plant, mine, oil refinery, etc.) to the developer or owner of a carbon sequestration process (owner of a forest reserve, biochar project developer, etc.). Carbon credits which are sold by sequestering carbon in biochar are economically competitive[4]. Application of higher amounts of biochar to the soil may increase the carbon credit benefit to the farmers. Carbon which is applied to the field in the form of biochar could provide the farmer carbon credits that could be sold in a C credit market for additional income[5].

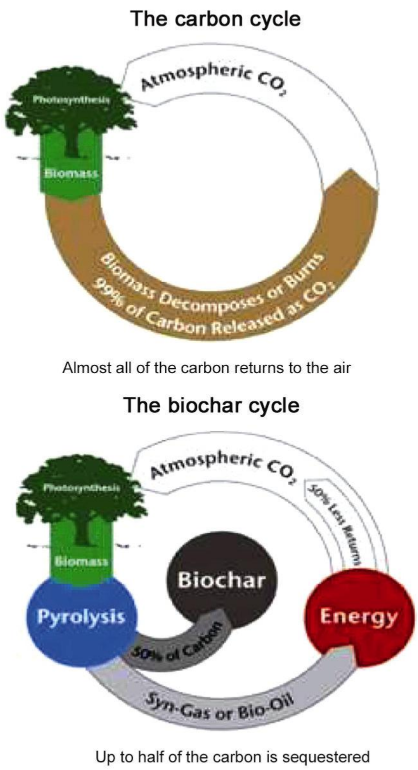

Figure 1. What makes biochar carbon negative[6].

Increasing the C sink in soil will help reduce the amounts of CO_2, CH_4 and N_2O emission in environment. Increased soil aeration from biochar addition reduces denitrification and increases sink capacity for CH_4. Biochar is able to reduce N_2O emission due to inhibition of either stage of nitrification and/or inhibition of denitrification, or promotion of the reduction of N_2O. Indian government initiatives may allow the farmers and land managers to earn carbon credits by reducing greenhouse gas emissions and storing carbon in vegetation and soil through changes in agricultural and land management practices (carbon farming). Besides this, it may also allow Indian agricultural landholders to generate offset credits from activities that reduce emissions or sequester carbon, including biochar application (carbon farming initiatives). The huge emitters will be able to utilize credits generated through the carbon farming initiative to meet their emission reduction targets. Huge volume of crop residues are produced both on-farm and off-farm in India. Most of the wastes are either burnt or end up in landfill, which produces large amounts of GHGs and also degrades the environment. The production of biochar from farm wastes and their application in farm soils may offer financial and environmental benefits. Once environmental cost of carbon-based greenhouse gas emission have been suitably internalized, we can expect market forces and the price mechanism.

Assuming that the science of biochar addition in soil is 'unambiguously beneficial', the soil scientists support the view that agriculture should be rewarded for carbon sequestration through biochar. However, before considering biochar eligible for any kind of carbon credit, the exact volume of carbon sequestered, and for how long, has to be verified. If a carbon market that recognizes the avoided emissions and carbon sequestration due to the application of biochar to agricultural soils exist, then the market price of biochar will be low enough for a farmer to earn profit by applying biochar to the crop field, and then biochar will start being promoted as a technology for carbon sequestration in India.

1. Woolf, D., Amonette, J. E., Street-Perrott, F. A., Lehmann, J. and Joseph. S., *Nat. Commun.*, 2010, **1**, 56, doi: 10.1038/ncomms1053; www.nature.com/nature-communications
2. Gaunt, J. L. and Lehmann, J., *Environ. Sci. Technol.*, 2008.
3. McCarl, B. A., Peacocke, C., Chrisman, R., Kung, C. C. and Sands, R. D., In *Biochar for Environmental Management* (eds Lehman, J. and Joseph, S.), Earthscan Press, UK, 2010.
4. Pandey, A., Biswas, S., Sukumaran, R. K. and Kaushik, N., Study on availability of Indian biomass resources for exploitation, A report based on a nationwide survey, TIFAC, New Delhi, 2009.
5. http://biocharproject.org/
6. http://sonomabiocharinitiative.org/about-biochar/

SHAON KUMAR DAS*
R. K. AVASTHE
RAGHAVENDRA SINGH
SUBHASH BABU

ICAR Research Complex for NEH Region,
Sikkim Centre,
Gangtok 737 102, India
**e-mail: shaon.iari@gmail.com*

Research and policy disconnect for heat wave deaths in India

India has a large population extremely vulnerable to heat wave-related deaths. Climate change weather projections highlight increasingly hot temperatures with increase in frequency, intensity and duration of heat waves. Additionally, the projected increases in atmospheric humidity will contribute to the difficulties in adjusting to increased temperatures. Heat stress indices like wet-bulb globe temperature (WBGT) and Humidex place a premium on atmospheric humidity in the estimation of thermal comfort. In the US, mortalities due to heat waves currently outnumber deaths due to all other climate change weather-related deaths combined. The recent IPCC report on adaptation paints a grim future picture with parts of the world experiencing temperatures exceeding physiological limits, making it impossible to work or carry out other physical activity outdoors. This risk will be borne by poor and disenfranchized groups, on poor countries, and/on poor children[1]. For an effective adaptation response, they call for disease surveillance, and strengthening the resilience of health systems to extreme weather events[2].

