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Population Growth, Energy Utilisation Pattern and Environmental Degradation: A Micro Study

Introduction

THE achievement of sustained development has been the greatest challenge facing mankind. The desirability of development is universally recognized, but, unfortunately, development policies in the past have not always been environmentally sound. In fact, environmental values have been neglected too often as a result of which, serious environmental problems have arisen.

There is, evidently, a two-way relationship between development and the environment—without adequate environmental protection, development is undermined, while without development, resources will be inadequate for needed investments and environmental protection will fail. There are two significant ways in which environmental problems can undermine the goals of development. First, environmental quality—water that is safe and plentiful and air that is healthy—is itself part of the improvement in welfare that development attempts to bring. If the benefits from rising incomes are offset by the costs imposed on health and the quality of life by pollution, this cannot be called development. Secondly, environmental damage undermines future productivity.

Development is accompanied by rapid population growth, at least in the initial stages. The world's population is now growing by about 1.7 per cent a year. During the period 1990-2030, the world's population is likely to grow by 3.7 billion—an increase much greater than in any previous generation. Ninety per cent of this increase will occur in the developing countries. Over the next four decades, Asia's population is expected to rise from 3.1 billion to 5.1 billion.

Rapid population growth brings in the risk of appalling environmental damage through greater demand for goods and services thereby exerting additional direct pressure on natural resources, and by producing more wastes which threaten local health conditions and imply additional stress on the earth's assimilative capacity.

Among the various forms of environmental degradation, deforestation has historically been an almost essential concomitant of industrial development. Tropical forests have

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declined by nearly one-fifth so far in this century. The latest statistics on deforestation suggest that for tropical forests the overall rate in the 1980s was 0.9 per cent a year, with Asia's rate somewhat higher (1.2%) than that of Africa and Latin America.

Deforestation is caused by farmers, ranchers, logging and mining companies, and fuelwood collectors, each pursuing private interests. Tree felling for firewood accounts for the largest share of wood use in developing countries. The rate of felling trees is accelerated by rapid population growth in developing countries as growth of population and income leads to a rising demand for fuelwood. Besides, in a hilly region of a developing country, the problem accentuates due to insufficient availability of commercial energy viz, coal, oil or electricity. In these regions the population, to meet the energy requirement of cooking, heating etc. depend on fuelwood which, in turn, increases the rate of deforestation.

In this paper, an attempt has been made to study the problem of environmental degradation in rural areas caused by the typical energy consumption pattern and the consequent deforestation which in turn is accentuated by rapid population growth, in the context of a hill economy. A micro level study involving a particular area—Gorubathan block—situated in the hilly district of Darjeeling (West Bengal) has been carried out to analyse the close relationship among population growth, felling of trees for firewood, and the consequent environmental damage. We have tried to address this issue of the selected block, in the context of the rural energy problem in India. The rural energy problem in India which can be briefly stated as inefficient use of locally available resources such as dung cakes, agricultural residues, dried leaves, twigs, branches of trees, etc., is all the more pronounced for hilly regions where use of chiefly forest resources gives rise to serious environmental problems.

This paper comprises of the following sections: Section I presents the specific features of the block (population, occupational structure, income distribution etc.) within the rural energy background. In Section II, the environmental problem will be discussed. Finally, in Section-III, concluding remarks and some policy prescriptions will be presented.

I

Salient Features of Gorubathan Block

A field survey has revealed that Gorubathan block exhibits the typical features of a hill economy—low density of population, severe scarcity of drinking water, dependence on single crop, acute poverty, lack of variety in locally available energy resources.

The total population of Gorubathan block as reported in census 1981 was 40,178. In 1971, the population was 32,302, showing the decadal growth rate of 24.38 percent. From Table 1 we find that in the surveyed villages total population for 292 households is 1409 of which 405 are children and 455 are female. Average size of the family is five approximately. Number of population and the literacy rates vary across the villages.

1. Field survey was conducted in 1991, covering a sample of 292 households from 18 villages of Gorubathan block, in Darjeeling district of West Bengal.

