Economic Analysis of Rural Pollution and Health Impacts in Northern India: A Multi-institutional Project

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Introduction

The rural population of India, and many other developing countries, suffer from serious problems of indoor air pollution due to kitchen smoke, unsafe water and lack of sanitation. These problems are critical to local environment. The World Bank estimates that improvements in local environmental conditions faced by the poor could lower incidences of the major killer diseases by up to 40 percent.

Much of the previous research on environment and health issues facing rural areas of developing countries is fragmented and contains only partial analysis. Causal links between symptoms and rural conditions have not been convincingly established. For example, disease analysis may be done, but pollution levels are not measured; or in some surveys, pollution levels are recorded, but socio-economic data is not collected. Wide-ranging and coherent studies are needed to address the problems prevalent in rural areas. It was with this objective in mind that the survey on *Energy, Water, Sanitation and Health Issues in Rural North India* was undertaken. The *comprehensive* and *multi-disciplinary study* was conducted in three states of rural north India; namely Uttar Pradesh, Rajasthan and Himachal Pradesh. It has a large random and representative sample population and incorporates a number of other relevant factors. It investigates the links between health and household fuel use, *indoor* air pollution, water safety and sanitation; concentrating in particular, on the role of and effects on *women*. A focus on economic aspects such as "willingness to pay" for clean fuels or infrastructure improvements and the health costs incurred due to illness are also key features included in the survey. A number of questions were addressed within each of these areas.

Objectives

The major objectives of the study are to:

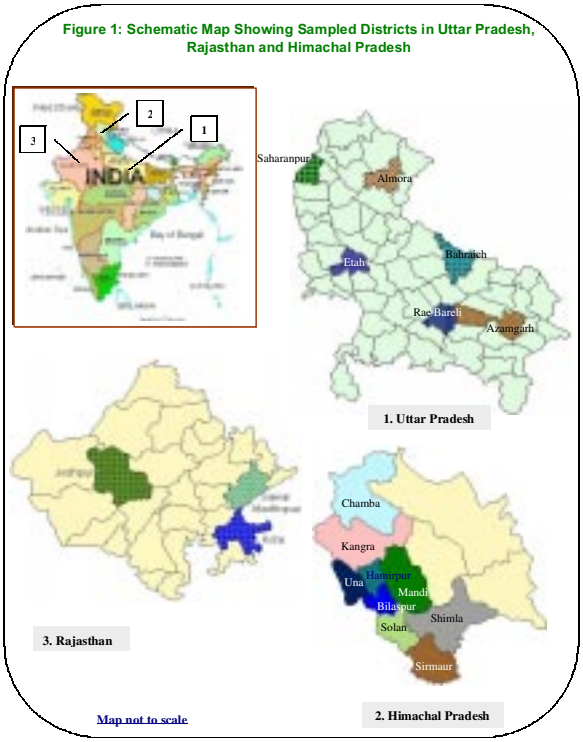
- Analyse energy consumption pattern, its procurement and energy transition.
- Factors affecting the use of clean fuels.
- Find out the levels of indoor air pollution due to cooking.
- Analyse water and sanitation issues.
- Record health impacts due to lack of clean energy, water and sanitation facilities.
- Assess willingness to pay to improve energy, water and sanitation facilities.
- Assess economic burden of using dirty fuels, unsafe water and inadequate sanitation facilities.
- Assess people's environmental priorities.

The Integrated Survey

To understand the impact of lack of energy, water and sanitation on health and human resources, an integrated survey was conducted covering 10,265 rural households (HHs) from 118 villages of 18 districts in three states of Rural North India (RNI) namely: Gangetic plains of Uttar Pradesh (UP includes Uttaranchal), dry desert zones of Rajasthan and the mountainous ecosystem of Himachal Pradesh (HP). These states were selected because of their geo-ecologic, socio-economic and locational conditions that represent Rural North India (RNI). Location of these states is given in Figure 1. The three sampled states represent a large share of many attributes of RNI. They cover over 87 percent of the inhabited villages, 83 percent of rural households, 82 percent rural population (187 million of 226.23 million people) and 69 percent of the land area in RNI. These three states constitute 63 percent of net domestic product at current prices (1998-99).

Data was collected from households and individuals relating to use of different fuels, access to clean water, sanitation facilities, symptoms of diseases, expenditure on health, demographic and socio-economic information. At the same time, measurements of air quality in the kitchen and outside the home were carried out in UP. Health surveys were carried out for 58,768 individuals. Indicators for lung functions (Peak Expiratory Flow) were measured for most of the adult individuals present at the time of the survey. Doctors examined a sub-sample of individuals for presence of diseases. Village level data on health centres, water related and other infrastructure facilities was also collected.

