

Indoor Air Pollution and Women Health in the Informal Sector

Post Doctoral Project Report

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Preface

Household energy and indoor air pollution pose a substantial vulnerability to the health of rural women and children. This report is based on household energy, indoor air pollution and health issues in rural North Bengal, India. The basic focus of the study is on the risks to health arising from exposure of women and children to smoke in the kitchen and by and large consequences of this for the health of rural poor women who are somehow engaged in informal activities. Use of biofuels for cooking in rural households in developing countries causes respiratory and other illnesses. It also has implications for household safety, allocation and use of the time of household members especially women, children below five years and local natural resource environment. Furthermore, indoor air pollution is a proxy indicator of inefficient use of limited sources of energy and household income. Biofuels are still the main source of energy for most of households in rural India. There is strong evidence that chronic exposure to indoor air pollutants enhances the risk of a range of respiratory illnesses, including acute lower respiratory infections in children and chronic obstructive pulmonary disease in adults, essentially women.

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Siddhartha Sarkar

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(Dr. Siddhartha Sarkar)

Executive Summary

The highest concentration of indoor air pollutants emerges from burning of biofuels such as wood, agriculture crops and dung cake, which are extensively used by rural households in India. The present study on indoor air pollution and women health in the informal sector of rural North Bengal, India is purely based on primary data using survey research technique. There is a definite need for better and comprehensive household energy survey in rural areas in developing countries with a view to better understanding the current and changing pattern of fuel use over time and to ensure women participation in planning and execution of programmes targeting indoor air pollution and build up their awareness towards health, environment and energy issues. The study strongly purports to seek interdisciplinary relevance with issue relating to gender studies, health economics, energy and environment perspective. The different characteristics of fuel uses such as major fuel used for cooking time and effort involved in getting that particular fuel and availability of other type of fuels in the study area, cooking practices, exposure to indoor air pollution, health impact along with socio-economic conditions of households in rural villages of North Bengal especially women engaged in the informal activities can be comprehended from the study. The pollutants released from indoor air pollution cause acute health problems especially to women and children who are present during cooking like acute respiratory infections, chronic obstructive lung disease, lung cancer, tuberculosis etc. Therefore the pollutants released due to biofuels for cooking need to pay more attention to the state of mass rural women living daily with exposure to indoor air pollutants and to cut down indoor air pollutants exposure to acceptable level, access to clean fuel is requisite for the better health of women.

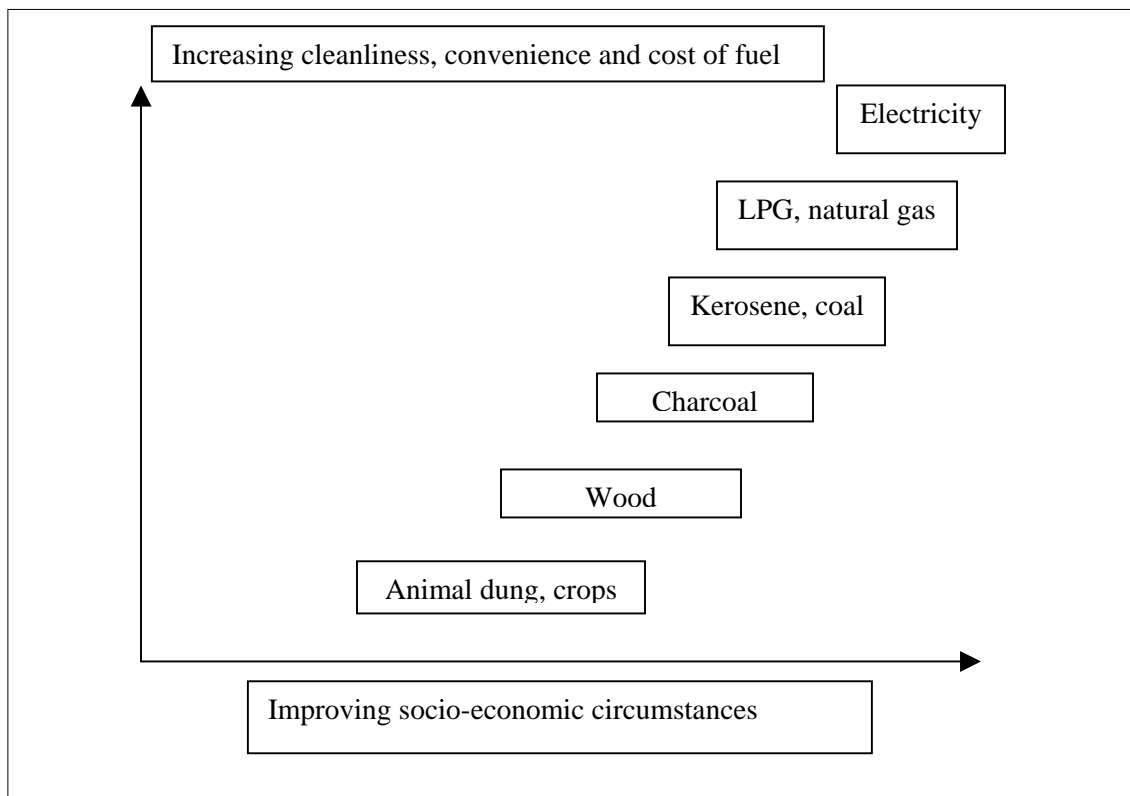
Background

The concentration of indoor air pollutants coming out from combustion of biofuels such as wood, agriculture crops and dung cake used by rural households in developing countries cause severe health problems especially to women and children below five years. It has been estimated that approximately half the global population and up to 90 percent of rural households in developing countries still rely on biomass fuels (World Resource Institute 1999) and about 75 per cent of Indian households use biofuels for cooking purposes. Typically cooked indoors in open fires or poorly functioning stoves, which leads to levels of air pollution that are among the highest ever measured. Therefore indoor air pollution with biofuels is an issue that requires to be addressed through gender, energy, environment and health policy. Some of highest concentrations of pollutants come about due to the use of biofuels for cooking in rural indoor environment (Sarkar 2004 a). In developed countries transformation has without exception been come with by a shift from biofuel to petroleum products (kerosene, LPG) and electricity. In developing countries even where cleaner more sophisticated fuels are available, households often continue to use biomass (Smith 1987). Although the portion of global energy derived from biofuel has fallen substantially which is evidence that biofuel use is increasing among the poor. Poverty is one of the main hurdles to the adoption of cleaner fuels and slow pace of development in many countries implies that biofuels will continue to be used by the poor for many years. Despite the magnitude of the problem of indoor air pollution, the health impact of this environmental exposure has been relatively neglected by research and policy makers.

