A framework for addressing health concerns related to biomass cookstoves

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1. Introduction

Governments, scientists, appropriate technologists and development workers have promoted improved biomass cookstoves over the last two decades in order to effect change in aspects of the social or natural environment. Different promotion strategies have been employed, and these reflect variations in perception, expectation, and approach. Globally, the most common goals of improved biomass cookstove programmes have been reduction in smoke levels and increase in the efficiency of fuel utilisation [Ramakrishna, 1991].

Because cookstoves are an integral part of the household energy system, and because they are closely connected to cultural and religious practices, health status, and survival tactics, it is easy to believe that they are the centre of the universe. This belief has often led to the expectation that the improved cookstove can solve a plethora of problems. In fact, rather than making them the universal panacea, the central position occupied by cookstoves makes them a very difficult technology to change.

Yet, we persist, for a variety of reasons, not least of all because working conditions in most of the world's kitchens have not changed significantly during the last 100 years. One might mention that this lack of change has as much to do with the status of women and with economic conditions as with stove technology itself.

Smoke from cookstoves has been identified by users and researchers as a problem, though the former see it more as an irritant than as a hazard. Undoubtedly, a decrease in smoke levels is a quality that the users seek and value in cookstoves. It is not an easy matter, though, to document the actual reduction of smoke levels in the field. Relying wholly on the user's perception of smoke levels is not feasible. Quantitative studies of actual pollution levels are extremely time-consuming, expensive, and difficult to conduct. Those who have tried to collect data simultaneously on health status so as to show correlations have found themselves faced with an even bigger challenge.

Given the nutrition and sanitation situation in most of rural India, and the lack of health facilities, it is very difficult to show a clear cause-and-effect relationship between exposure to smoke from biomass cookstoves and long-term health effects.

Further, there is a disturbing gap between research and action. While acknowledging that it is important to undertake rigorous scientific studies, and that the information gained will provide a partial basis for determining the most cost-effective way to use scarce resources, we would like to suggest that our actions need not wait for these determinations. Instead, one could assume that chronic exposures to high levels of smoke cannot possibly be conducive to human health and act on that basis.

One can also investigate cheaper, faster, rough-and-ready measures that rely on secondary data sources to analyse and assess indoor air pollution. For instance, health impact can be estimated by comparing the particulate concentrations measured in developing country urban settings with the air pollution data collected in industrialised countries. Smith [1994] has carried out this exercise, using data from historic air pollution "episodes" and more recent longitudinal data from U.S. cities. Comparing these data with records of particulate concentrations in Indian cities in the late 1980s, he concludes that air pollution is responsible for 8-62% increase in mortality in Indian cities and 16-130% increase in mortality in rural India.

Taking a different approach, in this paper we present a framework which could be used to identify areas where intervention is most necessary and where it would probably be most beneficial in terms of health. The framework is designed with particular reference to possible health impacts on women and children. We use a set of eight parameters, which includes the principal variables that are likely to influence the expected levels of pollutant concentration, of exposure, and of susceptibility to health effects. As an illustration, we have given scores to these parameters for each of the states of India. The system is neither infallible nor very precise. But we believe that this method can deliver a good, quick, rough-and-ready guide for action programmes. More parameters could be added, and more detailed data could be used to improve the quality of the output.

The paper is divided into three sections. The framework is described in the second section. The final section discusses the application of the framework and options for strengthening it.

2. The framework

The eight parameters used in the framework are number of rooms in the house, roof material, wall material. diet, cooking fuel, acute respiratory infection (ARI) cases. dissemination of improved cookstoves, and forest cover. Each of the parameters was chosen for its relevance to air pollution and to health effects resulting from the use of unvented biomass cookstoves.

The framework is summarised in Table 1. Some of the parameters and the criteria for scoring merit further discussion.

- In order to account for the effect that fuel quality has on air pollution, our scores jump one step in the scale between solid and liquid fuels.

Table 1[a]. A framework for estimating air pollution concentrations, exposures, and susceptibility to health effects

Parameter	Score[b]				
	5	4	3	2	1
No. of rooms in the house	1		2		> 2
Roof material	stone	concrete	asbestos, metal sheet	tile	thatch
Material of the walls	concrete, burnt brick	wood, stone	thatch	metal sheets	mud, unburnt brick
Type of cooking fuel	dung, crop residues	wood		kerosene	LPG, electricity
Diet[c]	smoked foods	wheat	millets	ragi	rice
No. of ARI cases[d]		> 458/1000	116-458/1000	< 116/1000	
No. of ICPs disseminated	0-20/1000	21-40/1000	41-60/1000	61-80/1000	> 80/1000
Forest cover			> 30% of land area		

Notes

a. Information on most of the parameters is quite readily available from census data, and from the publications of the Indian Council of Medical Research and the Ministry of Non-Conventional Energy Sources. Except for the data on the dissemination of improved cookstoves, the data used in this paper are for 1991. The cookstove data are for 1994.

b. A scale of 1-5 is used where 1 represents minimum contribution to air pollutant concentrations, exposures, and/or susceptibility to health effects and 5 represents the maximum.

c. Since rice is the principal crop in the northeastern states but smoked foods are also common, each of the northeastern states has been given a score of 3 for diet.

d. The distribution was skewed with most of the states reporting very low incidence. The highest rate was 1052/1000 in the Andaman & Nicobar Islands.