Limited studies have been done analysing heat wave-related mortalities in India and most of the information is from newspaper reports. International studies, however, show far higher mortalities at much lower temperatures than those routinely found in heat wave situations in

India. There are fears that due to higher population, vulnerability and weak healthcare system, the real magnitude/burden of heat wave mortalities may be much higher than what is reported in newspapers[3]. For example, the 2010 heat wave in Ahmedabad in news reports had 50 excess deaths while on analysis around 1400 excess mortalities had occurred during the same period[4]. It is important to emphasize the difference between hot weather and heat waves; while hot weather is common to India, heat waves represent a significant deviation (>5°C) from the normal (or expected) hot weather.

Following international evidence of excess mortalities, various countries have taken measures to address this public health issue. The importance of public health facilities and support infrastructure in the abatement and management of climate-related disasters is underrepresented in literature and policy framing. Given the tight integration between public health and heat wave management, the need for an increase in quantity and quality of these support systems becomes increasingly important given the predicted consequences of climate change. Proven intervention strategies at a population level – city and countrywide heat action plans systematically reduce these additional mortalities. And recent mortality studies show the effectiveness of these interventions both in terms of lives saved and minimal costs.

Policymakers in India have not yet made attempts to setup these intervention strategies systematically; only one such heat wave action plan has been piloted in Ahmedabad in 2013 with its efficacy still under study[5]. This highlights the vicious circle of inaction; little or no research generates less interest in the matter, which in turn propagates the inertia of researchers, funding agencies and policy makers to address the issue of rising high temperature environments in the subcontinent. The reasons for this apathy include both a lack of strong domestic evidence base documenting and characterizing excess mortalities to limited emphasis on translation of evidence to policy/intervention systems.

To address this issue, we suggest that a renewed interest be generated in what is to most, an age-old problem. Increase in awareness among the scientific community and laymen will go a long way in creating the necessary impetus from local authorities and special interest groups. We hope that heat waves be recognized as a disaster by key agencies such as the National Disaster Management Authority (NDMA) and leading to adoption of appropriate adaptation and response strategies. This would be a positive first step towards tackling the issue and ensuring that measures towards increasing climate adaptability are taken sooner rather than later.

1. Kakkad, K., Barzaga, M. L., Wallenstein, S., Azhar, G. S. and Sheffield, P. E., *J. Environ. Public Health*, 2014.
2. IPCC, Climate Change 2014: Impacts, adaptation, and vulnerability. In Fifth Assessment Report (AR5), Geneva, 2014.
3. Tran, K. V. *et al.*, *Int. J. Environ. Res. Public Health*, 2013, **10**(6), 2515–2543.
4. Azhar, G. S. *et al.*, *PLoS One*, 2014, **9**(3), e91831.
5. Knowlton, K. *et al.*, *Int. J. Environ. Res. Public Health*, 2014, **11**(4), 3473–3492.

ACKNOWLEDGEMENTS. We gratefully acknowledge the support of our partners Jeremy Hess, Perry Sheffield, Kim Knowlton, Peter Webster and Anjali Jaiswal of the Ahmedabad Heat and Climate Group.

GULREZ SHAH AZHAR[1,2,*]
AJIT RAJIVA[1]
PRIYA DUTTA[1]
DILEEP MAVALANKAR[1,2]

[1]*Indian Institute of Public Health Gandhinagar,*
Sardar Patel Institute Campus,
Ahmedabad 380 054, India
[2]*Public Health Foundation of India,*
4 Institutional Area, Vasant Kunj,
New Delhi 110 070, India
**e-mail: gsazhar@iiphg.org*

Budget allocation to state S&T councils

In India, science and technology (S&T) research and policy have largely been the domains of government since 1947. With nearly 17% of the global population residing in this country, the government has an arduous task ahead to convert these people into a scientifically and technically capable community. Therefore the real challenge today is to bring larger masses under the umbrella of S&T. For such a scenario to become possible, it is essential that S&T be at the heart of the strategies for national development. It is in this context that the initiative to establish state councils for S&T was first taken up in 1971. It was stressed that irrespective of large investments of the Central Government in S&T in various sectors and institutional infrastructure, the central S&T agencies must take the states along if the development goals are to be attained. State S&T councils have been hence established for wider reach of S&T programmes. Thus Karnataka, Kerala, Uttar Pradesh and West Bengal were the first to establish their state S&T councils by the end of the Fifth Five-Year Plan. Since then, each state and union territories have their own councils. These councils play a catalytic role for the promotion of S&T in the respective states and supplement/complement the developmental programmes of the state in different sectors.

Serving as a bridge between the central S&T sector and the states, these state S&T councils however, have remained weak links in promoting the applications of technologies as is categorically stated in the working group report of XII Five-Year Plan[1]. One of the said causal factors is the budget constraint. Apparently, the functioning of these councils depends upon the financial support from DST in the form of core support and grant from their respective state governments. If we look at the XI Five-Year Plan (2007–12), budget expenditure, a total of Rs 53.40 crores was provided to the councils through DST[2]. As a matter of fact, this core support by DST is far lesser compared to the state share for majority of the states, yet for some states like Himachal Pradesh and Punjab the grant is comparable. This portrays that the functioning of state S&T councils more or less depends upon the budget support by the state.

We tried to compare the state council's budget allocation by DST relatively with the GDP of the state and the number of institutes positioned in its jurisdiction and figure out whether these parameters