Biofuels, being an important traditional source of energy, has developed a burly context. It has been showed that nearly 2 million people across the world struggle to meet their basic needs without access to affordable and adequate energy services. In sixteen countries in South and South East Asia over 2 billion people rely on biofuel for cooking, space heating and agro-processing (United Nations 2000). Its crucial importance to sustaining social life, food and nutrition and production activities has supported various national governments to focus heavily on the production and management of biofuel resources. Biofuel refers to any plants or animal based material deliberately burned by human beings. Wood is the most common biofuel, but use of animal dung and crop

residues is also wide spread (De Koning *et al.* 1985). Some countries, including China and South Africa also use coal extensively for domestic needs. The types of fuels used typically amplify in cleanliness, convenience, efficiency and cost as people move up what has been termed the energy ladder (Figure 1.1). Animal dung is on the lowest rung of the ladder progressing to crop residues, wood, charcoal, kerosene, gas, and finally electricity. People generally move up the ladder as socio-economic conditions improve. Other sources of indoor air pollution in developing countries include smoke entering the home from nearby houses (Smith *et al.* 1994), burning of forests, agricultural land and household waste, the use of kerosene lamps (McCracken and Smith 1998), and industrial and vehicle pollution. Environmental tobacco smoke is another source of indoor air pollution exposures, which can be expected to increase in importance in developing countries. It is important also to recognise that the open hearth and resulting smoke often have considerable cultural and practical value in the home, including control of insects

Figure 1.1: The energy ladder



Source: Smith *et al.* [1994]

lighting, drying food, fuel and housing materials and for flavouring foods (Smith 1987). The need to encompass biofuel for food and nutritional security has recently been reorganised and the provision of this essential need from production sources to consumption units, mostly households and the process of converting raw biomass into consumable energy are related to overall development. The implications of this process for the physical and psychological well being of the population or the total well being of those who are engaged in this development paradigm are central to sustainability. Their access to production sources, authority over production, modes of transportation and technology and also a nutritionally adequate diet to bear their daily workload are crucial aspects. From these perspectives what is fundamental is the social domain within which a clear distinction between men's and women's responsibilities, work, social power and authority over resources and technology has been traditionally established. Their biological differences have been instrumental in the gender differentiation of their responsibilities in the biomass cycle. On this basis, the labour performed by women in the promotion of subsistence and well being has been separated from the work performed by men for cash and income. Similarly mostly in economically backward areas and communities, health repercussions are separated from energy systems and also from the benefits of using biomass as matters pertaining to women's ecology. Biofuel is composed of various portions of plants, including woody stems, barks, roots, twigs, and leaves, which can be burned in raw form to generate energy and it is used primarily by two sectors, wood energy based industries and the household sector, where it is used as a primary source of cooking energy. In South Asia the share of biofuel in the total energy consumption remains high, except in India (Table 1.1). These countries namely, Bangladesh, India, Pakistan, Nepal and Sri Lanka rely heavily on non-forest sources or on agricultural and other lands for fuel wood. Non-forest sources provide 75 per cent of the fuel wood requirement in Sri Lanka. This indicates the importance of users' access to production sources or the mechanisms through which users get access to resources. The renewable nature of biofuel, its ability to meet the local needs, and the possibility of getting it freely from various sources for direct day to day domestic consumption are the practical advantages that work to preserve the strong links between the household sector and biomass production sources. The implications of using biofuel energy for the society

and the economy, particularly of economically less advanced countries, communities and families, are important policy considerations. However, the biofuel energy scenario is marked by features of concern common to many developing countries (Wickramasinghe 2003).

- The first is that biofuel still remains a dirty, messy, unhealthy fuel. Its use is very time consuming and undervalued and dominated by women, and it is used by a majority in developing countries.
- The second is that the unmeasured human costs in terms of human energy, time, discomfort, and personal health are paid mostly by the providers of this basic need from the multiple sources of supply to the household units of consumption.

Table 1.1: Fuel wood consumption in some South Asian countries

Country	Total fuel wood consumption (Mt)	Share of forest wood (%)	Share of non forest wood (%)	Share of biofuel in total energy consumption (%)
Bangladesh	5.5	13	87	71
India	94.5	26-53	43-74	33
Nepal	11.3	66	34	92
Pakistan	29.0	10	90	46
Sri Lanka	9.1	25	75	55

Source: Bhattarai [1996]

- The third is that the contributions made by women to sustain biomass energy systems are reckoned solely in the domestic domain, especially as a matter pertaining to domestic cooking, rather than as contributions towards maintaining human capital and quality of life.
- The fourth is related to the underreported realities of psychological trauma and the physical exhaustion of those whose lives are trapped in the biofuel cycle.
- The fifth is that the health risks of procuring and transporting biofuel are on the increase because of many changes in the supply domain, including resource

tenure, deforestation, degradation, market demand and competition for better quality wood and the burden of poverty and malnutrition experienced by women in particular.