Figure 1: Schematic Map Showing Sampled Districts in Uttar Pradesh, Rajasthan and Himachal Pradesh



Methodology

Selection of Villages and Households: The survey was designed in such a way that it represented various socio-economic and geo-ecological and location zones. Accordingly, three states namely UP, Rajasthan and HP were selected from northern India. The households were selected by using multistage stratified sampling design to have a representative sample. At ***stage one***, stratification of each state was done on the basis of its broad socio-cultural regions (SCRs). A representative district from the median population was selected from each SCR. At ***stage two,*** stratification of districts was done by village population sizes. The villages were divided into four strata on the basis of population data available from Census 1991. In stratum 1, villages with population less than 1000 were included; stratum 2 had villages with population 1000-3000, whereas in stratum 3, villages with population between 3000-5000 were included. The 4th stratum with village population more than 5000 were excluded from the sample because these villages resemble semi urban areas. At ***stage three,*** the selection of the villages from each stratum was done using probability proportional to size (PPS) sampling method. Selection of households (***stage four***) within selected villages was done using systematic random sampling. The number of sample households in each district were in proportion with the universe distribution of rural households in these selected districts.

Survey Coverage: The survey was conducted at two levels, viz. individual level and household level. Pollution survey was conducted to record indoor air quality at household level and water quality analysis was done at village level. Additional surveys were carried out at village and health centre level, to get an overall picture of the village and health centre facilities.

Individual level survey: The individual level survey included physiological characteristics. viz. age, sex, height, weight, health related data and behavioural characteristics such as smoking habit, literacy, occupation, time activity pattern and cooking behaviour. The household level data was collected to get a comprehensive picture of socio-economic conditions, energy use pattern, water and sanitation related facilities, housing characteristics, cooking behaviour, environmental priorities of women, willingness to pay to reduce kitchen smoke and to improve water and sanitation facilities.

Health Survey: At the individual level, the Medical Research Council (MRC) questionnaire, 1986, UK, for respiratory symptoms was followed, which included questions regarding six symptom categories. The inquiry was made *direct*ly from those who were present during the survey for analysis, according to the MRC

protocol. In addition, proxy responses for those who were absent during the survey were obtained from the main respondent and mostly mother's responses for children below 15 years. According to the MRC protocol, only the *direct* responses can be analysed for the respiratory diseases. Therefore, the information collected for absent members and children are analysed separately. This gave us a picture of overall prevalence of respiratory diseases for the adults and also for the children. Measurement of PEF rate, an indicator of airways obstruction, which reflects lung function and the extent to which it is impaired, was conducted for direct cases. Information regarding pregnancy and childbirth related problems were also recorded from women.

Household level Survey:

Survey of energy use pattern and practices: Data on energy use patterns included information on the use of biofuels and commercial fuels for cooking, sources of procurement of cooking fuel, time, distance and effort involved in procurement, progress along the energy ladder of increasingly more convenient fuel, etc. Housing characteristics included information on the number of rooms, type of house and type of kitchen, location of kitchen and number of doors and windows in the kitchen. Further data collected on cooking behaviour, number of meals cooked using different fuels in a day, time spent for cooking, cooking involvement of different groups of individuals and type of involvement. Time activity pattern of the members of household was also recorded. Data collected to assess people's willingness to reduce the impact of indoor air pollution included information on people's choice of type of intervention, reason for not using clean fuels, willingness to pay for additional amount of clean fuel and additional demand for kerosene.

Survey of water and sanitation facilities and health: Data on water availability, source of collection, efforts required to fetch water, problems faced in collection, type of problems, water quality, water storage and purification practices, etc, was obtained. The occurrence of water related diseases such as worms in stool, diarrhoea and jaundice, and associated health expenditure and days lost due to suffering were recorded. Data on availability of sanitation and sewerage facilities and willingness to contribute to improve water, sanitation and sewerage facilities was also collected.

Additional Surveys

Measurement and monitoring of indoor air quality: (IAQ) were carried out in 519 households of UP. Kitchens were categorised into four types- i) inside living room; ii) separate kitchen - inside the house, iii) separate kitchen - outside the house, and iv) no kitchen - open air cooking. Locations of the personal samplers were decided based on the type of kitchen and layout of the house. To assess the personal exposure, one sampler was attached to the chief cook during the cooking period. One sample was collected at a distance of about 2m away from the stove but inside kitchen/room to assess exposure of other family members. One sample each was collected from the living room and one from the open space of house i.e. veranda, etc., where people spend most of their time, to assess the effects of cooking operations in these areas. In addition to Respirable Suspended Particulate Matter (RSPM) observations, measurements for SO_2, NOx and CO were taken during the cooking operation at these locations. Indoor air pollution monitoring was carried out during the cooking period extending upto 3 hrs.

Water quality tests were performed in all the selected villages across the three states. Water samples were taken directly from the sources accessed by the villagers. A total of 137 samples were tested for dissolved oxygen, biological oxygen demand (BOD), nitrate, total coliform and fecal coliform.

Village level surveys were done to corroborate the data acquired at the household and individual level, and also to get an overall picture of the village. The distances of a village from the nearest road, bus stop and railway station, as well as the distance from any air polluting industry were also recorded.

The *health centre survey* established the type of health facilities available to village residents in terms of number of beds, medical equipment and sanitation standards. Through the use of a questionnaire (that differed in content from the household questionnaire), facts about patient numbers and prevalence of respiratory and water

borne diseases including information about seasonal variations were gathered.