TABLE 1: POPULATION AND LITERACY RATE IN SELECTED VILLAGES

Villages Hold	Number of House	Population				Literacy Rate (%)
		Male	Female	Children	Total	
1. Mal. Basti	42	78	66	76	220	55.00
2. Subba Villa	9	15	15	11	47	85.11
3. Samsing Kumai	22	50	31	31	112	47.75
4. R.C. Mission	5	9	9	7	25	84.00
5. Paremar	14	24	19	22	65	38.46
6. Cairigaon	29	57	42	41	140	67.86
7. Pubong	14	19	23	13	55	50.91
8. Upper Fagu T.G.	25	55	50	15	120	37.50
9. Luncell	4	3	9	3	15	26.67
10. Sherpatarand Sherpagaon	14	26	13	24	63	26.98
11. Raigaon	4	8	5	12	25	72.00
12. Gumbadana	6	12	13	8	33	33.33
13. Bhyelgaon	2	4	3	3	10	70.00
14. Upper Tinkateni	35	60	54	57	171	22.22
15. Bhanighani	3	6	6	3	15	0
16. Chiplydana	12	21	23	20	64	14.00
17. Mission Hi U.T.E.	49	94	61	56	211	55.45
18. Manzing	3	5	10	3	18	50.00
Total	292	549	455	405	1409	46.29

Source: Field Survey.

There is a severe scarcity of good quality drinking water in this block. The sources of drinking water are the 'Jhoras' which are non-perennial in nature. Scarcity of drinking water becomes acute during the period beginning from November till the rainy season sets in. A considerable amount of human energy is spent on the procurement of drinking water.

The occupational structure reveals the economic backwardness of the Block. Only 4.15 per cent of the population is engaged in services and 0.84 per cent business. As much as 48 per cent of the population is engaged in agriculture. The rest of the population comprises primarily students and housewives. But there is dependence on single crop—a typical feature of cultivation in hilly areas. The important cash crops grown are cardamom in the high altitudes, ginger and arecanut in the low altitudes. Such crops as paddy and potato are grown in small quantities chiefly for personal consumption. The other important cash crop is tea. Citrus fruits, especially oranges, are also grown in this region.

Due to the nature of crops grown, availability of agricultural residues in Gorubathan is limited, only 34075.72 kg of agricultural residues has been available in 1991 which corresponds to a per-capita figure of 0.65 kg annually. This is another special feature of a hilly region as evidenced by the fact that availability of agricultural residues in the adjoining

plains of Sitalkucchi (Cooch Behar district) is much higher, with per-capita availability being 658.32 kg in 1991.

The field survey has, thus, revealed that the locally available energy resources in Gorubathan lack variety. Agricultural residues are extremely limited in quantity. Dung is available as a resource, but unlike some other rural areas of India, dung cakes are not used as fuel in this region. Dung cakes are generally used as a supplement to coal for cooking purpose wherever the latter is used. In Gorubathan, there is no use of coal for cooking purposes and hence no use of dung cakes as fuel. However, dung has its traditional use as manure in the agricultural sector.

A study of the pattern of income distribution in Gorubathan has revealed a larger proportion (44.07 per cent) of the households belonging to the low income group which has been taken as incomes upto Rs. 6,000 per annum. The middle income group including incomes in the range Rs. 6,001 to Rs. 12,000 per annum, and the high income group which includes income exceeding Rs. 12,000 per annum, contain respectively 29.17 per cent and 26.76 per cent of households. The energy-utilising activities of Gorubathan block, taking into consideration all forms of energy (inanimate, animal and human) are as follows:

- (a) domestic activities including cooking, gathering fuelwood, grazing of livestock, and fetching water for domestic use including drinking;
- (b) agricultural operations;
- (c) lighting; and
- (d) industry.

Domestic activities constitute the major energy utilising group of activities. The domestic sector alone consumed the bulk of the total energy consumed in the Block.

Industrial activities are extremely limited. In the villages surveyed, the only industries that have been found are rice-husking mill and flour mill, and these are very few in number. Though agriculture is the main source of livelihood, agricultural operations are entirely dependent on human and animal energy. Use of agricultural implements operated by inanimate energy is almost non-existent.