In the developing economies a substantial share of employment is indeed in informal category and women in all age groups depend on the informal sector more heavily than men. Women are over represented in this sector in the sense that their share in the sector is higher than their share in total labour force. Most women tend to be own account workers and only a few are heads of micro enterprises. Relatively lower level of education among women, compared to men, seems to explain, in part, this gender differential in informal employment. Discrimination in the labour market also explains in part the disproportionate concentration as it limits women's access to formal and wage employment. Women also face additional constraints because of their homemaking and childcare responsibilities, which limits their participation in formal employment. Even within the informal sector more women than men seem to be in poor quality employment. In Latin America more women seem to be in the unpaid categories than men. In Africa the proportion of unpaid workers working in family owned enterprises among women appears to be relatively high compared to other regions. The causes for participation in the informal sector can be economic and non-economic. Economic reasons are related to unemployment and an inflexible formal labour market, a declining real price of capital and the high cost of formal production. Besides, non-economic causes are concerned with a greater flexibility and satisfaction in work, a complete use of workers professional qualifications and increased leisure time. There are two groups of factors, which determine the decision to become active in the informal sector, more specifically, the structural as well as opportunity factors. The structural factors consist of financial pressure, socio-psychological pressure and institutional constraints. The opportunity factors consist of individual background, skills, education, living condition or non-individual components, environment, values, standards etc. (Sarkar 2004 b). Unlike modern fuels, the supply of biofuels such as wood and charcoal are still largely uncontrolled and based in the informal sector. Rural populations generally supply themselves from surrounding forests and from trees in the landscape, in most cases in quantities that do not exceed sustainability limits. The supply of biomass fuel for the

cities is also uncontrolled and in most cases, biomass production is unsustainable. Wood is felled in state-owned forests by dealers, but the cost of replacing the trees is not paid, with the result that forests are deteriorating rapidly around major cities. Past efforts to relieve the resulting firewood shortage by encouraging farmers to grow trees have largely failed because the costs of this far exceed the short term costs of gathering fuel from existing forests (French 1986). However new efforts to empower local communities to manage the forests in their areas in a sustainable way for the production, among other things, of biomass fuels are encouraging, particularly as this could provide income sources for the poor within the community. In most developing countries the majority of informal sector enterprises are owned and operated by women, with women making up the largest proportion of the work force. Despite this, the contribution of women entrepreneurs to national economies is not explicit in national statistics, leading to the development of policies that do not deal with the specific barriers faced by women linked to their gender-defined roles. Their enterprises tend to be concentrated in a relatively narrow range of activities such as knitting, dressmaking, crocheting, cane work and retail trading. These activities tend to have disproportionately low rates of return compared to the activities undertaken by men. However despite the low financial returns, women's enterprises provide important sources of household income, even in male-headed households. Women headed enterprises are frequently located in the home and these cottage industries tend to be overlooked by agencies because they are in the informal sector, which is diffuse and difficult to reach. When women are forced to close their enterprises, it is often for non-business reasons and linked to factors associated with working from home. The low rates of return prevent inward investment, hindering innovation and expansion, which are regarded as key factors in enterprise sustainability (Grosh and Somolekae 1996). There is little research to explain what forces drive these startups and shutdowns, and how gender influences these processes. Women's access to resources (such as credit, land and education, which are recognised as key factors in micro enterprise development) is significantly less than that of men. Generally, research in small and medium-scale enterprise sustainability indicates that a lack of working capital is one of the two most common causes of enterprise failure (Grosh and Somolekae 1996). Women's access to decision-making within the household and community is also

restricted, reducing their ability to influence processes and resource allocation. Given the disproportionate number of poor women in rural areas, research which takes into account gender aspects of the transformation of structures and processes could make a significant contribution to the development of gender equitable sustainable livelihoods. The role of energy in the sustainability of women's enterprises is also not well understood. In food processing enterprises it has been estimated that energy costs are 20 to 25 per cent of the total inputs, which would suggest that technological interventions could increase the scale and profitability of these businesses. Figure 1.2 gives some examples of how energy can act as an opportunity or a constraint on women's productive activities. The types of enterprises that women are traditionally involved in are energy intensive and rely on biomass fuels. Even in rural areas, women may have to buy fuelwood to run enterprises such as beer making (McCall 2001). An important issue is what sort of mechanisms can assist women in gaining access to improved energy services. Grain mills, which are very popular with women, since they improve product quality as well as reducing women's labour, are typically only provided by the private sector, and are still absent in many rural locations. A much more systematic approach is needed, possibly with some form of incentive to encourage the spread of mills to areas not yet served. A general rule that can be learnt from attempts to introduce technology for women is that if it does not reduce the labour in household tasks then, no matter how beneficial the technology, it is likely to have low acceptance. There are positive examples of women taking up energy technologies that have contributed to increasing their incomes. It is found that women's groups in Ghana use LPG for fish preservation, giving them a better quality product than when using wood, and enabling them to reach export standards, considerably improving their income (Mensah 2001). Women may in fact be best entrants to become energy entrepreneurs. It has indicated that improved stove programmes in India run by women tend to be rather successful because they are able to more easily approach their clients (Sarin 1984). However energy entrepreneurship could extend beyond stoves to include energy services, for example the supply of and even the repair of, modern energy appliances such as solar panels. There is an enormous need for agents in rural areas who can distribute such equipment on a viable basis, notwithstanding with some support in the short term. Women who live in rural areas know and understand local circumstances and

needs and may have a much clearer idea about the energy services that rural people desire. In addition a woman may be able to sell more effectively to other women, since access to female clients is not hindered by social constraints. This may in fact be the best route to greater women's participation in household energy choice.

Figure 1.2: Energy in livelihood strategies: improving the position of women

Energy availability that creates opportunities (increased income/more sustainable use of natural resources)

- Community level sustainable management of forests can provide income through organised firewood production and sale.
- Energy entrepreneurship as a secondary activity for community service and income generation.
- Improved technologies for charcoal production can boost sustainability and incomes.
- Availability of mechanical and process heat technologies can be a stimulus to the start up of various small-scale enterprises (sawing, food processing etc.).

