology. One of the major ones is the cost. At about \$75, it is about a month of wages for the head of the household. The second is that the mud stove provides lighting (the exposed fire) and the new advanced cook stoves cut the lighting since the combustion happens in enclosed chamber. So, we have to provide additional lighting for those using the improved cook stoves. Project Surya provides battery-operated lamps at cost of about \$25. The battery for the solar lamp and for the fan in the forced draft stoves is charged by photovoltaic (Solar). Replacement of kerosene lamps with solar-charged lamps saves another billion tons of CO_2 equivalent emissions. The package cost about \$110, further worsening the affordability issue.

Social scientists have learnt by experience that we are not going to solve this problem by giving away things to the poor, because it is not sustainable. We have to develop good business models, so that women earn their way to energy access and sustain it. Project Surya has initiated a major pilot project, Climate Credit Pilot Phase (see C2P2 in www.projectsurya.org), to explore if rewarding women directly with funds from voluntary carbon markets for using improved stoves and solar lighting will significantly enhance women's ability to sustain adoption of these energy efficient technologies. The secondary goal of the project is to establish a stable carbon market-based revenue source by developing a methodology that awards climate credits for reductions in carbon dioxide and in non-carbon dioxide climate pollutants (including black carbon). By accounting for reductions in non-CO_2 climate pollutants, along with reductions in CO_2, each household can triple the financial returns generated from a carbon market, thereby creating sufficient revenue to sustainably scale up this model. At $8 market value for the carbon credit in the voluntary carbon market, the participating woman can earn about $40 per year of usage, thus recovering the cost of the advanced stove and solar lamp in 2.5 years. One unique part of C2P2 is the use of cell phones to collect data on cook stove usage and on compliance by women participating in the program. The Energy Resource Institute of India, The University of California at San Diego (UCSD) and Nexleaf Analytics of Los Angeles has launched the project with 5000 stoves. A climate mitigation fund has been created by UCSD with funds from a private donor to demonstrate the viability of the method (C2P2_MC-QUOWN5000 in www.projectsurya.org).

The T4B can enable the adoption of clean cooking/lighting technologies by participating in the voluntary carbon market funds. If it is adopted by all of B3B (3 billion population with about 600 million homes) and each member of the 1.1 billion in T4B contribute to the climate credit for one cook stove ($30) or one solar lamp ($10) per year, the funds will generate about $22 billion to sustain the use of the clean cooking and lighting technologies by the 600 million homes.

2) Off-grid and Micro-grids for solar power for water access. Micro-grids or off-grid of solar power is required for farming and other small-scale industrial needs, i.e., instead of using highly polluting diesel pumps to extract water for irrigation, solar water pumps should be deployed, which are now available in the market in even remote rural locations in India. The reason I added the farming is that most villagers (at least in India) can afford to have only one crop per year due to energy and water limitations. The one crop per year, since the villagers only few acres each, is barely enough to meet their own food demand. They need the second and third cropping for extra income: education, buying other goods, and health care. Their water comes from rainwater or irrigation. In many parts the river water is either diverted to the burgeoning cities or dries out due to unsustainable draw down upstream. Solar micro-grids are a much better option since the

main grid is off limits or, if it is available, they are unreliable with just few hours of power supply. The micro-grids are becoming very popular in rural areas of S. Asia and Africa and have to be scaled-up. Distributed solar photovoltaic and solar micro-grids can provide electricity for lighting and small-scale industry, replacing highly polluting (and expensive) kerosene lamps and diesel generators. Diesel is one of the major sources of black carbon, the second largest contributor to global warming.