The data was analysed and then extrapolated for RNI to gain some macro level understanding and to get some policy insights. For energy and water related issues, extrapolations based on sample proportions were applied to the total rural households in RNI, whereas health related extrapolations were based on sample proportions applied to rural population in RNI.

The states wise break up of the sample is given in Table 1.

Table 1: State wise break up of the Sample

Coverage level	State			Total
	Uttar Pradesh	Rajasthan	Himachal Pradesh	
Districts	6	3	9	18
Villages	51	13	54	118
Households	7564	1989	712	10265
Individuals	42713	11955	4100	58768

Demographic profile of the individuals and socio-economic profile of the sample households are given in the Annexure.

Results

Highlights of the Energy Scene in Rural North India

A large proportion of households in RNI, as shown in Box 1, depend on biofuels, which are gathered by spending 8 billion human hours annually. Such a high amount of human labour, if put to better use, can bring prosperity in the region. In spite of high willingness to pay to purchase kerosene even at *higher than market price*, the kerosene supply is not adequate. If the demand of 49 percent of the households, who are willing to pay *more than market price,* to purchase kerosene for cooking is met, it can reduce pressure on human and forest resources substantially and also provide better living conditions. Twenty seven percent of the non-electrified houses, if electrified, could help divert kerosene (which is currently used for illumination) for cooking. This would also give relief to women from exposure due to kitchen smoke that cause serious health impact.

BOX 1: HOUSEHOLD ENERGY – Rural North India

- 96.6% of households (HHs) use biofeus, 4.9% use kerosene and 4.95% use LPG for cooking. Most of them however use multiple fuels.
- Forests contribute 39% of the fuel wood need.
- 56 million tonnes of biofuels (of which 37 million tonnes of fuel wood) are gathered annually.
- 23 million households spend 8 billion hours annually in fuel wood gathering.
- 35 million households use 1.74 million tonnes of kerosene per annum for cooking and lighting.
- 34% of HHs (out of the HHs using kerosene for cooking) procure kerosene form open market and 97% procure it from fair price shops.
- 49% of HHs are willing to pay more than market price to purchase kerosene for cooking.
- 0.2% HHs use Biogas for cooking.
- 63% of HHs are electrified.

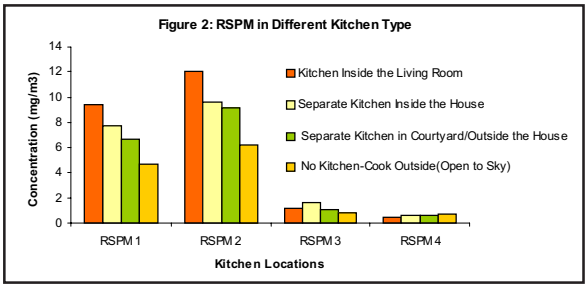
Exposure to Indoor Air Pollution and its Measurements

- When the kitchen is inside the living room or inside the house, the chief *cook* and other family members are exposed to a significant level of pollution during cooking hours (~ 3 hrs per day).
- *Cooks* are exposed to an average of 6.8 mg/m^3 of respirable suspended particulate matter (RSPM) while burning biofuels during cooking hours.
- While cooking with biofuels, RSPM concentration in the kitchen (about 2 meters away from stove) has a mean value of 9.2 mg/m^3. This shows that *those* who assist or

are in close proximity to the stove are exposed to even higher level of pollution than the *cook,* especially if they are in the direction of the plume of smoke.

- When the kitchen is located outside the house RSPM concentration inside the house reduces significantly.

- *Cook's* personal exposure to CO, SO_2 and NO_X are higher than the National Air Quality Standards. However, the concentration of SO_2 and NO_x reduce significantly below the NAQS as the *sampler* moved away two or more meters from the stove. Outside the house, SO_2 and NO_X levels sometimes drop below the detection level. RSPM concentration for different kitchen types is given in the Figure 2.



Respirable suspended particulate matter (RSPM) in Different Kitchen Types

RSPM 1 = Personal exposure, RSPM 2 = Concentration at 2 meter away from the stove,

RSPM 3 = Concentration in the living room, RSPM 4 = Concentration outside the house

Highlights of Water and Sanitation Coverage in Rural North India

Sixty two percent of the households (Box 2) do not have water supply in their homes; so they spend 32 billion hours annually, for water collection. Perhaps the same hours could be used to improve water supply in the region. The low economic development is both a cause and effect of low accessibility to clean drinking water, sanitation and sewerage facilities. However, some households are willing to contribute financially to avail clean drinking water, better sanitation and sewerage facilities, which could improve these facilities, if supported and integrated with other government programmes.