Energy scarcity as a constraint (which if removed, can bolster other activities, reduce vulnerability, improve food security, increase well being)

- Lack of transport for moving harvest products to storage and to market may be a disincentive to produce (increases vulnerability, and reduces food security).
- Poor cooking technology results in unnecessary ill health for women and children reducing their productivity (and threatening well being).
- Lack of cheap, easily available, fuel forces women to spend large amounts of time gathering fuel, and restricts the boiling of water and in some cases the adequate cooking of food resulting in ill health (threatens well being, increases vulnerability) as well as limiting time available for other enterprises.

Review of Literature

Air pollution has been consistently linked with substantial burden of ill health in developed and developing countries (Bruce *et al.* 2000, Schwartz 1994, Smith *et al.* 2000). The bulk of indoor air pollution research and control has focused on sources of concern in developed countries based on solid fuel and tobacco combustion (Smith and Mehta 2003). Exposures to indoor air pollution are of importance cause of morbidity and mortality in developed countries (World Health Organization 1997, 2002) as well as developing countries (Florig 1997, Saksena and Dayal 1997, World Bank 1997, World Health Organization 1997). However the most important indoor air pollutants are the combustion products of unprocessed solid biomass used by the vulnerable section urban and rural people in developing countries for cooking and heating purpose. Exposure to biomass smoke enhances the risk of acute respiratory infection among women and children below five years. A study in Gambia focuses that infants who were exposed to smoke by being carried on their mother's backs during cooking were nearly three times more likely to develop significant cases of acute respiratory infection. A study in Colombia expresses that women cooking over open fires had almost four times more chronic lung disease compared to those cooking in other manner (Parikh 1996). A study in Tanzania finds that children younger than five years who died of acute respiratory infection were almost three times more likely to be sleeping in a room with an open cook stove than healthy children in same age group. Studies in India, Nepal and Papua New Guinea show that non-smoking women who have cooked on biomass stoves for many years exhibit a higher prevalence of chronic lung disease. In Mexico, women exposed to wood smoke for many years faced 75 times more risk of acquiring chronic lung disease, about the level of risk that heavy cigarette smokers face than women not exposed to wood smoke. A recent study in Colombia discloses that women exposed to smoke during cooking were three times more likely to suffer from chronic lung diseases. A study in Japan delves into high rates of cancer among women who had previously used wood as fuel. The risk of lung cancer is high in Chinese women exposed to coal smoke in homes. Likewise a study in Africa encompasses that cooking with wood greatly increased the risk of stillbirth. Considerable amount of carbon monoxide have been detected in the bloodstream of women cooking with biomass in India and Guatemala (World Bank

2000). It has been estimated that about half a million women and child die each year from air pollution in India. Compared to other countries India has among the largest burden of disease due to the use of dirty household fuels and 28 per cent of all death due to indoor air pollution in developing countries occur in India (Smith 2000a). It is estimated that use of open fires with biofuels exposes nearly 2 billion people in the world to enhanced concentrations of particulate matter and gases, up to 10-20 times higher than health-based guideline values available for typical urban outdoor concentrations (Barnes *et al.* 1994, Reddy *et al.* 1996, World Health Organization 1999). Assessments of the burden of disease attributable to use of biofuels use in India have put the figure at 3-5 percent of the national burden of disease (Smith 2000b, Smith and Mehta 2003). Some of the earliest human evidence linking indoor air pollution from biomass combustion with respiratory health came from studies carried out in Nepal and India (Pandey 1984a, Ramakrishna *et al.* 1989, Smith *et al.* 1983). Since then, there has been a steady stream of studies, especially on women who cook with these fuels and young children (Bruce *et al.* 2000, Smith *et al.* 2000). Associations between exposure to indoor air pollution and increased incidence of chronic bronchitis in women and acute respiratory infections in children have been documented (Armstrong and Campbell 1991, Bruce *et al.* 1998, Ezzati and Kammen 2001, Robin *et al.* 1996). Many recent studies have also been conducted in rural Indian villages (Awasthi *et al.* 1996, Behera *et al.* 1991, Mishra and Retherford 1997, Smith 1993, Smith 1996). A recent study has also characterized the exposure response relationship between biomass smoke exposure and acute respiratory infection in children of rural Kenyan households (Ezzati *et al.* 2000a). The incidence of chronic obstructive pulmonary disease in non-smoking women using biomass for cooking has also been shown to be dependent on the number of years cooking with biofuels and often to be comparable to that of men who usually have high smoking rates. Based on this evidence, it has been estimated that the indoor air pollution contributes to 3-5 per cent other causes as well, it is difficult, lengthy, and of the national burden of disease in India (Smith 2000b).

Exposure to indoor air pollution, especially to particulate matter, from the combustion of biofuels has been implicated as a causal agent of respiratory diseases in developing countries (Chen *et al.* 1990, Ellegard 1996, Pandey 1984b). This association, coupled

with the fact that globally more than 2 billion people rely on biomass as the primary source of domestic energy, has put preventive measures to reduce exposure to indoor air pollution high on the agenda of international development and public health organizations (Ezzati *et al.* 2000b, World Bank 1993). The evaluation of the benefits and effectiveness of measures that aim to reduce these negative health impacts, such as design and dissemination of improved stoves and fuels, requires knowledge of the exposure response relationship between indoor particulate matter from biomass combustion and acute respiratory infections. There is little information on the shape of the exposure response relationship at concentrations of hundreds to thousands of micrograms per cubic meter that are commonly observed in indoor environments in developing countries (Ezzati *et al.* 2000b).