Cooking and lighting are, by far, the major energy utilising activities. The per capita energy consumption for cooking and lighting works out to 7850.32 thousand Kcal in 1991 (Table 2). This is higher than the corresponding figure for the adjoining plains of Sitalkucchi (4075.41 thousand Kcal per capita). Due to high altitude, per capita energy consumption in Gorubathan is higher—low temperature prevailing over a considerable part of the year necessitates greater use of energy for heating purposes.

The energy needs of this Block are met mostly from traditional renewable energy sources, chiefly forest resources like fuelwood, as well as dried leaves, twigs and branches of trees, etc. Fuelwood is the only resource that has been abundantly available and accounted for as much as 97.435 per cent of the total energy consumed in Gorubathan Block in 1991.

TABLE 2: SOURCE-WISE TOTAL ENERGY CONSUMPTION IN GORUBATHAN IN 1991

(in thousand kcal.)	
<i>Source</i>	<i>Consumption</i>
Kerosene	9,697,955.04 (2.359)
Electricity	165,562.06 (0.037)
Agricultural Residues	132,554.44 (0.028)
Fuel wood	400,726,223.70 (97.435)
Diesel/Petrol	569,512.55 (0.138)
Manpower	13,098.26* (0.003)
Total	4 11 304906.27 or 7850.32 (per capita)

Note: Figures within brackets indicate percentages.

Source: School of Energy Studies (1992).

+ Manpower estimated on the basis of average cycling time/day and the stock of bicycles used in transport.

The so-called commercial energy sources like kerosene and electricity in the case of Gorubathan, account for merely 2.36 per cent and 0.04 per cent of the total energy consumed in the Block as seen from Table 2. Kerosene is used chiefly for lighting purposes. Negligible use of commercial energy is the result, to a considerable extent, of non-availability of such sources in this hilly region.

As in most hilly areas, the pattern of energy utilization in Gorubathan is technically inefficient. The energy conversion device that is typically used in households is the U-shaped traditional *chulha* in which the efficiency of burning fuel wood is very low. Due to incomplete combustion, much smoke is emitted hereby polluting the atmosphere and causing health hazards. Its efficiency is further lowered during the rainy season when fuelwood has a high moisture content.

A few family size biogas plants had been installed in Gorubathan, but they were found to be out of operation at the time of this survey. It is presumed that due to the prevailing low temperature, the generation of gas is very poor.

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The Environmental Problem

The demand for fuel wood as the major source of energy in the absence of adequate supply of 'Commercial' energy at reasonable rates and any other alternative form of non-commer-

cial energy, has been increasing rapidly under the impact of population growth. Rising demand for fuelwood has accelerated the pace of deforestation which in turn accentuates environmental degradation. The exclusive dependence on biomass energy in the form of fuelwood which is burnt in traditional conversion devices with very low efficiency, is, in fact, achieved at an exorbitant cost.

The total forest area of the block is 69878 acres. But at the current rate of deforestation, this will not last long. With large-scale unplanned felling of trees fuelwood is a rapidly dwindling resource which means that the present pattern of fuelwood usage is unsustainable for more than a few years.

In the base period 1991, it has been assumed that the end-use demand for fuelwood is matched by the supply. The reason behind such an assumption is the absence of any reporting of unsatisfied demand for fuelwood during the survey.

Based on the projected growth of population for Gorubathan Block, we have estimated the demand for fuelwood upto the year 2011. For the supply of fuelwood, it is assumed that it will be maintained at the base period (1991) level, atleast, through afforestation programmes undertaken either by the Government or on private initiative.

TABLE 3 : FUELWOOD DEMAND AND SUPPLY AND SHORTFALL

(in'000kcal.)				
<i>Year</i>	<i>Demand</i>	<i>Supply</i>	<i>Shortfall/Gap</i>	<i>Gap as % of Demand</i>
1991	400,680,118	400,680,118	0	0
1996	543,315,083	400,680,118	142,634,965	26
2001	688,438,198	400,680,118	287,758,080	42
2006	864,166,592	400,680,118	463,486,474	54
2011	1,047,406,936	400,680,118	646,726,818	62

On the basis of estimated demand for fuelwood and the supply assumption, we find that there will be severe shortage of fuelwood to sustain the energy demand of the growing population (Table 3). In the year 2011, 62 percent of the demand will remain unsatisfied even if the present level of supply is maintained. This shows that unless otherwise controlled, the population in the region within next two decades will deplete the forest resources even at a faster rate than today simply to meet their basic necessity. This is an indication of very grave environmental problem of the Block and hence the Region.

