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IMPROVED STOVES IN MINIMIZATION OF FUELWOOD CONSUMPTION IN NEPAL

Bharat Raj Joshee

HMG-USAID-GTZ-IDRC-FORD-WINROCK PROJECT

STRENGTHENING INSTITUTIONAL CAPACITY IN THE

FOOD AND AGRICULTURAL SECTOR IN NEPAL

FOREWORD

This Forestry Research Paper Series is funded through the project, "Strengthening Institutional Capacity in the Food and Agricultural Sector in Nepal," a cooperative effort by the Ministry of Agriculture (MOA) of His Majesty's Government of Nepal and the Winrock International Institute for Agricultural Development. This project has been made possible by substantial financial support from the U.S. Agency for International Development (USAID), the German Agency for Technical Cooperation (GTZ), the Canadian International Development Research Centre (IDRC), and the Ford Foundation.

One of the most important activities of this project is funding for problem oriented research by young professional staff of agricultural agencies of the MOA and related institutions, as well as for concerned individuals in the private sector. In particular, funding is provided by the Ford Foundation to support research activities related to the human aspects of natural resource management. This research is carried out with the active professional assistance of the Winrock staff.

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IMPROVED STOVES IN MINIMIZATION OF FUELWOOD CONSUMPTION IN NEPAL

Bharat Raj Joshee*

INTRODUCTION

Nepal is on the threshold of 21st century and hopes to achieve the average Asian living standard within the next 15 years. During this period the country is groping to find solutions to its myriad problems of underdevelopment.

The two principal natural energy resources of Nepal are its forests and extensive river system. At present, the bulk of energy requirements are met by fuelwood from the disappearing forest while Nepal's immense water resources are almost untapped. Thus, Nepal's energy problems stem from the chronic imbalance between energy consumption and energy resource endowment. Accordingly, His Majesty's Government (HMG) has made various efforts to arouse interest in Nepal's two major energy resources--fuelwood and hydropower--and formulate long term plans for their development. The short term options are limited while medium to long term solutions such as harnessing the water resource potential, require major investment.

Thus, an appropriate energy strategy is important toward tackling the current problems of environmental degradation caused in large part by clearance of the forest for fuelwood. To meet future fuelwood demand and arrest ecological degradation simultaneously, various reports suggest additional tree plantations on 120,000 ha land by the year 2000. Besides this, massive dissemination of improved stoves is also imperative as young seedlings require at least ten years to mature. The dissemination of improved stoves is considered as the single most important short run action for energy conservation in Nepal. Improved stoves directly address the urgent problem of deforestation and reduces the scarcity of domestic fuelwood. It does not require complex technology or substantial investment. Estimates indicate that with a ten percent improved stoves acceptance rate by the population, Nepal could reduce fuelwood requirements by 720,000 metric tons (mt.) by 2000 which would be equivalent to producing about 100,000 ha of plantations (UNDP/World Bank, 1983, 1985).

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*Bharat Raj Joshee is an Economist at the Agricultural Projects Services Centre (APROSC), Kathmandu, Nepal. A longer version of this paper titled "Improved Stoves in Minimization of Fuelwood Consumption (Sundarijal and Bhadrabas Panchayats, Kathmandu, Nepal)" is available from the author.

Statement of the Problem

About 93 percent of the total population uses firewood and crop residues for cooking and heating. The growing population has increased the demand for firewood. Over seven and half million metric tons of fuelwood are annually consumed in Nepal. The annual extraction of wood from the forest of 2.1 percent is higher than the regenerative capacity of the forest. The present rate of afforestation of about 5000 ha per year is far below the necessary rate of planting. Thus, HMG should attempt to meet the production target to avert serious fuelwood shortages and alleviate pressure on the forest.

The collection of firewood is usually done by women. The demand for energy for domestic purposes is becoming more difficult to meet, and the task of gathering and fetching it is a time consuming burden. If farm families are relieved from this activity, they could utilize the spare time gained for other economic activities. The firewood used in the traditional mud-stove or Chulo is inefficient and does not exploit the end-use efficiency of the used firewood. In addition, about 46 percent of traditional stoves users are suffering from respiratory diseases. Viewed in this context of health hazards and excessive use of firewood in the traditional stoves, the propagation and adoption of improved stoves will have both short and long-term implications for future development efforts. The economic realities of Nepal also highlight the importance of improved stoves as 60 percent of its income in foreign currency is spent on importing other sources of fuels.

Rationale

In view of the growing scarcity of firewood and other consequences resulting from forest depletion, the search of alternative energy sources is imperative. However, this takes time--immediate measures are needed for large scale afforestation, and to reduce the total consumption of firewood by increasing its end-use efficiency. Increased end-use efficiency can be obtained through the use of improved stoves.

Similarly, a better understanding of firewood use, from wood collection habits, cooking methods, and the role of the hearth in the home can contribute significantly to the development of a more effective wood utilization and consumption program. Moreover, there is lack of information on these aspects. Hence, documentation of people's perceptions, attitudes, and practices toward improved stoves will help policymakers design suitable future programs.

Objectives

The broad objective of this study is to measure the effectiveness of improved stoves in minimizing fuelwood consumption and suggest appropriate measures for the increased adoption of improved stoves. Specifically, the study has the following objectives:

1. Identify people's perceptions towards improved stoves.

2. Identify problem areas in the adoption of improved stoves and suggest improvments.

3. Document firewood consumption practices for various purposes and measure the effectiveness of improved stoves.

4. Estimate fuelwood demand and analyze the factors affecting fuelwood demand in the study area.

5. Provide a general overview on the use of improved stoves and fuelwood situation in Nepal.

Limitations

The study focuses on the improved stoves use situation in two village panchayats adjoining to Kathmandu. As such the findings of the study reflect similar conditions for a large area in the hills of Nepal. The analysis indicates the gravity of energy situation prevailing in much of hill region. However, the specific prescriptions presented should not be generalized from too widely as the sample size is small. The findings of the study do not indicate the fuelwood needs and the extent of improved stoves use in the Tarai of Nepal. Fuelwood requirement for the study area refers to only the fuels used for food and feed preparation and heating needs. Therefore, the volume of fuel needs may be lower than the estimates indicated by other studies.

