

Which Type of Stove is Best? An Environmental Impact Assessment from Nepal

Across much of South Asia firewood is used as a primary source of domestic energy. However the burning of wood for cooking and heating homes is linked to a number of significant health, pollution and deforestation problems. Now, to help look for solutions to these problems, a new study from Nepal investigates whether the type of cook stove a household uses has an impact on its level of firewood use. The study is the work of Mani Nepal, Apsara Nepal and Kristine Grimsrud.

Not surprisingly, the study finds that households with traditional mud stoves use less firewood than those that use a traditional open-fire stove. More unexpectedly, the study finds that households that use so called 'improved' stoves seem to use more firewood than those with mud stoves. Thus, when it comes to cooking stove technology, converting traditional open-fire stoves to mud stoves may be the best short-term strategy from a conservation point of view. However, in the long run, the study recommends that making cleaner fuel more accessible to rural households should be made a government priority.

THE FIREWOOD CHALLENGE

Burning firewood and other biomass for cooking and to warm homes causes indoor air pollution that is linked to numerous health problems. Domestic firewood use is also linked to the emission of greenhouse gases and the production of brown clouds and black carbon. The use of firewood for fuel also leads to deforestation, which in turn is thought to have an impact on climate change. Despite these acknowledged problems, the use and collection of firewood seems to be increasing in Nepal. Information from two nationally representative household surveys show that in 1995/96 about 77% of Nepalese households used firewood for cooking. However, by 2003/04 the proportion of families doing this had increased to 84%. This trend in firewood collection and use threatens the sustainability of Nepal's forest resources and also jeopardizes people's health.

One response to this firewood challenge has been the introduction of the improved cook stoves (ICS) in Nepal. This type of stove was introduced in the 1980s to reduce the rate of deforestation, reduce indoor air pollution and increase the efficiency of household energy use. However, the adoption rate for these stoves has been relatively small and many other types of cooking stoves are in use throughout Nepal. For more on these stoves and the steps that have been taken to introduce them, please see the side bar.

FILLING THE INFORMATION GAP

Despite the widespread use of firewood in developing countries and its potential impacts on indoor air pollution and deforestation, literature on the contribution of improved stoves to firewood saving is very limited. What is more, results from existing studies show that evidence on the impact of improved stoves - on firewood use and on indoor air pollution - remains inconclusive. Most of the studies that have been completed focus on the technical aspects of stove design. Reasons for this paucity of research include poor understanding of the market for traditional fuels, such as firewood, and a general lack of information.

THE IMPROVED COOK STOVE STORY

Historically, deforestation in Nepal is due to the expansion of agriculture, illegal timber extraction and firewood collection. In the 1980s, to try and do something about these problems, the Nepalese government started transferring the user rights of government-managed forests to local communities. This initiative was the widely celebrated community forestry program. While transferring forest management to the local communities, the Nepalese government also tried to distribute improved cook stoves (ICS). This was done on a limited scale in the hope that these cook stoves would be able to reduce firewood demand.

In 1999, the Nepalese government introduced the National Improved Cook Stove Program under the Energy Sector Assistance Program which was funded by the Danish International Development Agency. The ICS program in Nepal is mostly supply driven. Interested organizations have introduced several types of ICS technology. These stoves are of many different shapes and sizes and include mud-brick ICS and metallic ICS. The most popular stove type is the mud-brick ICS. Such stoves can have one to three potholes, depending on a household's requirement. By 2004, the number of ICSs in the country was estimated to be 150,000. However, studies suggest that, while the use of ICS covers all geographical areas, the rate of adoption of this technology has been very low: only two percent of households in 31 districts (out of 75) used ICS during 2003/04. Other information indicates that very few households adopt the metallic cook-stoves that come with a damper to regulate air intake.

Even though this study calls into question the effectiveness of improved stoves at reducing firewood use, it should be remembered that they do have other benefits. Many studies have confirmed that improved stoves reduce $PM_{2.5}$ and CO pollution, improve indoor air quality and significantly help to reduce the incidence of respiratory diseases.



Open fire stove

To help fill this information gap and to help develop environmental policy in Nepal, this study analyzes the impact of the stove type on household firewood consumption using information from a nationally-representative household survey. Specifically, it investigates whether households with improved stoves use less firewood than households with traditional mud stoves or open-fire stoves.

The study used data from the Nepal Living Standards Survey 2003/04. This multi-topic survey is the most recent and most comprehensive household survey in Nepal. It is based on a nationally representative sample of 3,912 households. It provides socioeconomic and demographic information drawn from the sampled households. Since the main objective of this study is to investigate the impact of stove types on household firewood consumption, only information from households who collected and used firewood for energy was analyzed. As a result this study uses a sub-sample of 2,607 observations.