BOX 2: WATER and SANITATION : Rural North India

- 62% of HHs do not have water supply in or near their homes.
- 22.8 million HHs spend 32 billion hours per year to collect water from outside home.
- Only 5% of HHs are connected with sewerage facility.
- 10% of HHs have toilet facility inside the house
- 1 % of HHs use community toilets

Proportion of households *willing* to pay for:

- Clean drinking water: 7 %
- Community based drinking water supply: 25 %
- Sewerage facilities: 28 %
- 'In-home' toilets: 29 %
- Community toilets: 25 %

Water Quality Report

Water Quality data from 137 samples revealed that:

- Dissolved oxygen was in the range of 1.9 mg/l to 17.5 mg/l.
- BOD was above the drinking water/human use standard of 2 mg/l in 105 samples. In UP, all the 100 samples had BOD above the standard.
- Total coliform count was above the standard of 50 MPN/100 ml in 76 samples, whereas the fecal coliform count was found in 73 samples.
- In Rajasthan, all the water samples had fecal coliform, which as per standard should be nil in potable water.

Toll on Human Health

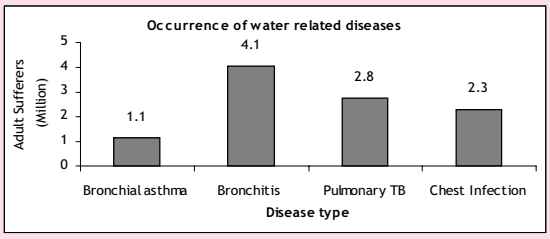
Analysis of prevalence of respiratory diseases (Box 3), shows that 17 percent of rural adults (24 million adults) have some respiratory symptoms. Nearly 13 percent (17 million adults) have serious respiratory symptoms and 7 percent (about 10 million adults) may have respiratory diseases. Prevalence of respiratory diseases works out as follows:

- 4.3 percent (6 million rural adults) suffer from Bronchitis
- 2.9 percent (4 million adults) suffer from Pulmonary TB
- 2.1 percent (3 million adults) suffer from Chest infection
- 1.45 percent (2 million) suffer from Bronchial asthma.

While the former two are strongly associated with indoor air pollution, the latter two are possibly triggered by indoor air pollution.

BOX 3: RESPIRATORY AND EYE DISEASES

- Respiratory symptoms are prevalent among 24 million adults, of which 17 million have serious symptoms
- Adults suffer from various respiratory diseases as given in the figure below:



LRI/ ARI prevalence among **children below 5 years:** 4.4 million (15.4%)

Expenditure on Respiratory Diseases

- Total private expenditure on health:
  - Rs. 15 billion per year for respiratory diseases
  - Rs.6 billion per year for eye related diseases
- Of the total expenditure incurred on:
  - **Respiratory diseases:** 56% is spent on medicine, 19% on special diet and doctor's fee each and 6% on hospitalisation
  - **Eye related diseases:** 70% is spent on medicine and 30% on doctor's fee.

Only about 20 percent of sufferers (adults and children) took some treatment and spent about Rs.15 billion[$] on doctors' fees, medicines, hospitalisation and special diets. Similarly, on eye related diseases, sufferers spent about Rs.6 billion on doctors' fees and medicines. This is a huge loss to this deprived community. Though all the health aliments leading to monetary loss are not due to exposure to indoor air pollution, it has a significant impact on health.

About 15.5 percent of children below 5 years of age (4.4 million rural children in RNI) suffer from Lower Respiratory Infections (LRI)/ Acute Respiratory Infections (ARI).

Risk Factors for Respiratory and Eye Diseases

Odd ratios* for respiratory and eye diseases among female adults for several important variables are given in Table 2.

Table 2: Odd ratios for respiratory and eye diseases among female adults

Variables	Splitting Criteria	Respiratory Disease				Eye Irritation
		Bronchitis	Asthma	Chest Infection	TB	
Age	More than 30 Yrs/ Upto 30 Yrs	**3.99**	**4.05**	**2.64**	**2.85**	**2.53**
Smoking Habit	Smokers/ Non-smokers	**3.22**	**2.94**	**2.66**	**1.66**	-
Illiteracy	Illiterate/ Literate	**3.95**	**6.43**	**3.97**	**3.00**	**1.95**
Fuel index~	>15.56/ Up to 15.56	**2.53**	**2.47**	**2.08**	**1.94**	**1.99**
Asset index*	<0.25/>= 0.25	**1.88**	**3.51**	**3.01**	**1.93**	**1.53**
Type of Fuel used	Biofuel/Both fuel or Clean fuel	**1.99**	**2.55**	**1.83**	**2.36**	1.37
Number of rooms	<2/>2 rooms	1.39	**1.81**	**1.64**	1.43	1.39

Number in bold represents statistical significance

~ A composite indicator based on multiple variables such as age, type of involvement (such as chief cook, assisting in cooking, etc), number of years spent cooking and fuel type used.