HOUSEHOLD ENERGY CONSUMPTION

Fuelwood Consumption Pattern

The total energy consumption in Nepal was around 6.1 million tons of coal equivalent during 1984/85. In case of fuelwood, about three-fourths (76 percent) of the present fuelwood consumption is obtained from domestic public forest and 24 percent from domestic private community lands and farm woodlots. Of the total fuelwood consumption, households consume 98 percent while the remaining 2 percent is used by industries. In the urban areas, this figure is reduced to 83 percent mainly because of access to commercial fuels. (UNDP/World Bank, 1983).

It is clear that individuals in the hills consume two-thirds (638 kg) more energy than those in the Tarai (383 kg) because of their greater need for heating (ADB/M, 1982). On the whole, Nepal's reliance on fuelwood as the main source of energy has placed too much pressure on the country's forest reserves. As a result, the forest has shrunk considerably in the past two decades.

Economic Cost of Fuelwood Consumption

In rural areas, households gather a large part of their fuelwood supplies from nearby forests. By law, they are required to pay royalties but in practice individuals taking head loads are not charged. The implicit price of fuelwood is, therefore, only the time taken to collect and carry it. However, with overuse, the forest is receding further from the villages and people spend more time gathering fuelwood. As a result, the labor force is diverted from other productive activities as more time and labor are required to collect fuelwood. This process has

greatly hindered development activities in Nepal. It is estimated that about 11 days per month are required to fulfill the household fuelwood requirement. Indeed, almost 16 percent of human labor in the country is utilized in the task of fuelwood and fodder collection (UNDP/World Bank, 1985). At present, it takes an average of about one work day to obtain a head load of 35 kg.

Although the access to firewood in public forest is "free," valuing it on the wage for unskilled labor of NRs.12 per day produces an opportunity price for fuelwood in rural areas of NRs.343 per ton.

Fuel Pricing Policies

The current fuel crisis resulting from the overuse of the forest is further aggravated from the unscientific fuel pricing policies of the government. These policies have not been set with the goal of relieving the pressure on forest. The price of the fuelwood is comparatively lower than other fuels--particularly electricity--thus encouraging villagers to use more fuelwood to fulfill their needs. With an imbalance between illegal fuelwood cutting and low electricity production, the free play of demand and supply in fixing the price of fuelwood neither is desirable from an environmental perspective nor justifiable in bringing greater attention toward tapping the immense hydropower at a faster pace in the future. The subsistence nature of much Nepal's rural economy also limits the scope for energy pricing. However, in urban areas, the price scheme developed for greater electricity consumption is an important means for an efficient pattern of energy consumption.

USE OF IMPROVED STOVES

The most common feature of improved stoves is fuelwood efficiency. It works on the principle of increasing the concentration of heat directly under the first cooking pot and then channels the heat back to the second burner to cook two pots at once. It conserves heat and reduces heat dissipation with minimum waste. It has been reported that 30 to 50 percent fuelwood could be saved through the proper use of improved stoves. Even a reduction of fuelwood consumption by one-third corresponds to a cash savings of NRs.8 to 13 per week which would greatly effect family income and help forest conservation. (CFDP, 1984).

The second feature is that improved stoves are smokeless. In Nepal, many people are suffering from long run health hazards particularly from emphysema (chronic cough) resulting from the daily inhalation of enormous amounts of smoke. In the villages, whether in a tea stall, hotel, or private home, smoke filled rooms are common, affecting eyes, nose tissues, and lungs. If a change from traditional stoves to improved stoves occured, it would significantly help to improve health and comfort.

Improved Stoves in Nepal

Improved stoves were first introduced in Nepal during the early 1950s using an Indian model. But because of the large forests in Nepal and poor awareness of health hazards, these stoves did not draw national interest and use died out by the end of the decade.

The world energy crisis combined with the deterioration of Nepalese forest resources aroused the government's attention, as well as different foreign aid agencies interested in natural resource development. The Research Centre for Applied Sciences and Technology of Tribhuvan University (RECAST) initiated a program in 1979 to design, develop, field test, and disseminate improved stoves throughout the country. Its effort received further momentum when HMG, the United Nations Development Program (UNDP), Food and Agriculture Organization (FAO), and the Community Forest Development Project (CFDP) joined forces in this venture during September 1981. Moreover, the Community Forestry Development Project is the first forestry project with a specified commitment to the development and dissemination of improved stoves. By mid 1984 it had covered 29 hill districts and 350 panchayats. CFDP has made notable advances in identifying suitable stove designs as well as in disseminating many stoves.

Effectiveness of Improved Stoves

At present, several thousand improved stoves have been distributed and it is believed that about 70 percent of the installed stoves are in use. Fuelwood savings per distributed stove is estimated at 462 kg per household, except in some small ethnic groups and in larger families. Similarly, out of the stoves distributed by CFDP in Kathmandu, Bhaktapur, and Dhading districts, 70 percent were reported to be in use (CFDP, 1984). The lowest percentage for improved stoves use (55 percent) was in Kathmandu. The improved stoves correspond favourably with cooking patterns among different groups for rice, lentils, and curried vegetables and give excellent fuel efficiency.

The effectiveness of improved stoves use is reflected by the degree of stove use and the amount of perceived fuel savings. The previous estimates indicate that the consumption of fuelwood by improved stoves varies considerably by region, source, and other variables posed by the user households.