3) The Transportation Sector. This is a case where sub-national participation can go a long way toward mitigation of air pollution and climate change and help promote human wellbeing. The transportation sector consumes about 28% (91 Exa joules) of the global energy demand and contributes to 23% of fossil fuel CO_2 emissions. It is also slated for the fastest growth in the coming decades with respect to energy consumption and CO_2 emissions. In addition, in industrialized nations it is a major source of black carbon and NOx in cities, which leads to ozone production (SLCPs). Even in developing nations like India, the transportation sector (diesel vehicles) contributes more than 40% to black carbon emission in cities such as Bangalore. California which had some of the most polluted cities in the world (e.g. Los Angeles) in the 1960s, employed cleaner diesel fuels, engine technologies and diesel particulate filters to cut down its black carbon and ozone precursor emissions by 90% from 1960s to now. A program has been started, called India-California Air Pollution Mitigation Program (http://ramanathan.ucsd.edu/about/icamp.php), which brought scientists, technologists and policy makers from California and several states in India to exchange knowledge and expertise to develop an action agenda to reduce emissions of air pollutants, including short-lived climate pollutants in India. Similar national and sub-national partnerships are being formed under the Climate and Clean Air Coalition of UNEP to reduce short-lived climate pollutants (http://www.unep.org/ccac/).

Synergy with Sustainable Development Goals

Basically the world we live in has about 3 billion in rural areas and 4 billion in urban areas with 1 billion of urban dwellers in slums, mostly migrated from rural areas for a better life. In the two-world approach, we included the slum dwellers under the Top 4 Billion world because they have access to energy. Whether or not they can afford it are a socio-economic issue and not an energy access issue.

Goals of sustainable development include meeting the needs of the population (in both worlds), eliminating hunger and poverty and preserving the life support systems. In this concluding section I explore the synergy between the two-world approach for mitigation of air pollution/climate change and sustainable development.

Local and regional climate changes unleashed by a 2°C to 4°C warming are likely the biggest threat to sustainability of the present or future generations. Basically, we have to hold carbon dioxide emission at current levels until 2030 and reduce it to near zero by 2070. For the 2030 period, the required reduction is about 13 billion tons/year of carbon dioxide emission compared with business-as-usual scenarios. With current growth rates, carbon dioxide emission in projected to increase by about 50% by 2050. Even under such fast growth rate scenarios, the B3B still have very poor access to fossil fuel energy. To meet sustainable development goals, however, my analyses suggests the following mitigation actions:

- Limit maximum per capita emission to about 10 tons/PP/year until 2030 and reduce it to near zero by 2070. This action will mainly affect the 1.1 billion high-income groups in T4B (10). The per capita emission by the rest of 6.9 billion population is less than this upper limit.

- Reduce both CO_2 and the four short-lived climate pollutants (methane; black carbon; ozone and HFCs). The SLCPs, by themselves, can reduce the rate of warming in the coming decades by about half; save 4 million lives; avoid hundred million tons of crop damages; and slow down the meting of Himalaya glaciers.

- Enable clean energy for cooking and lighting to B3B. We show how by using voluntary carbon markets funded by T4B at a cost of about $22 per person per year, just among the high-income 1.1 billion emitters, advanced cook stoves and solar lighting can be accessed by every one in B3B. If the new technologies are adopted by every one in B3B, it will reduce carbon dioxide emissions from deforestation by about 1 billion tons every year; will reduce black carbon emissions sufficiently that the climate mitigation potential is equivalent to eliminating another 2 billion tons of carbon dioxide emissions. With respect to sustainability goals, this will save 4 million lives every year; slow the rate of warming and melting of Himalayan-Tibetan glaciers; increase monsoon rainfall. More importantly, it will save each woman using the new technologies about 1 to 5 hours of lost time in collecting firewood and dung.

- Enable micro-grid and off-grid solar power for access to water (potable water and irrigation water) of B3B. This would make rural life much more sustainable and mitigate carbon dioxide and black carbon emissions from diesel generators.

- Initiate sub-national and nation-to-nation collaborative projects to share the knowledge and actions to reduce air pollution and GHGs emissions from out-dated technologies in the transportation and industrial sectors in developing nations. Examples of such initiatives are given in the text.

- Drastically reduce the food waste. About 1/3 of the global food production is wasted (FAO Report, 2014). Roughly 3.3 billion tons of CO_2 emissions were emitted to produce this wasted food. If we can cut this waste by half, we can reduce CO_2 emissions by 1.6 billion tons, which is the total emission by the entire B3B and can account for 12% of the 13 giga tons/year emissions we need to reduce by 2030.

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