- Diet often determines the behaviour ot the cook and the level of smoke in the kitchen. Where the staple is a millet or wheat that is made into roti (unleavened bread), the cook needs to remain near the stove, and therefore is more likely to receive a higher exposure. Since state-level data on diet were unavailable, we have used information on principal crops in different agroclimatic zones and have assumed that the staple food is most likely to coincide with the principal cereal grown in an area.
- Areas where the number of ARI cases are high may be appropriate places for intervention. The ARI data could be used as a proxy indicator for the prevalence of chronic respiratory diseases among women as well. The annual incidence of ARI per 1000 population in the 0-6 year age group was used. Disaggregated data by age group for ARI were unavailable. We were able to obtain aggregate data on the annual incidence of ARI in each state (each episode was counted as incidence). We assumed that ARI cases predominantly occur in the 0-6 year age group. So as to allow comparison among states, we calculated the incidence rate per 1000 population in the 0-6 year age group. Although it may appear that such an assumption would result in an overestimate, given the prevalence of under-reporting, we do not think that overestimates are likely.

  Our scoring was perforce arbitrary since we were unable to find suitable statistical data from other countries for comparison. We have not used the highest and lowest scores on the scale because we suspect that the extent of reporting coverage and the manner of case reporting are distorting the picture. The data are derived from hospital records.
- The number of improved cookstoves per 1000 rural population has been used as a measure of the dissemination of improved cookstoves in different states.
- Past studies have shown that “excess” fuel consumption (i.e., 4-5 times more than necessary) occurs in states where forest cover is more than 30% of total land area. We have tried to capture that situation with this parameter. Since this effect of excess consumption would either be present or absent, states were given no score if forest cover was less than 30% of land area, and a mid-scale score if forest cover exceeded 30%.

Some of the parameters included in this framework cannot be reduced to a single number. For instance, for type of cooking fuel, wall and roof materials, and number of rooms in the house, the situation in each state reflected a combination. In the case of cooking fuels, for instance, we included all fuels (starting with the one with the largest share) until 80% of all households in the state were accounted for. Each fuel type was given a score. These scores were totalled and averaged in order to obtain a state score.

3. Discussion

The outcome of applying the framework to Indian states (Table 2) and possibilities for improving the framework are discussed in this section.

3.1. Applying the framework

The contents of Table 2 cannot be taken at face value at this stage since our illustration suffers from missing data,

Table 2. An illustration of the framework: application to the states and Union Territories of India

State/UT	ForCov	CFuel	NumRoom	Wall	Roof	Diet	ARI	IC	Total
Andhra Pradesh	0	4	4	2.7	2.3	1.6	2	4	21
Arunachal Pradesh	3	4	4	2.5	2	3	3	4	25
Assam	3	4	3	2	2	3	3	5	25
Bihar	0	4.5	3	3	1.5	1	?	5	18#
Goa	3	2.5	3	3.5	2	1	2	4	21
Gujarat	0	2.3	4	2.7	3	2.4	2	1	17
Haryana	0	3.3	3	1	2.5	4	3	3	20
Himachal Pradesh	0	4	3	3.5	2.3	3.3	4	1	21
Karnataka	0	3	3	2.7	2.3	1.7	2	4	19
Kerala	0	4	2	2	1.5	1	4	5	19
Madhya Pradesh	3	4.5	3	3	3	2.8	2	4	22
Maharashtra	0	2.3	4	2.7	2	2.5	2	4	19
Manipur	3	4	2	4	2	3	2	4	21
Meghalaya	3	4	3	2	2	3	3	5	25
Mizoram	3	3	3	*	2	3	2	3	19#
Nagaland	3	4	3	2.5	2	3	2	5	24
Orissa	3	4.5	3	3	1.5	1	3	4	23
Punjab	0	3.7	3	1	2.3	4	2	3	19
Rajasthan	0	4.5	3	3.5	2.3	3.3	2	3	22
Sikkim	3	3	3	**	2	1	3	1	15#
Tamil Nadu	0	4	4	3	2.3	1.4	2	4	21
Tripura	3	4	4	4	2	3	3	5	28
Uttar Pradesh	0	4.5	3	3	2.3	3.2	2	5	23
West Bengal	0	4.7	4	3	2.3	1	2	5	22
Andaman & Nicobar Islands	3	3	3	2.5	2	?	4	1	18#
Chandigarh	0	1.5	3	1	2.5	4	4	1	17
Dadra & Nagar Haveli	3	4	4	2	***	2.4	4	2	21#
Daman & Diu	?	2.3	3	1.5	***	2.4	3	5	17#
Delhi	0	1.5	3	1	3.3	4	2	1	16
Lakshadweep	?	4	2	1.5	2.5	?	4	1	15#
Pondicherry	?	3	4	3	2.5	1	4	2	19#