Realizing the varying degree of improved stoves efficiency, installed in different places, design modifications are taking place giving due consideration to the cooking habits of people in different regions. Among the stoves that are already developed, the most widely disseminated are ceramic insert stoves. These are cheaper and easier to transport while as efficient as other stove models. All the ceramic stoves, except mud-brick stoves, and mud-sand stoves, are portable.

Distribution of Improved Stoves

At present, the following agencies, stated earlier, are involved in the distribution of improved stoves.

- The Forest Department under the guidance of the Stove Improvement Unit.

- Multilateral or bilateral foreign funded projects operating out-outside the project area of the Community Forestry Development Project.

- Non-government and voluntary organizations.

- RECAST is involved in stove design and laboratory testing.

The ceramic insert improved stoves are distributed free of charge to interested households in panchayats participating in the Community Forestry Development Program. These stoves are distributed and installed free of cost to the user or they have been distributed free but installed at user cost, or distributed at a subsidized rate and installed at user cost.

There is a favorable situation for large scale dissemination of improved stoves. In the Seventh Plan (1985-1990) (NPC, 1985), the importance and significance of fuelwood efficient stoves is recognized and a modest target set for installing 160,000 stoves during the plan period.

As the benefits of fuelwood efficient stoves accrue to the nation as a whole and the user households, it is important that both bear the financial responsibility. An encouraging development is that potters in the Kathmandu Valley are starting to sell stoves to individuals and stove components have been seen in pottery retail shops.

Problem Areas for Improved Stoves Adoption

Different ethnic groups have different rituals associated with the positioning, construction, and use of the stove or fireplace. Various studies indicate that socioeconomic and technical variables affect the use and inhibit greater acceptance of improved stoves (CFDP, 1984).

Therefore, the factors that hinder the acceptance and performance of stoves should be removed to achieve the national goal of preserving forest base and reducing the fuelwood crisis in Nepal.

Measures. For any stove program to have significant impact, it needs large scale adoption by the intended users. Previous experience within Nepal and other countries indicates that development of acceptable fuel efficient stoves is a difficult and complex process. The following are critical areas to be addressed for success of the improved stoves development program in Nepal.

- Stove design should match the requirement and cooking practices of the target group.

- The construction materials should be based on local materials so they can be locally manufactured.

- The quality of improved stoves should be maintained particularly in the fuelwood saving and smoke control aspects.

- A given design may not meet all the expected standards and should be sufficiently monitored for performance and efficiency.

Inaccurate installation, inadequate maintenance, poorly cut holes, connecting pipes, installation of chimneys, firing, and dimensional accuracy are critical construction problems still to be solved. Careful examination of both the good and bad features of the existing stoves or

fireplaces on the these aspects are important for the rapid adoption of improved stoves in Nepal.

METHODOLOGY

To solicit required information for the study, primary as well as secondary level of data were gathered. The findings of the study are based on primary level information. Secondary level information has been extracted from previous studies in related areas.

To gather the primary data, two sets of questionnaires were developed. The questionnaires were administered to both the improved stoves users as well as traditional stoves users. Both the questionnaires were used to measure the attitude and perceptions of the villagers. Fuelwood consumption rate, problems in rapid adoption of improved stoves, mitigating measures and other information were gathered from both users and nonusers of improved stoves.

About 50 households in each of the two groups were selected for interview according to stratified sampling procedures. Out of 50 households, 25 from each group of both panchayats were chosen. In course of interview with households, only nine were found using improved stoves, therefore, the sample size drawn from each group was reduced accordingly. Thus, only 25 households from the improved stoves-abandoned group, followed by 20 from traditional stoves user group and 9 from improved stoves-continuing group were interviewed. For the simplicity of the analysis, these groups are identified as group A (nine households using improved stoves), group B (25 households which abandoned using improved stoves), and group C (20 households using traditional stoves). Aside from direct interviews, information was also gathered through observation. This exercise helped identify feelings of the elders, panchayat leaders, and other concerned officials on improved stoves management.

Finally, multiple regression was used to analyze the effects of various variables on fuelwood consumption.

THE CASE STUDY

Setting

Sundarijal and Bhadrabas village panchayats are situated on the outskirts of Kathmandu, 20 kilometers north of the city center.

Sundarijal Village Panchayat. Sundarijal is a well known resort area. The first hydropower house of Nepal was built there in 1930, Sundarijal also has a water reservoir supplying Kathmandu. A 10 km road up to the power house from Jorpati links Sundarijal to Kathmandu. The main occupation of most households in this panchayat is agriculture. In general, maize, paddy, wheat, millet, and potato are the main crops grown.

The population of Sundarijal panchayat according to the 1981 census was 4685 people. The Ganesh Yuba Club actively participates in social work activities undertaken within the panchayat. There are three primary schools. Mrigendra Chikitsa Guthi (MCG), a medical and social

service trust, is involved in improving the health status in the panchayat. To reduce health hazards from smoke inhalation from the use of traditional stoves, MCG launched an improved stoves distribution program in 1980 which has significantly improved villagers health.

Bhadrabas Village Panchayat. Bhadrabas Village Panchayat is the adjoining panchayat to the east of Sundarijal in Kathmandu district. According to the 1981 census, the total population was 3550. From Jorpati to Dainchi an all weather main road of about 10 km is available. From Dainchi to the Bhadrabash panchayat is a fair weather motorable road 2 km long. This panchayat has virtually no access to clean drinking water facilities, irrigation systems, or electricity. Agriculture is the main occupation, with paddy, maize, and wheat grown. Though small in size, this panchayat is influential in Kathmandu district regarding political, social, and educational status. The Bhadrabas Yuba Club has greatly contributed to expose the panchayat to other areas. This panchayat has one high school and one primary school.