*Asset index has negative impact on respiratory diseases

$ Rs. 44 = 1 US Dollar in 2000

** Commonly used in epidemiological studies to describe the likely harm an exposure might cause. It is calculated by dividing the odds in the more susceptible group by the odds in the less susceptible group. Higher the odd ratio, higher is the chance of a symptom.*

Table 2 shows that:

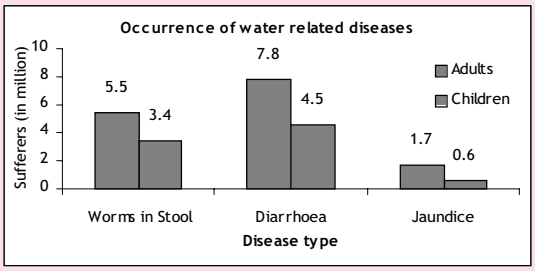
- Women above 30 years are at higher risk than younger women by a factor of 3.99 for Bronchitis, 4.05 for Asthma, 2.64 for chest infection and 2.85 for TB.
- Smoking is a high risk factor for all respiratory diseases but not for eye irritation.
- Illiterate women are at 3 to 6 times higher risk compared to literates for *all respiratory diseases*. Most benefits of literacy occur at the primary level education itself. i.e. odd ratios sharply fall with primary education.
- Fuel index was constructed to capture lifetime exposure. Higher index is associated with high lifetime exposure and risk for all respiratory and eye diseases.
- Asset index (used as a proxy for income or economic status, as enquiry on income is usually less reliable) shows negative impacts on respiratory and eye related diseases.
- Biofuel users have higher risk of respiratory diseases as compared to clean fuel users.
- Number of rooms has significant impacts only on Asthma and chest infection.
- Water and sanitation related diseases (Box 4) occur in 13 million rural adults and 7.7 million rural children as recorded in the survey for water related diseases in the past. Diarrhoea and worms in stool in the past one month and jaundice in past 2 years were recorded. These diseases lead to an expenditure of Rs.13 billion per year (by adults and children in RNI).

Risk Factors for Water Related Diseases

- Water storage in an open bucket or drum has 3 times higher risk for diarrhoea and 2 times for worm in stool, compared to safe water storage practices such as *pot covered with a lid.*
- Adults from the households not using any *purification methods* have high risk by a factor of 1.5 for diarrhoea and 4 for worm in stool.

BOX 4: WATER RELATED DISEASES *

- 13 million adults (9.7% of total adults) and 7.7 million children (8.7% of total children) in RNI suffered from *some water related diseases* in the past. Occurrence of major diseases are as given in the figure below:



- Prevalence of diarrhoea is high among children below 5 years (in 9% children).

Expenditure

Total expenditure for water related diseases for adults and children: Rs. 13 billion per year.

- Of the total expenditure incurred, 37% is spent on special diet, 33% on doctor's fee, 17% on hospitalisation and 13% on medicine.

Total Medical Expenditure

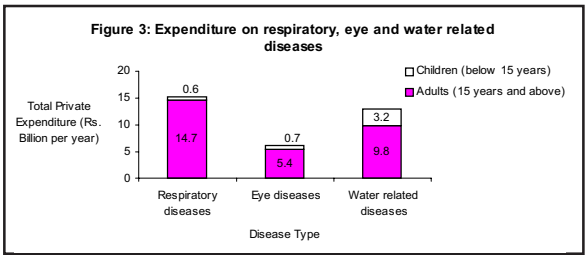
Rs.29.9 billion per year is spent for adults and Rs.4.5 billion for children in RNI towards healthcare related to inadequate energy and water facilities. Disease-wise expenditure is as given in Figure 3. Improved medical care facilities with a reach to all the villages and improved energy, water, sanitation can help reduce the expenditure substantially.

Total Economic Burden

Total economic loss due to lack of energy, water and sanitation and its impact on health and human resources is summarised in Box 5, which shows that, 4,815 million days per year are spent or lost, due to inadequate facilities and resources. The total *economic loss* due to the health impact of dirty fuel, unsafe water and time spent in their procurement is over Rs.323 billion per year in RNI. Availability of clean energy and water sources, accessibility to

**** Notes:***

1. *Worms in stool was taken for an individual where worms were passed any time during past one month*
2. ***Diarrhoea** was taken for an individual when it lasted for more than 2 days during past one month*
3. ***Occurrence of Jaundice** was considered any time in past 2 years*



better sanitation and health facilities can improve economic and social conditions of the rural poor. Also, better access to energy and water resources could improve efficiency of agriculture and allied activities, which can create opportunities for better employment and better livelihood. When such a large human resource is spent, just to meet the basic survival need, how can people improve their living conditions and participate in economic growth process? An integrated approach and participation from various ministries, government departments, NGOs and village communities are required to achieve the sustainable economic development of Rural North India.

BOX 5: Economic burden due to energy, water, sanitation and health problems (per year)

	Energy (a)	Water (b)	Total (a + b)
Days spent/ lost (Million)			
• Days+ spent in collection	822	3,212	4,034
• Days lost due to diseases	260	521	78
TOTAL	1,082	3,733	4,815
Monetary value* of working days spent/ lost (Rs. Billion)			
• Fuelwood gathering and water collection	49	193	242
• Due to diseases	16	31	47
Direct expenditure on health (Rs. Billion)	21	13	34
Total economic loss (due to improper energy and water facilities and due to health impacts of their procurement and use)	86	237	323

Notes:

1. Days spent in fuel wood gathering and water collection are given in column (a) and (b) respectively
2. Diseases includes: respiratory and eye related diseases under energy column (a) and water and sanitation related diseases under water column (b)

+ Taking 10 hrs as a standard working hours per day

* Includes imputed cost per working day taken at Rs. 60 per day (approx. wage rate)

Transportation Burden

Collection of fuel wood and water require transporting them. While the number of hours are accounted, physical strain from carrying heavy loads is not. It leads to headache, neckache, backache and also bruises, injuries and dangers of snakebites etc. Box 6 shows that on an average, members of a household walk 325 km per year for fuel wood collection and 2,774 km per year for water collection.