The epidemiological studies have provided some evidence of an association between cataract or blindness and exposure to indoor smoke from household use of solid biofuels such as animal dung, wood and crop residues (Mishra *et al.* 1999, Zodpey and Ughade 1999). However, these studies have had limitations that have precluded establishment of a definitive causal relationship. The study of Zodpey and Ughade (1999) found an association between cataract and cheaper cooking fuels such as coal, cow dung and wood presented limited data on potential confounding factors, other than age and socioeconomic status. The other study, with a cross sectional design, used data from the 1992-93 Indian National Family Health Survey which found an association between biomass fuel use and partial and complete blindness after adjustment for a number of potentially confounding factors (Mishra *et al.* 1999). Use of biofuels causes a number of respiratory problems, which include acute respiratory infections in children, chronic obstructive lung disease in nonsmokers (Samet *et al.* 1987). It has also been implicated as a risk factor for lung cancer in women (Gao 1996, Wu and Du 1996).

Objective and Methodology

Rural women have often been ignored in policies to enhanced access of the poor to more efficient and convenient forms of energy in developing countries including India. Rural development programmes have therefore had limited success in alleviating air pollution, including the drudgery of fuel wood collection and biomass based cooking that cause danger to the health of rural women and children. The challenge has to be addressed in a broader perspective including social and behavioural aspect. A community cooking with biofuels can be exposed to several health diseases and to alleviate such problem gender participation promotion may be an appropriate solution. The highest concentration of indoor air pollutants emerges from burning of biofuels such as wood, agriculture crops and dung cake, which are widely used by rural households in rural North Bengal. Compared to the thousand of studies an outdoor air pollution in developed country urban settings, only a handful of studies nearly a few dozen have been carried out in biomass using households in developing countries, most of which are rural settings. The different characteristics of fuel uses such as major fuel used for cooking time and effort involved in getting that particular fuel and availability of other type of fuels in the area, cooking practices, exposure to indoor pollution, health impact along with socio-economic conditions of households in rural villages especially women in rural North Bengal can be comprehended from the study. The pollutants released due to use of biofuels for cooking need to pay more attention to the mass rural women living daily with exposure to indoor air pollutants and to curb indoor air pollutants exposure to acceptable level access of clean fuels is required for the better health of rural women. Policies for rural areas that encourage the uptake of efficient use of biomass fuels can effectively address the problem of indoor air pollution and physical drudgery of women. But women must involve in the planning of these policies and interventions to ensure their successful implementation and sustainability. Energy policies and projects by themselves will not change the plight of women in the society, but these can be used as entry point for reducing a preventable burden of death and illness among women and promoting greater fairness in the allocation of opportunities and resources between men and women.

The present study on indoor air pollution and women health in the informal sector of rural North Bengal is purely based on primary data using survey research technique.

There is a definite need for better and comprehensive household energy survey in rural areas in developing countries with a view to better understanding the current and changing pattern of fuel use over time and to ensure women participation in planning and execution of programmes targeting indoor air pollution and build up their awareness towards health, environment and energy issues. The study strongly purports to seek interdisciplinary relevance with issue relating to gender studies, health economics, energy and environment perspective. The different characteristics of fuel uses such as major fuel used for cooking time and effort involved in getting that particular fuel and availability of other type of fuels in the study area, cooking practices, exposure to indoor air pollution, health impact along with socio-economic conditions of households in rural villages of North Bengal especially women engaged in informal activities and children below five years of age can be comprehended from the study. However the major objective of the study include the following:

- Socio-economic status of the households
- Fuel use pattern and cooking practices of the households
- Reasons for not using clean fuel and willingness to pay for it
- Association among combustion of biofuels, air pollution and women health

The selection of villages from rural North Bengal for the purpose of extensive survey was carried out using multistage sampling method. At primary stage stratification of the regions was done on the basis of socio-cultural districts. At the second stage selection of one district per socio-cultural districts was done based on the population median class. At the third stage allocation of households to each district based on the universe of rural households was undertaken. Then stratification of each selected district was done by village population size. The villages were catagorised into four different strata on the basis of population. In stratum I villages with population less than 1500 were included, stratum II had villages with population 1500-3500, whereas in stratum III villages with population between 3500-5500 were included. In stratum IV villages with population more than 5500 were considered. Stratum IV was excluded from the sample because these villages resemble semi urban areas. The selection of the villages from each stratum was done using population proportion sampling and selection of households within the selected villages was performed based on systematic random sampling. The survey was

carried out at household level including individual responses for health status, village level as well as local health care facility. Village level and health centre surveys were performed for the sake of validation of data acquired at household and individual level. At the household level a multi pronged approach was used while collecting different types of information. Data were collected through face-to-face interview of the chief cook of the house along with any helping hands and health status were assessed with the help of qualified medical practitioners. Various socio-economic information and other details as well as individual self-reported data were gathered through structure questionnaire survey. The information collected for the study comprise of socio-economic characteristics, fuel consumption pattern, cooking behaviour along with health profile.

The survey was conducted in rural villages of Cooch Behar, Darjeeling, Jalpaiguri, and Malda districts covering 2,580 individuals, of which 967 women, 1,082 men, 255 girls and 276 boys below 14 years in 740 households in 20 villages. The sample respondents were selected using stratified random sampling techniques from the surveyed villages. The village level information was collected from the head of village *panchayat* whereas health centre level information was gathered from administrative officer or chief doctor. The data at household level were congregated to get a comprehensive picture of socio-economic conditions, energy use pattern, cooking behaviour, willingness to pay to curb indoor air pollution and health considerations.

Findings

In rural North Bengal most of the people are engaged in the informal sector, of which women are generally employed in domestic services, *beedi* making, agriculture and allied activities, construction work, brick making and rural artisans. It is observed that most of the surveyed villages are linked with road network and have some mode of transportation. In the selected villages 13 villages have *pucca* road within a kilometre distance and other 2 villages have *pucca* road within 2 kilometres distance and 5 villages have *pucca* road beyond 2 kilometres but less than 4 kilometres distance. Only 2 villages have railway station within a distance of 3 to 6 kilometres and people in rest of the 18 villages face difficulties to avail railway transportation because of locating station at long distance. Most of the villages (60 per cent) have a town within a distance of 2 to 5 kilometres. As the majority of the surveyed villages are close to *pucca* roads, the main mode of transportation is bus. Add to there is other modes of transportation such as van rickshaw and bicycle. Almost all villages have at least a primary school and 7 villages have secondary school also. 16 villages have primary health centres with an average distance of 2 to 4 kilometres.