RESEARCH FINDINGS

Socioeconomic Characteristics

Household Population. Average household population of the sample households is estimated at 7.9 persons. Group A (improved stove users) has the largest family size (11.0) followed by group C (traditional stove users) (8.0) and group B (those who abandoned using improved stoves) (6.8).

Landholding. Average landholding of the sample households is estimated at 0.4 hectares. By stoves used, group A has the largest average landholding of 0.9 hectares followed by group C (0.4 hectares) and group B (0.3 hectares).

Employment Status. On an average, about 2.8 people per household are engaged in agriculture while 1.3 persons perform nonagricultural activities. By stoves used, group B (3.0) has highest number of persons engaged in agricultural activities followed by group C (2.6) and group A (2.5). In case of nonagricultural activities, group A (2.0) has the highest number of persons followed by group C (1.2) and group B (1.4).

Labor for Fuelwood Collection. On average, about 25 persons per household were engaged in fuelwood collection last year. By stoves used, about 29 persons were found in the group A followed by group B (26 persons) and group C (21 persons). In all groups, women predominated the fuelwood management activities. By age, individuals over 15 years old perform this activity.

Literacy. On average, about 2.2 persons per household of 7.9 persons are literate. By stoves used, group A has the highest literacy rate (3.4) followed by group B (2.2) and group C (1.7). By sex, more men are literate than women--the ratio was almost double in all three groups. Regarding the school-going population, it is estimated at 2.7 persons per household which is highest in group A (3.7), followed by group C (3.0), and group B (2.1). Boys are 40 to 50 percent more likely to be enrolled in school than girls.

Income and Expenditure Pattern. Average net annual income of the household is estimated at NRs.5506, this was highest in group B (NRs.7939), followed by group A (NRs.6279), and group C (NRs.2122). Most of the income comes from the nonagricultural sector (84 percent). Similarly, most of expenditure is for nonagricultural activities (68 percent). A marginal amount of expenditure is for fuelwood purchase, which is four percent in the case of group A and C, while three percent for group B. The rest of income and expenditure is from and for agricultural activities which is 84 and 68 percent, respectively. The Table 1 shows the average income and expenditure of the households.

Table 1. Average Household Income and Expenditure, Rupees (percent)

Item of income and expenditure	Group A	B	C	Average
Agricultural income	4756	3611	2833	2833
	(16)	(19)	(9)	(16)
Nonagricultural income	24333	15100	9793	14673
	(84)	(81)	(91)	(84)
Income from fuelwood sale	-	-	55	20
			(0)	(.1)
Total income	29089	18711	10843	17526
	(100)	(100)	(100)	(100)
Agricultural expenditure	6411	3563	2031	3470
	(28)	(33)	(23)	(29)
Nonagricultural expenditure	15561	6920	5323	8139
	(68)	(64)	(73)	(68)
Expenditure on fuelwood purchase	838	289	367	409
	(4)	(3)	(4)	(3)
Total expenditure	22810	10772	8728	12018
	(100)	(100)	(100)	(100)
Net income (income-expenditure)	6279	725	2122	5506
Per capita net income	578	1167	2650	688

Livestock Holding. Average livestock holding including all categories is 57 units. By stoves used, group A has the most livestock units (139), followed by group B (5 units), and group C (26 units). By categories of livestock, the average number of cattle and buffalo per household is estimated at 2.3 units, with goat, sheep, and pig at 1.3 units, and poultry about 53 units.

Livestock Feed Preparation. Average fuelwood consumption for livestock feed preparation is determined by the number of livestock served with cooked feed and the frequency served. Generally, livestock feed is comprised of maize or maize flour, rice husk, grain residues, and vegetables. The livestock feed is mixed in water and boiled with salt according to the number of livestock to be served per preparation. To prepare livestock feed, the households in all three groups used open fire or a tripod stand.

Food Cooking Practices. The type of food in the household is comprised of rice, curry vegetables, lentils, meat, bread (roti), fried maize, tea, and other foods. Generally, the morning and evening meals are comprised of rice, curry, lentils, and bread, while early morning

and midday meals are usually comprised of tea and bread. However, for midday meals, fried maize is also sometimes prepared. There are significant differences in the amount of fuelwood consumed to prepare these meals. As the quantity and dish type prepared at a time directly influences fuelwood consumption, the quantity of dish and type included in different meals was analyzed.

Use of Different Stoves

The use of improved stoves to prepare tea, maize, and bread eaten for early morning and midday meals is negligible. Instead, use of earthen oven is followed by tripod stand, electic heater, and traditional stoves. In case of group B, use of traditional mud-stoves comes before electric heaters with the use of other stoves as with group A. In group C, the earthen oven is used followed by traditional stoves. Husk-stoves are also used by all groups but to a negligible extent.

The frequent use of different stoves indicates that the households used improved stoves about three percent of the time for the early morning and midday meals while the rest of the use is for main meal preparation (morning and evening meals). Group A used the improved stoves to prepare main meals about 85 percent of the time followed by earthen oven (nine percent), traditional stoves (four percent), and tripod-stand (two percent). In the case of group B, the use of traditional stoves was 53 percent followed by tripod stand (27 percent), and earthen oven (20 percent). Unlike group B, group C used traditional stoves 71 percent of the time, followed by earthen-oven (19 percent), tripod-stand (seven percent), and husk-stoves (three percent).

The use of different vessels to cook food also determines the volume of fuelwood and cooking time requirement, as different metals have varying capacity to absorb heat.