BOX 6: Transportation burden (per year per households) due to due to lack of energy and water facilities

	Fuelwood	Water
Proportion of households collecting (%)	62	62
Average distance walked per trip (km)	2.6	0.8
Average number of trips	125	3468
Total distance walked (km)	325	2774
Average quantity collected (tonnes/Kilolitres)	1.3	73

Conclusions and Recommendations

Access to energy, water, sanitation and health need to be stressed for social and economic development. They also concern poverty - gender - environment linkages and need a holistic view so as to reach a consensus to achieve the common goals. In addition to current status of energy, water, sanitation and people's priorities, health impacts of exposure to pollutants due to cooking with biofuels and lack of clean drinking water are also recorded.

In Himachal Pradesh, which has good access to clean fuels and water, one notices a sharp difference in all socio-economic indicators such as literacy, female/male ratio, health, income levels and other infrastructure. Could this be due to the decision taken to give them clean fuels to prevent deforestation in the hilly areas 10 years ago? If so, this decision has had many unintended benefits beyond preventing

deforestation. One wishes that such a decision was taken for all the states in India. Almora district, which is a hilly district and was under UP at the time of the survey, also is well ahead of the other districts in UP, where the same government prevails.

A comprehensive policy and programme is needed that could integrate energy, water, sanitation and health with development goals such as employment generation, poverty alleviation and sustainable livelihood so as to bring about cohesive development in all arenas of life of the rural people. This requires focused linkages, participatory, collective and coordinated efforts of different ministries such as the Ministries of Education, Environment and Forests, Petroleum, Rural Development, Health, Agriculture, Non-conventional Energy Sources and the Central Water Commission along with local government and non-government organisations. Multipronged approach is needed as suggested below.

Energy Supply and Utilisation:

Biofuels:

- It is clear from the survey that substantial proportions of households have developed their own fuel wood supply (60% in UP, 47% in Rajasthan and 64% in HP). In spite of this, large proportions of households procure fuel wood from forests (36% in UP, 40% in Rajasthan and 49% in HP). To reduce this pressure on forests and to ensure fuel wood supply, afforestation on common lands, village lands and wastelands should be promoted. The Wasteland Development Board, Forest Department, Rural Development Department and MNES should come together to improve the fuel wood supply, by either supplying it as it is or converting it into clean fuel by means of biogasification.
- There are many factors that hinder the use of clean fuels, the most important being affordability and availability. Government intervention plays a crucial role in promoting any technology, but lack of effective financial and institutional mechanisms have proved to be the barriers. Therefore, we need to invent new financial and institutional mechanisms, which would help people to avail of better fuel sources and other facilities and services of their choice.
- *Reduce biofuel use* for cooking either by improving efficiency of usage or by replacing it with available alternative fuels such as kerosene, LPG or renewable energy technologies such as biogas, solar cookers and so on.
- *Biomass gasification:* Huge quantity of biomass available in rural areas is currently used inefficiently. This can be brought to productive and efficient use if it is converted into electricity by *biogasification*. Afforestation and energy plantation programmes can be connected with this initiative so that supply of raw material is ensured. However, this would require a feasibility study before it is taken up. This programme can generate large employment, satisfy local needs with local resources and avoid transmission and distribution loss that is currently incurred by state electricity boards.

Kerosene:

- Kerosene is an inferior lighting fuel compared to electricity, but is still used in majority of the households in the absence of regular electrical supply. Even the minimum allocated quantity of 3 to 5 litres per month does not reach the target households regularly, due to its diversion to other *lucrative* uses such as transportation. The quota was fixed as per lighting needs several decades ago. It has not been revised except in hilly areas. It is easy to adulterate or use subsidised kerosene for adulteration of other petroleum products. Therefore, it is necessary to streamline kerosene supply and direct it to the targeted users below the poverty line.
- However, kerosene can be a cleaner cooking fuel compared to biofuels, if burned with a blue flame in a pressured stove. Moreover, it is the most preferred cooking fuel in the energy ladder after fuel wood, even in low-income households due to the convenience of turning on and off as and when required.
- To strengthen kerosene supply and to ensure that the subsidy is given to the target population, we suggest the following policy options:
  - Restructure subsidy pattern and deliver it directly to the consumer. It could be done by issuing *coupons* to the poor

households, instead of the subsidy at the supplier level. *IT Enabled Electronic Card (ITEE-Card)* can be issued to each household. This concept, which was suggested by Reliance Ltd. during a meeting at IGIDR in September 2001, where petroleum minister Shri. Ram Naik presided. This can be explored further to understand the pros and cons of such *technology*. This could assure accountable and assured benefits to the target consumers.