Economic compulsion is the main reasons of the women behind taking the job as informal workers (98 per cent). However there are a tiny percentage (2 per cent) of the workers mostly the wives from middle class families, who entered the informal job market for passing out idle time. Besides child labourers entered the workforce for meeting their own educational expenses. 16.96 per cent of women workers reported that they have chosen the job for supporting their family and 29.68 per cent of the workers serve for independent income. It is also reported that most of the adult male members of the households are agriculture workers (62.01 per cent). Others engage as casual labour (5.53 per cent), rickshaw puller (9.89 per cent), petty trader (7.76 per cent), wholesale trader (3.79 per cent) and government employee (1.02 per cent). It is found that 10 percent among them do not work at all.

The women do simultaneously their own household task. They combine wage work with their domestic responsibilities. Table 4.1 discloses the level of participation in own household task as reported by female members of the households.

Table 4.1: Level of participation in own household task

Household task	Self	Husband/Other members	Jointly
Washing clothes and utensils	1043 (85.35)	57 (4.67)	122 (9.98)
Water collection	1117 (91.41)	32 (2.62)	73 (5.97)
Fuel collection	937 (76.68)	187 (15.30)	98 (8.02)
Food preparation	1222 (100.00)	0 (0)	0 (0)
Maintenance of house	482 (39.44)	527 (43.13)	213 (17.43)
Childcare	1098 (89.85)	83 (6.79)	41 (3.36)

Note: Figures in the parentheses are percentages and female members include girl children also

Therefore women including girl children have nearly full responsibilities in activities such as washing clothes and utensils, water collection, fuel collections, food preparation and childcare activities. Apart from the large bulk of sundry task often some workers are to assist their counterparts in agriculture activities. In addition girl children are to help their mother in sundry household task especially water collection, fuel collection and food preparation.

The survey shows that 52.3 per cent of the households have annual income less than Rs.25,000 while 35.54 per cent of the households have annual income above Rs.25,000 but below Rs. 50,000. only 7.16 per cent of the households have income more than Rs.50,000 but below Rs.75,000. The different types of durables owned by the households reveal the purchasing power/economic status of the households. The survey discloses that majority of the households are unable to buy anything additional for the family. It is also found that female members of the households working for more than ten years failed to save sufficient amount of money to buy durables.

It is found that almost all (94.46 per cent) of surveyed households in rural villages North Bengal use biofuels for cooking. Among biofuels using households, 78.25 per cent use fuel wood. Dung cake and crop residue are used in 73.4 per cent and 35.48 per cent of households respectively. The average consumption of fuel wood is about 5.4 kgs per

households, supplemented by other biofuel sources. Kerosene is mostly used for lighting and its use for cooking is restricted to only 5.68 per cent of the households. Only 14 households make use of LPG and use of electricity and biogas for cooking is almost trivial. The study reveals that most of the households cook (87.03 per cent) twice meals a day. 5.41 per cent of the households cook once. Remaining 7.57 per cent of the households cook thrice a day. The average time spent for cooking a day is about 4 hours along with other associate sundry household task.

Willingness to pay of the participants estimates the probable demand for kerosene. The kerosene supplied through public distribution system is mostly limited to quota. The study shows that most of the villages do not get kerosene through rationing system and 3 villages reported to have an irregular supply of kerosene. The use of clean fuel is higher among higher income group. Only 48.24 per cent of the households are drawing kerosene as per quota from ration shop. About 53.78 per cent of the households are to buy an average quantity of 8 litres kerosene per month for lighting and cooking from open market. The survey reveals that at the ration price almost all sampled households (99.05 per cent) are willing to purchase an additional quantity of kerosene. 62.03 per cent of the households are ready to switch over to clean fuel if made available. The results of the survey show that only 6.35 per cent of the households are willing to spend some money to improved air quality in the kitchen. There is a higher willingness to pay for ventilation in houses than for improved stoves.

Table 4.2: Reasons for not using clean fuels

Reasons	Percentage agree
Lack of availability	83.67
Costly	69.78
Not willing to switch over	17.91
Anxious of using	23.93
Taste of food changes	78.52
Not persuaded of the advantages	8.31
Wood smoke repels for insects	1.58
Wood smoke enhances the longevity of thatched roof	3.3
Base: household not using kerosene for cooking	698

The households not using kerosene for cooking are asked for the reasons for not using clean fuels. 83.67 per cent of the households reported non-availability as the reason for not using it, while 69.78 per cent do not use clean fuels because of non-affordability. 17.91 per cent are not interested to switch over to clean fuel and a tiny percentage of households agree with other reasons (Table 4.2).

The air pollution has been consistently associated with substantial burdens of ill health in developed and developing countries. The study of selected villages reveals that women and children are badly affected by pollution. It is found that most of the diseases are indoor air such as bronchitis, tuberculosis, asthma, eye disease, adverse pregnancy outcomes, skin infection, joint pain, other respiratory diseases etc. Also general muscular weakness, phlegm and cough among children have been noticed in the villages. A majority of complaints are about problems regarding bronchitis and tuberculosis. The women suffering from respiratory diseases are 46.4 per cent. Asthma was reported by 10.1 per cent whereas 4.8 per cent reported bronchitis. The reporting of symptoms and diseases were kept into account on the basis of respondent's memory recall for all the members of the households. Incidence of asthmatic symptoms noticed to be higher among women who cook inside compared to those who cook open air. On the basis of self reported symptomatic cases of respiratory diseases cough, breathlessness, wheezing are found to be significantly higher among those living *kachcha* houses and using biofuels for cooking compared to those living *pucca* houses and using clean fuels for cooking.