* "Other" is prominent (34%)
** "Ekra" is prominent (24%)
*** "Other" is prominent (57% and 13%)
? Data not available
\# Data missing for one or more parameters for this state
ForCov = Forest cover
CFuel = Type of cooking fuel used
NumRoom = Number of rooms in house
Wall = Type of wall material in house
Roof = Type of roof material in house
Diet = Diet
ARI = Incidence rate of acute respiratory infections
IC = Number of improved cookstoves per 1000 rural population

exclusion of some important parameters, and the utilization of a geographic unit that is too large. Some general observations are in order, nonetheless.

- The range of scores is not very large (16-28, not counting the states with data missing for one or more parameters), considering the possible range of 8-37.
- The higher scores were recorded mainly in the northeastern states. Unfortunately, we are not aware of any quantitative field studies of indoor air pollution from these states to validate or refute this finding. Based on our admittedly limited knowledge of the area, it does not seem to be an unreasonable finding. Perhaps the northeastern states should be a priority area for further investigation and work.
- Two parameters that play a pivotal role in the high scores received by the northeastern states are forest cover and the number of improved cookstoves per 1000 rural population.
- The lower scores were recorded in states and union territories that have traditionally been considered "more developed" economically. These include Haryana, Kerala, Punjab, Gujarat, Chandigarh, Delhi, Karnataka, and Maharashtra.
- In several instances, the lower scores are a product of missing or suspect data and, therefore, cannot be accepted without reservation.
- The framework should be strengthened and refined before further application. It is a potentially useful tool.

3.2. Improving the framework

We suggest four ways of improving the utility, reliability, and accuracy of the framework presented in this paper:

- adding more parameters;
- more accurate data on existing parameters;
- use of smaller units – districts, blocks, or agroclimatic sub-zones; and
- weighting the parameters by their relative importance.

3.2.1. Adding parameters

Some obvious parameters that could be added are ambient temperature, humidity, and past performance of improved cookstoves. Ambient temperature is especially relevant because of its relation to the need for space heating, and because it may determine kitchen location and characteristics. In some parts of India, people cook outside in a shady area during the summer, and indoors during the monsoon. The kitchen does not have a fixed location or ventilation characteristics. It may be difficult to include such a parameter at the state level but it could be very useful at the micro-level.

The past performance of improved cookstoves could be measured by the number of working improved cookstoves, the extent of their use, and the potential for saving fuel. These would be important variables to include as they relate to past experience with interventions in a given area.

Smith, Joshi, and Raiyani are presently engaged in producing a national assessment of human exposure and risk from particulate air pollution (from all sources) in India [Smith et al., 1994]. Smith et al. will use exposure models to estimate exposure by district, age group, and location (urban or rural) based on existing data on sources and exposures. In addition to using the parameters described in this paper, Smith et al. will include: per capita fuel consumption, elevation above mean sea level, population, population density, percentage of population that is urban/rural, socio-economic status, sanitation, distance from a primary health care centre, total mortality, and infant/child mortality.

3.2.2. Better data on existing parameters

Perhaps the greatest lacuna in the parameters utilised in the present framework lies in the ARI incidence statistics. There is probably considerable under-reporting since the segment of the population that would go to a record-keeping hospital or clinic is relatively small. The statistics are impossibly low for some states (e.g., West Bengal reports 0.4/1000). In fact, if one studies the data, one notices that the highest rates are reported from Union Territories (these are territories under the direct rule of the central government) and states with small populations, whereas the populous states (e.g., Uttar Pradesh, Rajasthan, Tamil Nadu, Madhya Pradesh, Gujarat, Maharashtra) all report rates less than 100/1000. Clearly, case reporting is neither adequate nor uniform.

Some measures of health status and susceptibility to the health effects of exposure to air pollution are necessary. It may be worthwhile to seek actual survey statistics for this or to conduct small sample surveys. We have included ARI cases primarily to emphasize the importance of incorporating this variable.