Time Required to Cook

The time required to cook a dish depends on the quantity cooked, vessel, fuel, and stove type used. Irrespective of other factors, the use of improved stoves takes more time, followed by traditional stoves, earthen-ovens, and the tripod-stand. However, to cook meat, tea, bread, and fried maize, the tripod stand takes more time in the case of group B. The performance of husk-stove is similar to that improved stoves. However, it takes more time to cook lentils and meat. Tea, bread, and egg sometimes are also prepared on electric heaters by groups A and B. It takes the same amount of time as improved stoves.

Improved Stoves in the Study Area

In the study area, MCG distributed about 49 stoves in 1980. Out of the 34 households with improved stoves, only nine households were using them while the remaining households stopped using the stoves after one to three months. Out of the nine users, three were Newar families and six were Brahmin. By ethnicity, 17 Brahmin families stopped using improved stoves, followed by seven Chhetry and one Newar families.

Cost of Improved Stoves Construction

Most of the households own one to two stoves, such as traditional mud-stoves, earthen-oven, tripod stands joined with earthen-ovens, and improved stoves. These stoves are generally made with dung, husk, clay, and bricks. The cost of improved stoves for the household includes only labor cost. The cost of stoves is estimated at NRs.72. If the transportation cost of the chimney pipe is excluded the cost is NRs.42.

Respiratory Diseases and Use of Stoves

A study by MCG (1978) indicates that 18 percent of the total population in the project area have respiratory diseases. The major factor responsible for diseases is the smoke emmitted by kitchen stoves. The improved stoves user households reported that the stoves emitted less smoke compared to traditional stoves located inside the house. Hence, improved stoves have greatly contributed to the reduction of respiratory problems faced by the household members.

Social Taboo on Stove Use

As both traditional and improved stoves are made with the same materials, none of the households face a taboo on using improved stoves. However, some of the households report that they prefer traditional stoves over improved stoves because smoke inside a house protects grains and the house from the insects. They believe that the house which has smoke inside from time to time is more durable than houses without smoke. Such households display less care toward personal health than to home maintenance. As the cooking time and fuelwood required for various stoves are not significantly different, some of the households believe that traditional stoves are superior over improved stoves. The other strong factor perpetuating traditional stove use are cultural values of Brahmins. Brahmins generally do not cook livestock feed and human food on the same stove. Thus, the Brahmin households which have improved stoves also maintain traditional stoves for livestock feed preparation.

Reasons for Abandoning Improved Stoves

Out of the 34 households sampled from the 49 improved stove receiving households only nine are still using improved stoves while the remaining households switched back to traditional stoves after 1 to 6 months use. By ethnicity, Newars tended to use improved stoves while other castes stopped use in most cases. The most common reasons for abandoning use of improved stoves are as follows:

- More time and fuelwood were required to cook meals on the improved stoves than traditional stoves because of defective design and improper kitchen placement.

- The wrong size of internal diameter (firebox) of the stoves, defective slope of the baffle, and chimney hindered the proper exhaustion system for expelling smoke and proper cleaning.

- Most of the stoves had three pot holes, making it difficult to rely only on the improved stoves for all cooking needs.

- Cooking restrictions hindered greater use of improved stoves by Brahmins.

- Fuelwood consumption was reported not that much different for both stove types.

THE FACTORS AFFECTING FUELWOOD CONSUMPTION

In the previous section, different characteristics of the sample households concerned with fuelwood consumption and in use of improved stoves were discussed. This section analyzes the relationship between fuelwood consumption and various causative factors through tabular and multiple regression.

Fuelwood Consumption by Ethnicity

The distribution of sample population indicates that 56 percent are Brahmin with an average family size is 7.3 persons, followed by Chhetry (13 percent) with a family size of 8 persons, Newar (21 percent) with a family size of 10.3 persons, and others (9 percent) with a family size of 7.6 persons. The average annual household consumption of fuelwood by these castes is observed at 1464 kg, 1744 kg, 1978 kg, and 1860 kg, respectively. Likewise the annual per capita consumption is estimated at 200 kg, 218 kg, 191 kg, and 245 kg, for these castes. The high per capita consumption in the case of Tamang (other castes) is probably due to different food habits. Generally they cook grain mush on traditional fireplaces which are much less fuel efficient than the traditional stoves of other castes. The differences are observed to be significant only in the case of Brahmin and Tamang castes which are significant at the 95 percent confidence level.

Fuelwood Consumption by Literacy

The households sending their children to school are identified as literate and those who do not as illiterate. The average family size of these households is estimated to be 8.3 and 5.4 persons. The average fuelwood consumption of the literate household is 1641 kg with a per capita consumption of 197 kg, while the figure for illiterate households is 1503 kg and 277 kg. The difference is significant at the 90 percent confidence level.

Fuelwood Consumption by Labor Use

Households using family labor for fuelwood collection comsume more fuelwood than households who did not use such labor. The former case uses 1608 kg of fuelwood with a per capita consumption of 214 kg, while the latter case uses 1675 kg per household with a per capita level of 176 kg. This difference is significant at the 90 percent confidence level.

Table 2. Fuelwood Consumption by Ethnicity

Ethnicity	Households	Family size	Average fuelwood consumption (kg)	Per capita fuelwood consumption (kg)
Brahmin	33	7.3	1464	200
Chhetry	7	8.0	1744	218
Newar	9	10.3	1978	191
Tamang (others)	5	7.6	1860	245

Table 3. Fuelwood Consumption by Literacy

Status	Households	Family size	Average fuelwood consumption (kg)	Per capita fuelwood consumption (kg)
Literate	47	8.3	1641	197
Illiterate	7	5.4	1503	277

Table 4. Fuelwood Consumption by Labor Use

	Households	Family size	Per household fuelwood consumption (kg)	Per capita fuelwood consumption (kg)
Using family labor	42	7.5	1608	214
Not using family labor	12	9.5	1675	176

Fuelwood Consumption by Occupation

Of the sample households, some 27 percent derive large shares of their income from agricultural activities. Hence, they are identified as agriculturalist households. Similarly, the merchant and service holders households are also indentified. The average fuelwood consumption for agriculturalists is 1613 kg with a per capita consumption of 234 kg. Service holder households use 1789 kg with a per capita rate of 176 kg. The difference is observed significant only in the case of service holder--at 90 percent confidence level.