- If 49 percent of the households are willing to pay a price for additional quantity of kerosene, which is much higher than the subsidised price, the open market needs to be improved. Open market can take care of some share of demand of the households that are economically better off and in a position to pay a higher price. This would help to reduce pressure on fuel wood sources and associated impacts.

LPG:

- LPG (liquefied petroleum gas) is the *best available* cooking fuel, but access to LPG is very low in the rural areas of Uttar Pradesh and Rajasthan. The situation in HP however, is far better. Therefore, it is important to improve access to this fuel. Currently available cylinders are heavy and difficult to carry to remote areas due to inadequate transportation facilities, and require a large investment upfront. LPG, if available in small containers, would be convenient even for poor people located in remote villages.
  - Bottling of small cylinders (Union Minister for Petroleum and Natural Gas, announced during a discussion in a seminar at IGIDR in September 2001 that 5 kg cylinders of LPG would be introduced for domestic purpose). These cylinders are targeted at low-income group households in the rural and hilly terrain areas due to ease of transportation, compared to the existing 14.2 kg cylinder. Every town or village with a population of 10,000 or more would be given an LPG distribution agency (as against 20,000 now) for easy transportation and affordability. This initiative can play a crucial role in breaking the barriers of affordability and availability of LPG in rural north India. This programme would also have a social impact on people's lives.

Biogas:

- Biogas is another feasible option available in rural areas of north India. The government, with support from NGOs and the community, has a crucial role to play if this potential is to be tapped.
- The survery shows that about 3.7 percent of the households have more than 3 to 5 animals, which is sufficient to install a biogas plant of 2 cubic meter capacity that can satisfy cooking energy needs of 5 to 8 individuals. These households fall into the economically *better off* class and therefore, with strategic promotion it is possible to install biogas plants.
- The survey showed that over 24 percent of households have less than 3 animals per household, but together they can install family size biogas plants if '*sharing mechanism for dung, slurry and cost'* can be developed.
- Apart from family sized biogas plants, there is a large potential for community biogas plants. In fact, in many cases community size biogas plants would be beneficial in many ways. The advantages community biogas plants provide are:
  - Cater to the energy needs of the households who do not possess livestock
  - Generate employment
  - Remote villages without access to electricity are best suitable for community biogas installation, which can also be used to generate electricity
- Training programmes can be initiated in industrial training institutes with the emphasis on installation, management and service of biogas plants. This would ensure better functioning of biogas plants.

Conservation, Technology and Institutions:

- For illuminating homes, night schools, etc, solar lanterns are suitable in rural areas, where, power supply is erratic. Servicing and perhaps assembling of these lamps, can be initiated in some villages so that employment is generated and people have access to such products and services

- Promotion of energy conserving systems, where integrated choices of fuels, improved stoves and appropriate pots and lids have to be made. Improved cooking stoves and pressure cookers can save large quantities of fuel wood. It is a less expensive and feasible option to save biofuels. However, the survey showed lack of awareness about the advantages and functioning (though simple) of improved stoves. It is therefore, necessary to initiate community awareness programmes.

- Improved and accessible financial mechanism: Initial investment is the main constraint in promotion of most technologies in rural areas. Therefore, financial support through Self Help Groups (SHGs) formed in villages across these states can be very effective in their promotion.Due to their financial strengths, SHGs can generate and use money for such purposes.

Water and Sanitation Facilities

Water scarcity is the most important issue that leads to all other related problems. Availability of safe drinking water, upon which, health of individuals and welfare of the people depend, requires an integrated approach for comprehensive and sustainable solutions.

The aim of the policy should be to provide safe sources of drinking water within people's reach, and to minimise the hardships faced by people in collecting water. Priorities in sanitation should be to provide people with sanitation facilities so that water does not get contaminated and does not harm health. We recommend the following policy measures and interventions:

- In many villages people use surface water sources such as ponds and lakes. These sources are prone to contamination from poor sanitation, agriculture run off, etc. that contains harmful disease causing agents, which affect human health. Therefore, such open sources should be restricted from use and alternative water sources should be strengthened. If these sources are used, water testing and monitoring should be practiced regularly at delivery point.

- On an average, 2,774 km is walked per year per households to collect 73 kilolitres of water. This takes substantial time and hard work. Therefore, it is necessary to improve local water resource base by various methods:

  - Improving ground water resource and rain water harvesting and storing water for use during scarcity seasons

  - Tapping rainwater by various rainwater harvesting techniques can minimise water shortage. The advantages of rainwater harvesting are that it provides safe water supply and helps in groundwater recharge. Therefore, area-specific rainwater harvesting should be promoted with community, government and NGOs participation.

  - Watershed management programmes can also play a crucial role in improving water resource base

- It is observed that water is contaminated further in households, due to poor storage and unhygienic conditions, especially in poor households. Contamination occurs mainly due to lack of awareness about simple methods, which, if practiced, can influence health outcome in a positive way.