The existing pattern of fuelwood usage also entails significant health hazards. Fuelwood burn in U-shaped traditional *chulhas* emit much smoke thereby causing indoor air pollution which mostly affects women and children. According to the World Development Report,

2. Population projection for the years extending upto 2011 has been done on the following growth rates (per annum):

1991-96	- 1.74%
1996-2001	- 1.53%
2001-2006	- 1.35%
2006-2011	- 1.19%

Keeping in view the advancement in the family planning programme, health and medical care and also the projection made by the Planning Commission.

1992, studies measuring biomass smoke in household kitchens in poor rural areas have found SPM (Suspended Particulate Matter) levels exceeding, by several orders of magnitude, the safe levels of WHO guidelines. Meal preparation exposes those doing the cooking to such levels for several hours a day. The smoke contributes to acute respiratory infections that even cause death in many cases. Recurrent episodes of such infections lead to permanent lung damage that shows up in adults as chronic bronchitis and emphysema contributing to heart failure. Studies have shown that the women who are exposed to such smoke suffer from abnormally high levels of chronic respiratory disease. It has been found that about 50 per cent of households in Gorubathan block are aware of the indoor environmental pollution caused by their energy using appliances (Table 4). Despite this awareness the endusers' preference for traditional cooking device can be rationalised by the prevailing market price for fuelwood which does not include the environmental cost. Moreover, given the economic condition of the Block and the family size, the fuelwood is collected (within the institutional set-up of forestry management where no penalty is charged from the tree-fellers) at zero private cost. So, it is necessary to find some estimates for environmental cost to see how the real price (price that includes environmental hazard cost) deviates from the market price and in turn may be used as guidelines for removal of price distortion and hence control of depletion through market mechanism.

TABLE 4: AWARENESS OF POLLUTION BY ENERGY APPLIANCES

Block: Gorubathan		Vi		Jlage: Total 18 Villages
Attribute	Total Observations (. No. of			Total
	Income Group			
	I	II	III	
Aware	78 (64.46)	26 (39.39)	21 (33.87)	125 (49.80)
Unaware	43 (35.54)	40 (60.61)	41 (66.13)	124 (50.20)
Awareness of Deforestation				
Aware	127 (95.49)	73 (91.25)	46 (70.77)	246 (88.49)
Unaware	6 (4.51)	7 (8.75)	19 (29.23)	32 (11.51)

Note : Figures within brackets indicate percentages.

Estimate of Environmental Cost

It is often said that, for the user, fuelwood burnt in traditional *chulha* involves practically no cost as much of it is collected from the surrounding forests by women and children. This is not really true. Even if we ignore the considerable amount of time and energy that

collection of fuelwood involves (which could have been devoted to some form of wage employment), the private environmental cost that fuelwood burnt in traditional *chulha*, entails, cannot be ignored. Since it is difficult to measure the social cost of pollution due to deforestation, in this study, we have only estimated the private environmental cost (Das *et al.* 1991) borne by the households of Gorubathan Block.

The surveyed households have reported their approximate annual expenditure for abating health hazards and for repairing houses, on account of the damage caused by pollution from energy using appliances and the afforestation programme taken up by themselves. These data have been used in the estimation of environmental cost per unit (thousand kilocalories) of energy obtained from fuelwood burnt in traditional *chulha*. The environmental cost has been classified into three types:

- (i) Cost of re-plantation (A_1^k)
- (ii) Cost to abate health hazards (A_2^k)
- (iii) Cost to abate damage to house (A_3^k)

The total environmental cost and the three types of environmental cost have been estimated using the following formula (1) and (2) respectively.

$$C_e^j = \sum_{i=1}^3 C_i^j \quad (1)$$

$$C_i^j = \frac{\sum_k A_{ij}^k}{\sum_k Q_j^k}$$

where

C_e^j = Private environmental cost borne by the j -th income group per unit of energy obtained from fuelwood burnt in traditional *chulha*;

A_{ij} = i -th type of environmental cost borne by the k -th household in j -th income group;

i = 1,2,3; types of environmental cost;

Q_{ij}^k = net energy obtained at the users' end from fuelwood burnt in traditional *chulha* by the k -th household in j -th income group.