Table 5. Fuelwood Consumption by Occupation

Occupation	Households	Family size	Per household fuelwood consumption (kg)	Per capita fuelwood consumption (kg)
Agriculturist	17	6.9	1613	234
Merchant	12	7.7	1780	233
Service holder	25	8.8	1549	176

Fuelwood Use by Income

The households with annual income more than NRs.20,000 show low per capita fuelwood consumption (181 kg) with an average household consumption of 1996 kg, while households with annual income of NRs.15,000 to 20,000 have a higher per capita fuelwood consumption (251 kg). For the latter group, annual average household level consumption is 2005 kg. In the case of households with an annual income of NRs.10,000 to NRs.15,000 the average household fuelwood consumption is 1663 kg with a per capita level of 217 kg, while that for income brackets of NRs.5000 to 10,000, is 1278 kg for household consumption and 188 kg for the per capita level. The per household and per capita consumption of fuelwood with an income of less than NRs.5000 is 1358 kg and 218 kg, respectively. It can be concluded that more fuelwood consumption occurs among low income households than those with higher incomes. This may be because low income families tend to be illiterate, while that of top income level households tend to be literate as are service holders. Additionally, most of the improved stoves users are in these two groups.

Table 6. Fuelwood Consumption by Income

Income	Households	Family size	Per household fuelwood consumption (kg)	Per capita fuelwood consumption (kg)
Less than NRs. 5,000	13	6.2	1358	218
NRs 5,000 to 10,000	11	6.8	1278	188
NRs 10,000 to 15,000	12	7.7	1663	217
NRs 15,000 to 20,000	4	8.0	2005	251

Except the households with income level NRs.5000 to 10,000 and those of over 20,000, the differences in the per capita consumption of fuelwood for the rest are significant at the 90 percent confidence level.

Multiple Regression Analysis

Consumption of fuelwood (excluding other fuels) depends on many variables. Some of the variables affecting fuelwood consumption have been measured using logarithmic regression analysis. The most powerful variable which maintained a positive relationship with fuelwood consumption is the population size of the household. In most of the equations, the regression coefficient is estimated at 0.70 and is highly significant. This coefficient implies that, other variables remaining constant, a percentage increase in family size will lead to increase the fuelwood consumption by 0.70 percent, indicating the magnitude of inelasticity in economic terms. The coefficients for other variables can likewise be explained.

The second most powerful variable with a positive relationship with fuelwood consumption is the level of household income. Its coefficient is estimated at 0.10 in all the equations, and is significant at the 95 percent confidence level.

The third most powerful variable is electricity which maintained the expected negative relationship with fuelwood consumption in most of the equations and is significant at 95 percent confidence level. The other variables which significantly affect fuelwood consumption are ethnicity, occupation, education, and labor status. Compared with the base category of the Tamang caste, fuelwood consumption by Brahmin, Chhetry, and Newar are observed to have inverse effects. However, these effects are significant only for Brahmin and Newars, and only with 20 percent chance of error.

In the case of literacy, fuelwood consumption is inversely correlated with educated households, compared to the base variable--noneducated household. The coefficient is estimated to be 0.26 and is significant at 90 percent confidence level. Households who use family labor to collect fuelwood, is positively correlated with fuelwood consumption. The coefficient for this variable is 0.20 and significant at the 90 percent confidence level. The effect of occupation is also found as expected. Agriculturists and merchants respond positively to fuelwood consumption compared with the base variable, service holder, whose coefficients are 0.21 and 0.17, respectively. These coefficients are significant at 90 percent and 80 percent confidence level.

Except crop residue, livestock size, and improved stove use, the variables dungcakes and price of fuelwood have negative relationships with fuelwood consumption as expected, but are not significant. The F-value which explains the overall significance of the equation was above 7.0 for all equations for these variables and is highly significant. Similarly, in most of the equations, the coefficient of determination is more than 50 percent indicating that the explanatory variables explain changes in fuelwood consumption by more than 50 percent.

Fuelwood Consumption Pattern

Share of Different Fuels. The consumption of different fuels for cooking and heating indicate that about 90 percent is derived from fuelwood, followed by crop residue (six percent), electricity (two percent), and dungcakes and kerosene (one percent each). By stoves used, group A derived 85 percent from fuelwood, while groups B and C derived 90 percent each. In case of dungcakes, group B used two percent while group A and C used less than one percent. The use of crop residue is highest for group C (eight percent) followed by group B (five percent), and group A (four percent). The use of kerosene is highest in group A (four percent), but is hardly used by groups B and C. For electricity, group A uses it seven percent of the time, followed by group B (two percent), and group C (0.3 percent).

Fuelwood Use Collection Source. Most of fuelwood used by the household is collected from the traditional source--the forest. About 36 percent of the fuelwood used is obtained through purchase from the local market while 54 percent came from the forest. By stoves used, about 48 percent of the total fuelwood used by group A is purchased from local markets, while 43 and 24 percent, respectively, for groups C and B. This trend indicates that the households who use purchased fuelwood economize their overall fuelwood consumption.

Household and Per Capita Consumption of Fuelwood. Per capita consumption of total fuel in terms of fuelwood is estimated at 212 kg annually. This figure increases for group B (226 kg), followed by group C (221 kg), and is lowest for group A (194 kg). The average (group B and group C) per capita consumption of fuelwood for traditional stove users is 221 kg. Comparing the average family size of the different groups, it is clear that greater the family size, the greater the average household consumption of fuelwood, while for per capita consumption the inverse holds.