  - Covering water storage pots, use of pots with long handles (this would avoid contamination of water by dirty hands and dirt in the air) and other hygienic storage methods need to be popularised

  - *Water pots should be kept* above the ground level so that dust does not enter into the pots

  - Simple cloth filter can avoid many diseases

- Boil water before drinking

- Awareness programmes (especially for women) on these *simple* techniques should be popularised in villages so that people practice these methods. NGOs could play a crucial role in this endeavour.
- Development of village level information systems on various aspects of water resources: As stressed in India's National Water Policy document of 2001, a village level information system need to be developed so that information about various water related issues is easily available to people.
- Human excreta are the most important disease-carrying agents due to defecation in open spaces. In some villages, community toilets can be popularised with awareness programmes about keeping them clean. The survey suggests that people are willing to contribute to the construction of in-home and community toilets. This contribution can reduce the burden on the government funds and provide the required facility.

Health Care Facilities

- Training of healthcare professionals is needed to spot the problems relating to pollution and to sensitise them to be alert. Many villages do not have convenient health facilities. In many cases, in spite of having health centre facilities, the centres are not equipped with basics instruments/ infrastructure required for simple treatment.
- Many diseases spread due to negligence, lack of awareness of their origin and lack of measures to check them. Such diseases can be avoided by simple precautions such as cleaning hands and utensils properly and avoiding delay in treatment. Awareness about such techniques can be promoted with the support NGOs, the Health Ministry and Rural Development Ministry.
- Exposure to air pollutants can be minimised by structural changes in housing e.g. by improving ventilation of the kitchen and house, and having a separate kitchen or installing chimanys.
- The study shows that with improvement in female literacy, adverse health impacts of respiratory and water related diseases could be reduced.
- Health centres should be networked with information systems to communicate with each other for better implementation of public health policy.
- It is reported that sick people and pregnant women suffer as they travel long distances to reach to health centres, due to lack of medical facilities nearby. To minimise their drudgery and to support them with health care access, mobile vans can be introduced that go around villages to provide medical aid.

Transportation Facilities

- As the results suggest, over 822 and 3,212 million days are spent in fuel wood and water collection respectively, which impose hardship and loss of productive time on the rural poor. This also creates physical strain and health damage. To reduce this damage:
  - Village level cooperative transport facility such as trolleys or wheelbarrows to carry water pots and fuel wood loads could be made available.
  - Alternatively, small motorised vehicles can be provided to communities to carry fuel wood and water on a cooperative basis. This would substantially reduce the physical burden on women and children if collectively financed.

Annexure

Household and Population of Northern India, 2001 (Million)				
	UP	Rajasthan	HP	Total (Rural North India)
Total number of households	22.27	7.10	1.00	36.73
Total Rural Population	137.85	43.27	5.48	226.23
• Male	72.24	22.39	2.75	118.42
• Female	65.61	20.87	2.73	107.81

Socio-demographic profile of the sample (percent)								
	All		UP		Rajasthan		HP	
Gender	Female	Male	Female	Male	Female	Male	Female	Male
Base: All individuals	28,560	30,208	20,921	21,792	5,552	6,403	2,087	2,013
Proportion (%)	49	51	49	51	46	54	51	49
Age								
Up to 15 years	42	45	42	45	43	46	30	32
16 – 40 years	40	36	40	36	41	38	48	44
> 40 years	18	19	18	19	16	16	22	24
Literacy *(adults)*	26	59	24	56	17	59	69	84
Occupation (adults)								
Farm based	2	40	2	42	3	35	4	30
Industry/Service	2	20	2	16	2	26	4	35
Home based/Housewife	85	4	88	4	83	4	69	3
Unemployed/Others	10	36	8	38	12	35	23	32
Base: All adults (above 14 yrs.)	17,417	17,410	12,583	12,346	3,325	3,662	1,509	1,402

Socio-Economic profile of the sample households (percent)				
Land holding	All	UP	Rajasthan	HP
Landless and non-farm households	48	53	27	60
Marginal & small (up to 5 acres)	42	41	48	35
Medium & large (more than 6 acres)	10	6	25	5
Annual household income (in Rs)				
Up to Rs. 20,000	58	61	50	43
More than Rs 20,000	42	39	50	57
Kitchen appliances				
Kerosene Stove	22	21	18	49
Pressure Cooker	17	14	5	86
Gas Stove	9	6	4	57
Water Filter	1	1	0.2	5
Livestock				
Buffalo	46	46	49	43
Cow	37	33	44	58
Bullock	24	26	13	31
Sheep / Goat	25	21	42	17
Number of rooms				
1 Room	35	36	34	18
2 Rooms	32	32	30	26
3 or more rooms	33	31	34	55
Kitchen location				
Inside living room (No separate kitchen)	26	28	23	9
Separate Kitchen: Inside home	39	44	12	57
Separate Kitchen: Outside home	14	9	29	31
No kitchen room: Open air cooking	21	18	36	3
Base: All Households	10,265	7,564	1,989	712