Policy Implication

Indoor air pollution comes out to be a major environmental and public health hazard for large numbers of the world's poorest, most disadvantaged people. The existing studies on indoor air pollution in developing countries, while providing important evidence of associations with a range of serious and common health problems, suffer from a number of methodological limitations. There is also a strong case for carrying out a limited number of intervention studies, particularly for the most common and serious health outcomes from indoor air pollution due to burning of biofuels. Such studies may adopt a randomised controlled trial design, which will provide the most powerful evidence and remove the problem of confounding, or be based on natural experiments if appropriate settings are found. Case-control or cohort studies may also serve this purpose if suitable areas can be identified where a good range of exposure levels are distributed fairly evenly and confounding factors are not too strongly associated with exposure. The stress that future studies should shell out more attention to exposure assessment implies a need to further develop practical and valid methods for measuring the exposure levels and patterns particularly for women and children. However the following policy and strategy recommendations have been made.

- A general improvement in the health status especially that of women and children, is a critical input for economic growth and poverty reduction, thus addressing the health impacts of household energy and indoor air pollution should be an integral part of poverty reduction efforts.
- Improved biomass stoves and cleaner biomass based fuels will continue to be an option for reducing exposure for a large majority of the rural poor in developing countries. Facilitating behavioural changes in women, children and other household members is another way of reducing exposure and alleviating the associated health impacts. Improving the status of women can be an effective method of promoting markets for better stoves and other household energy use services.
- The government should ensure sustained upshot market mechanisms for distribution of improved stoves and commercial fuels. Programmes that propagate improved biomass stoves with higher efficiency and lower emissions

commercially, with proper certification and quality control by government agencies, have greater financial sustainability, respond better to user demand and produce more durable stoves. Therefore, government interventions should be re-oriented towards creating an effective regulatory framework and incentive structure that works with the market.

- One of the most important elements of a strategy to mitigate indoor air pollution is to bring about a behavioural change, including a greater demand for cleaner cooking. This will require raising awareness amongst rural households about the health impacts of traditional household energy use and providing specific information on the range and effectiveness of mitigation options.
- Among the rural poor, at the household level the decision making regarding fuel use patterns largely depend on men, while girls and women continue to put up with the burden of collecting fuel wood and use it for cooking, thus exposing themselves to highest levels of indoor air pollution. It is therefore important to ensure mechanisms that allow both women and men to make choices and influence household decisions regarding the use of fuels. Creating self-help groups, promoting energy entrepreneurship and ensuring income generation opportunities for women as part of household energy strategy are the approaches that may improve rural living standards.
- The effective household energy programmes should address the range of sustainable livelihood and poverty needs of both women and men. In poor households, energy and time use for consumption and production are closely interrelated such as food and beverages may be prepared for family use as well as for sale; fuel wood may be collected for cooking and for sale etc. Increasing opportunities for women to earn income outside of the household may be the only way to reduce the use of fuel wood collected with unpaid family labour and therefore engagement in paid informal activities may generate income for the rural women. Programmes to improve household energy services and mitigate indoor air pollution need to address these aspects, by providing opportunities for income earning for women engaged in the informal economic activities.

References

- Armstrong, J.R and Campbell, H.1991.Indoor air pollution and lower respiratory infections in young Gambian children. *Int J Epidemiol*, 20(2): 424-429.
- Awasthi, S, Glick, H and Fletcher, R.1996.Effect of cooking fuels on respiratory diseases in preschool children in Lucknow, India. *Am J Trop Med Hyg*, 55(1): 48-51.
- Barnes, D.F, Openshaw, K, Smith, K.R and Van der Plas, R. 1994.What makes people cook with improved biomass stoves? A comparative international review of stove programs. World Bank Technical Paper, Energy Series 242, Washington DC.
- Behera, D, Jindal, S.K and Malhotra, H.S. 1991. Ventilatory function in non-smoking rural Indian women using different cooking fuels. *Thorax*, 46(5): 344-346.
- Bhattarai, T.N.1996.Integrating wood fuel production in the implementation of agriculture, forestry and rural extension programmes in South Asia. Regional Wood Energy Development Programme in Asia, Report No. 26, Food and Agriculture Organisation, Bangkok.
- Bruce, N. 2000. Global technical consultation on the health impacts of indoor air pollution and household energy in developing countries. USAID/WHO, Washington DC.
- Bruce, N, Perez-Padilla, R and Albalak, R. 2000. Indoor air pollution in developing countries: a major environmental and public health challenge for new millennium. *Bulletin of the World Health Organization*, 78(9): 1078-1092.
- Chen, B.H, Hong, C.J, Pandey, M.R and Smith KR.1990.Indoor air pollution in developing countries. *World Health Stat Q*, 43:127-138.
- De Koning, H.W, Smith, K.R and Last, J.M.1985.Biomass fuel combustion and health. *Bull WHO*, 63(1): 11-26.
- Ellegard, A. 1996.Cooking fuel smoke and respiratory symptoms among women in low-income areas in Maputo. *Environ Health Perspect*, 104: 980-985.
- Ezzati, M, Saleh, H and Kammen, D.M. 2000a. The contributions of emissions and spatial microenvironments to exposure to indoor air pollution from biomass combustion in Kenya. *Environ Health Perspect*, 108: 833-839.