Table 7. Household and Per Capita Consumption of Fuelwood

Fuel types	Average fuelwood consumption per family (kg)				Per capita fuelwood (kg)			
	A	B	C	Average	A	B	C	Average
Total fuelwood	1805	1401	1538	1519	164	206	192	192
	(85)	(91)	(91)	(90)				
Collected	936	1060	882	973	85	156	110	123
	(44)	(69)	(52)	(58)				
Purchase	869	341	656	546	79	50	82	69
	(41)	(22)	(39)	(32)				
Dung cakes	3	24	6	14	0.3	4	0.8	2
	(7)*	(57)*	(13)*					
	(0.1)	(2)	(0.4)	(1)				
Crop residue	90	84	138	105	8	12	17	13
	(4)	(5)	(8)	(6)				
Kerosene	93	-	4	17	9	-	0.5	2
	(11)*		(1)*	(2)*				
	(4)	(0.3)	(1)					
Electricity	146	25	5	38	13	4	0.6	5
	(139)*	(23)*	(5)*	(36)*				
	(7)	(2)	(0.3)	(2)				
Total fuels in terms of fuelwood	2137	1534	1691	1693	194	226	211	214
	(100)	(100)	(100)	(100)				

Note: Figures within the brackets without asterisk are the percentage of different fuels to the total fuels consumed. The value marked with asterisk are the fuels converted into fuelwood by using following conversion factors.

One kg of dry dungcakes = 0.42 kg of fuelwood replacement.
One kg of crop residue = 1.0 kg of fuelwood replacement.
One liter of kerosene = 8.74 kg of fuelwood replacement.
One unit of electricity = 1.05 kg of fuelwood replacement.

Fuelwood Consumption by Purpose

The percentage use of fuelwood used for various purposes indicates that some four percent is used for heating (especially in winter), followed by 80 percent for human food preparation, and 16 percent for livestock feed preparation. For all three groups, the use of fuelwood for various purposes is generally in equal proportion.

Table 8. Percentage Use of Fuelwood by Purpose

Purpose	A	B	C	Average
Heating	4.4	3.9	5.3	4.5
Human food preparation	82.2	78.7	79.6	79.8
Livestock feed preparation	13.4	17.4	15.0	15.7
Total	100.0	100.0	100.0	100.0

Sources of Fuelwood

Most of the fuelwood used in the study area is utis (*Ulnus nepalensis* D.Don), whose calorific value is estimated at 3500 kcal. Much of the fuelwood is collected from Sivapuri, Bagmati, Shyalmati, Nagamati, and Bhaludada forest areas. All these forests are three to four km from the sample households. Some of the households obtained fuelwood from their own farm land and some purchased it from the local market. In general, two hours are required to fetch a bundle of fuelwood--excluding the time taken to bring it home. There are no significant differences in time required to fetch a bundle of fuelwood in summer or winter. The average weight and price per bundle of the fuelwood is 30 kg and NRs.25.

Fuelwood Requirement for the Study Area

The current efficiency level of various improved stoves with respect to fuelwood consumption were tested and ranged from 30 to 50 percent over traditional stoves. Previous estimates indicate a 22 percent level of efficiency for improved stoves in Kathmandu district.

If one kg of fuelwood is priced at NRs.1, it would result in saving the same amount in gross terms from the use of improved stoves. Considering the maximum price of improved stoves as NRs.100, the resulting fuelwood savings from improved stoves by all households would correspond to the price of three improved stoves to each of the 600 households in the project area. Moreover, the community gain is large in terms of preserved forest and improved environment. If the effort is made to double the present level of efficiency (12 to 24 percent) which could be reached through careful tackling of stove defects pointed by the users, the resulting gain would be doubled. Therefore, if certain model of improved stoves gained success under the management of an average Nepali housewife, nothing would be more valuable than the promotion of such improved stoves, because it would substantially help in reducing fuelwood consumption and conserve the forest area.

CONCLUSIONS

An appropriate energy strategy is an important element in addressing the problem of environmental degradation caused in large part by clearance of forest for fuelwood.

Improved stoves have intrinsic potential for short run energy conservation in Nepal. Improved stoves directly address containing the urgent problems of deforestation and reducing domestic fuelwood scarcity and respiratory diseases that result from excess smoke inhalation. They do not require complex technology or substantial investment. However, the use of improved stoves in Nepal has so far been negligible. A major difficulty is the adoption and dissemination of several proven, affordable models which meet local traditions. If improved stoves are developed considering user characteristics and regional differences, they help reduce pressure on the forest and fuel crisis. Thus, a plan should be developed to disseminate and develop experience in improved stove mass production, promotion, and distribution.

Of the total energy consumption, 84 percent is derived from forest. Of the total fuelwood consumed, 98 percent is consumed by the household sector. Of which, 93 percent is used for cooking and heating needs and is burnt mainly in traditional stoves. It has also been claimed that some 46 percent of traditional stoves users suffer from respiratory diseases. The incidence of chronic bronchitis in Nepal is reported to be the highest in the world and has been found correlated with domestic smoke pollution largely caused by the use of traditional stoves.

Previous research indicates that over 20 thousand of improved stoves have been distributed in Nepal, of which 50 percent are expected to be in use on regular basis. Among the improved stoves distributed, ceramic insert stoves are used the most because of the higher degree of acceptability and lower relative cost.

As in most of the cases over 50 percent of fuelwood is collected from public forest, improved stoves could save 231 to 540 kg of wood in the public forest. Fuelwood saving per distributed stove is estimated at 462 kg to a ton per household. Most of the improved stoves are found in use for main meal preparation, thus, the fuelwood saving for the main meal is greatly realized and ranges 30 to 50 percent over traditional stoves. If it is to be considered with other cooking items, the overall potential of fuelwood saving is found somewhat low--26 percent. This is occurs because improved stoves are generally not used for other meal preparation.