STOVE TYPES

The impact of four main types of cook-stoves is assessed. These stove types are: open-fire stoves (i.e., the traditional tripod type), mud stoves, improved stoves and kerosene stoves. Of these four stove-types, the traditional open-fire stove is used as a benchmark for comparison. The open-fire stove has poor heat transmission because the fire is open in all directions. In comparison, the mud-stove is more enclosed and can transfer more heat energy for cooking. It was expected that mud stoves and improved stoves would require less firewood fuel than the open-fire stove. It was therefore predicted that households will use less firewood if they adopt mud stoves or improved stoves.

The study takes into account a wide range of factors that might affect firewood use. These factors include household size, the gender of the household head and the presence of a child below the age of six. Firewood demand is also affected by the time it takes to collect wood. This is because

the firewood market is very ‘thin’ in Nepal – a very small portion of household buy from the market, the majority collect their own firewood. For this reason firewood collection time was also considered.

Table: Summary Statistics on firewood using households

Variables	Mean	SD	Min	Max
Firewood collection per month (bhari) per HH	6.92	4.6	1	40
Time to collect one bhari firewood (hr)	3.67	2.1	0.02	13
% of households with open-fire stove	38.0	0.49	0	1
% of households with mud stove	56.0	0.5	0	1
% of households with improved stove	2.0	0.15	0	1
% of households with kerosene stove	4.0	0.19	0	1
Household size	5.31	2.52	1	32
% of households with male head	80.	0.4	0	1
% of households collecting firewood from community forest	31.0	0.46	0	1
% of households collecting firewood from government forest	31.0	0.46	0	1
Wage rate (hired female labor) (Rs)	60.6	25.4	9.3	150
% of Bhramin or Chhetri households	32.0	0.46	0	1
Years of schooling of household head	2.36	3.69	0	17
% of households living in mountain/hilly region	61.0	0.49	0	1

Factors that influence stove choice were also incorporated into the study’s analysis, so that their impact on firewood use could be accounted for. For example, stove choice can often depend on cultural factors (such as cooking habits), on the level of household education and on the availability of firewood. The choice of stove can also depend on the geographical location of the household that is using it. For example, households that are located in hills or mountainous regions normally use open-fire stoves as they can use these fires to keep themselves warm during winter, as well as for drying food grains and other items. On the other hand, mud-stoves are normally placed in a corner of a living room, which prevents household members from sitting around them to avoid the cold. They are therefore not as popular in cold regions.

HOW THE STOVES PERFORM

After controlling for the different variables described above, the study finds that the type of cook-stoves significantly affects the amount of firewood that households use. The study shows that a household with a mud stove on average consumes 0.85 *bhari* (a local unit of quantity) less firewood per month, or over 10 *bharis* less firewood in a given year, compared to a household that uses a traditional open-fire stove. In the case of the kerosene stove user households, the monthly firewood saving per household is about 3.5 *bharis* per month or about 42 *bharis* per year on average.

While the above results are expected, the study also finds that, contrary to the common belief regarding the efficiency of improved stoves, households with an improved stove may use more firewood than households with a traditional mud stove or an open-fire stove. Two alternative estimation methods broadly confirm these findings. This result may seem counter-intuitive but it actually confirms what some researchers have been reporting regarding the inefficiency of improved stoves with respect to firewood

consumption and cooking time. This issue, however, needs further investigation before a definite conclusion is arrived at, since only 2% of households in the data set used by the survey were using improved stoves.

WHY DON'T IMPROVED STOVES SAVE WOOD?

One possible explanation of why households using improved stoves appear to consume more firewood than those with traditional open-fire stoves or mud stoves could be the rebound effect. This occurs when an improved stove initially reduces firewood demand. Once this happens the shadow price of firewood drops. A lower shadow price, in turn, prompts households to consume more firewood.

An alternative explanation could be that most improved stoves come with attached chimneys that help reduce the amount of smoke in a house. Traditionally, the chimney is not a part of Nepalese traditional open-fire or mud stoves. As the chimney causes smoke levels to decline, household members may feel better and less worried about the health impact of indoor air pollution. Consequently, they may either keep their stoves running for longer hours to keep their houses warm or they may cook more frequently. Both of these actions require more firewood.



Improved cookstove

SANDEE

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Traditional mud stove

MUD STOVES AND CLEANER FUELS

The results show that, if policymakers want to reduce demand for firewood, one short-term solution is to replace open-fire stoves with mud stoves. The study finds that this approach would be quite acceptable as about 56% of the households in the study are already using mud stoves. What is more, the replacement of open-fire traditional stoves with mud stoves would not require any significant investment, since it can be done with simple and locally available technology.

The study also notes that if a switch is made from open-fire stoves to mud stoves then the addition of smoke-hoods or chimneys could help address indoor air pollution problems; although it cautions that such moves might generate a rebound effect similar to that outlined above. The study concludes by stating that, although forest conservation through a reduction in firewood use is a clear priority for Nepal, other issues associated with stove use, such as indoor air pollution and greenhouse gas emissions, should not be ignored. It therefore recommends that long-term solutions should make cleaner fuels more accessible to rural people.

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