The traditional methodology for estimating the cost burden associated with a particular pattern of energy consumption, takes into consideration only the capital cost, operation and maintenance cost and the fuel cost. This methodology ignores a very important aspect (the environmental) of developmental activities which has relevance in the context of sustained development. In Table 5 we have calculated the cost of energy per unit, based on traditional methodology (i.e. including fuel cost only since capital cost and operation and maintenance costs, or the traditional *chulha* are nil) as 0.07 only. This estimate has been derived through the following formula.

$$\text{Fuel Cost} = C_f = p_t \quad (3)$$

where P = market price of fuelwood; t = time.

Thus, given the growth of population and family size— we find that the existing energy consumption pattern does entail severe deforestation and indoor pollution problems which are detrimental to the sustenance of development.

TABLE 5: COST OF ENERGY PER UNIT

Cost Components	Income Group		
	I	II	III
Capital	0	0	0
Fuel	0.07	0.07	0.07
Operation and Maintenance	0	0	0
Environment (Total)	0.042	0.08	0.169
(a) Health	0.020	0.0	0.04
(b) House	0.014	0.04	0.115
(c) Re-Plantation	0.008	0.01	0.014
Total excluding Environment Cost	0.07	0.07	0.07
Total including Environment Cost	0.112	0.15	0.239

(in '000 kcal.)

Note: Income Group I: upto Rs. 6000/- p.a.; II: Rs. (6001-12000) p.a.; III: above Rs. 12000 p.a.

Another point of significance that emerges from this estimation of the cost of energy from fuelwood, is that if the traditional *chulha* is to compare unfavourably with alternative conversion devices on the basis of cost efficiency which alone can serve to include a shift from traditional conversion devices to newer and improved devices, then it is clearly the energy cost inclusive of environmental cost that should be taken into account. The cost of

III

Conclusions

The study has indicated, in a modest way, the relation between population growth, energy utilisation pattern, and environment in a hilly region. The typical dependency on fuelwood has been severely affecting that of the local population, especially women and children and is also leading to a rapid decline in forest area. Thus, fuelwood which appears to be an attractive natural resource for the local population involves serious environmental hazards, thereby creating negative link with the development of the Block.

Policy prescriptions or improvement of the situation involve measures aimed at both demand management and supply management of locally available resources. Demand management primarily involves popularisation of new and efficient energy conversion devices among the local people. Such devices will not only help to conserve fuelwood but will also simultaneously take care of the problem of indoor air pollution. On the supply management front, re-plantation efforts should be directed towards planting fast-growing trees (Reddy and Subramanian) to meet the growing demand of the population, appropriate pricing and subsidisation principles should be evolved taking environmental costs into consideration to make the new technologies competitive enough to the traditional ones. However, unless enough purchasing power is created through rural poverty eradication and employment generation programmes, illegal felling of trees due to population pressure with surplus labour can in no way be controlled.

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References

- Das, T. K., Roy, Joyashree and Chakraborty, D., 1991, New Technological option in energy Sector Cost Burden on Rural Households. Working paper no. 1, DSA Center for Regional Economic Studies, Economics Department, Jadavpur University, Calcutta. Hosier, H. Richard and Bernstein, A. Mark, 1992, Wood fuel use and sustainable development in Haiti, *The Energy Journal*, **13** (2), 129-156.
- Jain, B. C., 1992, Purchase of power by State Electricity Boards from biomass gasifier systems. *Urja*, **31** (1), 5-53.
- Reddy, A. K. and Subramanian, D. K., 1979, Design of Rural Energy Centres, Report of ASTRA. Integrated Rural Energy Programme - *Survey Report and Action Plan Frame, 1992*. School of Energy Studies, Jadavpur University, Calcutta. World Development *Report-Development and the Environment, 1992*, Published for the World Bank, Oxford University Press.