The improved stoves used in the study area, certainly have an effect in reducing fuelwood consumption and lessening the pressure on forest reserves. However, the improved stoves use in the study area is negligible. Only about 18 percent of the distributed improved stoves are reported to be in use. As a result, the aggregate impact of the improved stoves use is insignificant.

Again, the improved stoves used in the study area have a fuelwood saving efficiency of about 12 percent over traditional stoves while the improved stoves distributed in other parts of Nepal show an efficiency level ranging 30 to 50 percent in most of cases. However, the low level of fuelwood efficiency occurs in Kathmandu (22 percent) while highest is in Doti (40 percent).

The low level efficiency of the improved stoves in the study area is largely attributed to the bias of the agency (MCG) concerned, as the improved stoves were primarily distributed to those households where a

member had a respiratory disease. Thus, the design and construction of the stoves concentrated on reducing smoke inside the house rather than reducing fuelwood consumption. As a result, this meant both a low level of fuel savings and lower adoption rates. However, individuals within study area are responsive toward using improved stoves which have both qualities (smokeless and fuelwood efficiency). So far, the improved stoves have proved useful in reducing the respiratory problems of the household members.

The most common reasons for the low use of improved stoves are the inadequate extension facilities and design defects. Extension service is a decisive factor greatly determining the rate of adoption and continued use. All households which received training on stove construction and maintenance were using improved stoves in the study area while others stopped after one to six months use. The other reason for abandoning the use of improved stoves are bad location in the kitchen, chimney defects, and wrong size of the internal diameter of the firebox. Frequent breakages in the wood inlet and pot holes as well as insufficient fire in the second pot hole also contributed to abandonment of the improved stoves in the study area.

In most cases, improved stoves are not used for grain mush and livestock feed preparation. Furthermore, human food and livestock feed are not prepared on the same stoves in Brahmin households, and in still other households improved stoves are considered inadequate for this purpose. Similarly, when a single item is to be prepared the traditional stoves are mostly used. Thus, households generally maintained both traditional and improved stoves.

The annual per capita fuelwood consumption for improved stoves users is 194 kg while traditional stove users consume 221 kg. Irrespective of the stoves used, annual per capita fuelwood consumption for all groups is estimated at 214 kg. Based on these estimates, the total fuelwood requirement in the study area is estimated at 1820 mt. This indicates an annual per capita saving of 27 kg (222 mt.) through the use of improved stoves over traditional stoves. Ignoring the stove type used, the requirement would be 1762 mt. a year. It is assumed that the resulting fuelwood saving could purchase three improved stoves for each household within the study area.

The tabular analysis indicates that the larger the family size the higher the household fuelwood consumption while this is opposite for per capita consumption, indicating an economy of scale for large households. Similarly, the households using family labor for fuelwood collection consume more fuelwood than others. Literate households economized on the amount of fuelwood consumed per family member compared to their illiterate counterparts. In this study, different income levels did not clearly reflect their relationship to fuelwood consumption. The top income brackets and second lower income brackets show low levels of fuelwood consumption. By ethnic groups, Newar consume less compared to Brahmins, and Brahmins consume less than Chhetry, while Chhetry consumes less than Tamangs. It should be remembered that Newar constitute the largest group of improved stoves users. Likewise, in case of occupational status, agriculturalists consume more compared to merchants, and merchants consume less than service holders.

The regression analysis illustrates the significant positive relationship between fuelwood consumption with income level (coefficient = 0.10) and population size (0.70). In terms of the dummy variables used in the analysis, Brahmin (0.30) and Newar castes (0.30) show significant negative relationships with fuelwood consumption compared with the base dummy variable, Tamang caste. The use of electricity (0.02) also is negative. Family labor has a positive relationship (0.20). Similarly, agriculturalists respond positively (0.20) to fuelwood consumption compared with the base dummy variable, service holders. Literate households (0.30) respond negatively. The rest of the variables are insignificant.

The correlation analysis indicates that fuelwood consumption has a strong positive relation with population size (0.58) but is negative with Brahmin caste (0.27) comparing with the base dummy variable, Tamang caste. The remaining variables have weak relationships. Similarly, improved stoves use has a strong positive relationship with electricity use (0.27), followed by Newar caste (0.20), and literate households (0.17). Chhetry caste (0.18), followed by use of dung for fuel (0.16), and family labor (0.12) have negative relationships with improved stoves use, while the remaining variables have negligible relationships.

Though the villagers within the study area have participated in forest preservation activities to some extent, they are generally passive because of their socioeconomic status. Previous studies indicate that the longer the forest remains government property, the greater is the chance of overexploitation. The present approach of gradually transferring forest for local community protection should be accelerated for effective preservation of the forest because of its proven results. Similarly, most households in the study areas show an interest in the introduction of Panchayat Protected Forests and Panchayat Forests.

In conclusion, the lack of subsidiary occupations is the main cause for the rapid forest devastation in the study area. Creation of employment opportunities other than fuelwood selling could help reduce fuelwood consumption and relieve pressure on the forest reserves. Similarly, the forest preservation activities which include dissemination of improved stoves are also effective in this direction. Any rural health project seeking to raise the level of rural health should integrate with improved stoves dissemination activities to achieve their goals and contribute to forest preservation. As most of the improved stoves distributed are not in use largely due to design and construction, defects, appropriate measures are urgently called for to overcome these problems.

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Winrock International Institute
for Agricultural Development

Route 3, Petit Jean Mtn.
Morrilton, AR 72110-9537
U.S.A.

P.O. Box 1312
Kathmandu
Nepal