We also had difficulty in obtaining data on diet. Our next-best solution was to use data on principal crops grown in different agroclimatic zones. Though some years ago our assumption that people eat what they grow would have been valid, this is no longer true. The public distribution system, commerce, and migration have altered the availability of and demand for different food grains. To understand prevailing cooking systems better, we need more information on what people are eating.

3.2.3. Using smaller units

States are very large heterogeneous units. In our illustration we have not paid adequate attention to the diversity of micro-environments that exist within each state. The framework presented here could be more usefully applied to smaller geographic units. Agroclimatic zones and subzones might be appropriate choices. Much depends on the scale at which one intends to intervene.

3.2.4. Weighting the parameters

Reviewing the eight parameters used here, it is apparent that not all of them equally influence pollutant concentrations, exposures, and susceptibility. One way to strengthen the framework would be to give greater weightage to primary parameters while decreasing the weightage of secondary parameters. For instance, forest cover is clearly a secondary parameter, whereas cooking fuel is a primary parameter. We have treated them equally, however, for the sake of simplicity.

Finally, we would like to stress the importance of choosing parameters that are relevant and appropriate to the socio-cultural and physical characteristics of given settings. Our illustration focused on India but the framework could be applied in other settings, whether these are agroclimatic zones, administrative units, or countries.

4. Conclusion

We have presented here a framework that can be used to identify areas where smoke from biomass cookstoves is likely to be a significant health concern. While, in its present form, the framework has some shortcomings, we believe that it can be strengthened and refined, and that it has the potential to become a useful tool especially in micro-settings. It is our opinion that such tools, if adequately developed, can play an important role in closing the gap between research and action. Tools and techniques, in themselves, are insufficient, of course. We conclude, therefore, with six broad recommendations.

- Formulate comprehensive programmes, whether for research or intervention, which employ interdisciplinary teams (health, environment, and stove/kitchen designers) to work on different aspects of biomass cooking energy systems.
- Conduct health benefit studies that are not limited to determining the perceptions of users and adopt a rigorous scientific design (e.g., case control, before and after) in areas where dissemination of improved cookstoves is planned or has been a success.
- Compile existing data from small-scale surveys on the relevant parameters, so that this information becomes easily accessible and can be used when working at the district or more local scale.
- Widely disseminate experiences in stove designing and testing in order to inform planners and policy-makers of the actual performance of improved biomass stoves in terms of fuel efficiency and emissions.
- Strengthen the social component of research and intervention by undertaking time budget studies, and studies of seasonal work, diet, and child-care patterns in different agroclimatic zones.
- Address air pollution from biomass combustion as a public health concern. ■

Note

1. On leave from Tata Energy Research Institute, New Delhi

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Biogas for household use: the case of Nepal

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1. The Biogas Support Programme

1.1. The institutional framework of the BSP

The Biogas Support Programme (BSP) is a joint venture of the Agricultural Development Bank (ADB/N), Gobar Gas Company (GGC) and the Netherlands Development Organization (SNV/N), and was launched during the fiscal year (FY) 1992-93. The programme is supported and executed by these organisations, each with specific tasks and responsibilities.

GGC started as the Government's major vehicle for the installation and dissemination of biogas plants. The company, hitherto operating as a non-profit organization, has incurred losses because it has also had to bear the cost of promotional activities, training and R&D, for which it was not compensated. Up to the FY 1993-94 only plants built by GGC (which was de facto the only biogas construction company) were entitled to receive the subsidies of the BSP.

The ADB/N has a strategic position in the extension of biogas plants in the rural areas of Nepal for three reasons.

1. The bank has an extended network of 244 branches and sub-branches and 420 Small Farmer Development Project offices in the rural areas.
2. ADB/N is a development bank. Its mission is to provide credits for the development of the rural areas.
3. ADB/N has about 85% of the shares in GGC, the largest producer of biogas plants, and is the major creditor of GGC.

SNV/N is a NGO supported by the Dutch Government and is well established in Nepal. SNV/N provides a manager for the BSP, coordinates the programme with the Nepali authorities, renders technical assistance to GGC, performs the monitoring of the programme, and does the quality control of the installed biogas plants.

The objectives, conditions and regulations are described in an agreement between His Majesty's Government of Nepal (HMG/N) and SNV/N signed in November 1992. The long-term objectives of the BSP [BSP, 1992] are as follows:

- to reduce the rate of deforestation and environmental deterioration by providing biogas as a substitute for firewood and dung cakes to meet the energy demand of the rural population;
- to improve hygiene and health of the rural population, especially women, by elimination of smoke produced during cooking on firewood, by reduction in the hardships of collection of firewood and by stimulation of better management of dung and night-soil; and
- to increase agricultural production by promoting optimal utilization of digested dung as organic fertilizer.

The first phase of the BSP, of two years, ended in July