- Ezzati, M, Mbinda, B.M and Kammen, D.M. 2000b. Comparison of emissions and residential exposure from traditional and improved biofuel stoves in rural Kenya. *Environ Sci Technol*, 34:578-583.
- Ezzati, M and Kammen, D.M. 2001. Quantifying the effects of exposure to indoor air pollution from biomass combustion on acute respiratory infections in developing countries. *Env Health Perspect*, 109:481-489.
- Florig, H.K. 1997. China's air pollution risks. *Environ Sci Tech*, 31(6): 276A-279A.
- French, D. 1986. Confronting an unsolvable problem: deforestation in Malawi. *World Development*, 14 (4): 531-540.
- Gao, Y.T. 1996. Risk factors for lung cancer among nonsmokers with emphasis on lifestyle factors. *Lung Cancer*, 14 (Supplementary 1): S39-S45.
- Grosh, B and Somolekae, G. 1996. Mighty oaks from little acorns: can micro enterprise serve as the seedbed of industrialisation? *World Development*, 24 (12): 1879-1890.
- McCall, M. 2001. Brewing rural beer should be a hotter issue. *Boiling Point*, 47: 23-25.
- McCracken, J.P and Smith, K.R. 1998. Emissions and efficiency of improved wood burning cook stoves in highland Guatemala. *Environ Int*, 24(7): 739-47.
- Menash, S.A. 2001. Energy for rural women's enterprises. In: *Generating opportunities: case studies on energy and women*. United Nations Development Programme, New York.
- Mishra, V and Rutherford, R. 1997. Cooking smoke increases the risk of acute respiratory infections in children. *National Family Health Survey Bulletin* (8).
- Mishra, V.K, Rutherford, R.D and Smith, K.R. 1999. Biomass cooking fuels and prevalence of blindness in India. *J Environ Med*, 1:189-199.
- Pandey, M.R. 1984a. Prevalence of chronic bronchitis in a rural community of the hill region of Nepal. *Thorax*, 39:331-336.
- Pandey, M.R. 1984b. Domestic smoke pollution and chronic bronchitis in a rural community of the hill region of Nepal. *Thorax*, 39:337-339.
- Parik, J. 1996. Poverty, environment and development nexus. *Human Development Report*. UNDP.
- Ramakrishna, J, Durgaprasad, M.B and Smith, K.R. 1989. Cooking in India: the impact of improved stoves on indoor air quality. *Environ Int* 15: 341-352.

- Reddy, A.K.N, Williams, R.H, Johansson, T.B.1996. Energy after Rio: prospects and challenges. United Nations Publications, New York.
- Robin, L.F, Lees, P.S.J, Winget, M, Steinhoff, M, Moulton, L.H, Santhosham, M and Correa A. 1996. Wood burning stoves and lower respiratory illness in Navajo children. *Pediatr Infect Dis J*, 15: 859-865.
- Saksena, S and Dayal, V. 1997. Total exposure as a basis for the economic valuation of air pollution in India. *Energy Environment Monitor*, 13(2): 93-102.
- Samet, J. M, Marbury, M.C and Spengler, J.D. 1987. Health effects and source of indoor air pollution. Part I. *Am Rev Respir Dis*, 136:1486-508.
- Sarin, M.1984. *Nada chula: a handbook*. Voluntary Health Association of India, Delhi.
- Sarkar, S.2004a. Air pollution: its perilous chronic hygienic impacts. *J Hum Ecol*, 16(2): 129-132.
- Sarkar, S.2004b.Theorising in informal sector: concept and context. *Social Action*, 54(40): 359-373.
- Schwartz, J.1994. Air pollution and daily mortality: a review and Meta analysis. *Environ Res*, 64:36-52.
- Smith, K.R, Aggarwal, A.L and Dave, R.M. 1983. Air pollution and rural biomass fuels in developing countries: a pilot village study in India and implications for research and policy. *Atmos Environ*, 17: 2343-2362.
- Smith, K.R.1987. *Biofuels, air pollution, and health. A global review*. Plenum Press, New York.
- Smith, K.R.1993.Fuel combustion, air pollution and health: the situation in developing countries. *An Rev Energy Env*, 18: 529-566.
- Smith, K.R, Apte, M.G, Yoqing, M, Wongsekiarttirat, W and Kulkarni, A.1994. Air pollution and the energy ladder in Asian cities. *Energy*, 19(5): 587-600.
- Smith, K.R. 1996. Indoor air pollution in developing countries: growing evidence of its role in the global disease burden. Organising Committee of the 7th International Conference on Indoor Air Quality and Climate. SEEC ISHIBASHI Inc., Japan.
- Smith, K.R.2000a. Indoor air pollution implicated in alarming health problems. In: *Indoor air pollution-energy and health for the poor*. Newsletter Published by World Bank.

- Smith, K.R.2000b.The national burden of disease in India from indoor air pollution. Proc Nat Acad Sci, 97: 13286-13293.
- Smith, K.R, Samet, J.M, Romieu, I and Bruce, N. 2000. Indoor air pollution in developing countries and acute lower respiratory infections in children. Thorax, 55:518-532.
- Smith, K.R and Mehta, S.2003. The burden of disease from indoor air pollution in developing countries: compared of estimates. Int J Hyg Environ Health, 206:279-289.
- United Nations.2000.World energy assessment: the challenge of sustainability. United Nations, New York.
- Wickramasinghe, A.2003.Gender and health issues in the biomass energy cycle: impediments to sustainable development. Energy for Sustainable Development, VII (3): 51-61.
- World Bank. 1993. Investing in health. World Development Report, Oxford University Press, New York.
- World Bank.1997. Clean water, blue skies: China's environment in the new century. World Bank: 114, Washington, D C.
- World Bank.2000.Household energy, air pollution and health. UNDP/ESMAP.
- World Health Organization.1997. Health and environment in sustainable development. Geneva.
- World Health Organization.1999. Guidelines for air quality. Geneva.
- World Health Organization.2002. Reducing risks, promoting healthy life. World Health Report, Geneva.
- World Resource Institute.1999.1998-99 World resources: a guide to the global environment. Oxford University Press.
- Wu, J.M and Du, Y. X. 1996.Overview and highlights of the panel discussion. Lung Cancer, 14 (Supplementary 1): S3-S8.
- Zodpey, S.P and Ughade, S.N. 1999.Exposure to cheaper cooking fuels and risk of age related cataract in women. Ind J Occupational Environ Med, 3:159-161.