Misuse of domestic resources increases import dependency

Case of dung cake fuel and demand for chemical fertilizers in Nepal

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Abstract

Purpose – Over 10 percent of rural poor in Nepal are still using animal dung cake as the major cooking fuel, reducing the availability of plant nutrients or increasing the need for chemical fertilizers. The purpose of this paper is to assess the effects of dung fuel use on demand for chemical fertilizers and explore factors affecting the household decisions to use dung fuel.

Design/methodology/approach – The data are generated from survey of 331 households using either dung fuel or biogas, randomly selected from Kapilvastu district in Nepal. Test of mean differences and ordinary least square are used for finding the effect of dung fuel use on demand for chemical fertilizers. Probit regression is used to explore the factors affecting use of dung cake fuel by rural people.

Findings – The study quantified that burning animal dung for fuel increases the demand for chemical fertilizers by 32.35 kg per household for just maintaining the crop yield at the level of non-burning households. At the national level, this accounts to 26,551 tons of chemical fertilizers costing NPR 687 million per year. The amount, however, does not include the health costs and drudgery of the households and pollution and green house gas emission costs to the society. The study finds income, education and ethnicity as the major factors affecting the dung cake use and recommends some policy measures to reduce it.

Research limitations/implications – The research was conducted in a district with survey of a sample of households as a case study, and most probably cannot be generalized at the national or international levels. The sample includes the households using dung cake fuel and biogas exclusively. Other households using both the fuels and some other fuels are excluded in the study.

Practical implications – The findings are useful for policy makers working in agriculture and household energy for designing appropriate policy necessary for increasing agriculture policies and household energy technology (such a biogas) adoption.

Social implications – The recommendations help in understanding the costs of dung burning at the household and national level. The understanding helps in increasing farm productivity and saving health of the residents.

Originality/value – The study is original in its design, data and findings. It will help the policy makers and the rural poor.

Keywords Nepal, Agriculture, Fuel consumption, Energy sources, Crops, Crop yield, Dung cake fuel, Chemical fertilizer demand, Household choice, Nepal, Probit

Paper type Research paper

Introduction

Dung cake (bricked and dried animal dung, shown in Plate 1) is used as a cooking fuel by poor in many South Asian countries including Nepal, India, Bangladesh and Pakistan (Aggarwal and Singh, 1984; Aggarwal, 1989; Bala *et al.*, 1992; Pant, 2010).

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Plate 1.
Drying dung cake for fuel

Millions of farmers in Africa and in parts of the Near East and Latin America also use the dung as fuel (Sansoucy *et al.*, 1995). For the rural farmers who rear large ruminant animals the dung cake fuel involves no cash cost. The dung is available at barn yard and opportunity cost of labour is very low for women and children who prepare dung cake in rural areas. Even the households with no animals are found to prepare dung cake by collecting dung from trails of animals and pasture land with no out of pocket expenses. The dung cake fuel use is common and persistent behaviour of the rural poor in developing countries.

Though the dung cake is being used as fuel for time immemorial and that signifies low level of living, no adequate efforts are made to stop this practice. Instead, some energy studies recommend for diverting the animal dung from farm to fuel in energy scarce villages (Aggarwal, 1989). But, there are several costs of dung cake fuel to the households like health costs due to indoor pollution (Pant, 2012), decrease in farm productivity due to reduced plant nutrients, increase in drudgery to women in making and using dung cakes, and emission of carbon dioxide (Pant, 2010). Though the dung from different animals have differing nutrient value, cattle dung contains about 0.8 per cent nitrogen, 0.4 per cent phosphorus and 1.6 per cent of potash on dry matter basis (Ange, 1994). Dung burning reduces the organic manure input to the farms, which is very vital to crop production. This forces the farmers either to use costly and environmentally unsafe chemical fertilizers or produce less food that leads to malnutrition to their family members. Waithaka *et al.* (2007) report that use of organic manure and chemical fertilizer reciprocally influences each other. Dung burning has brought about deficiency on farmyard manure, which has negative impacts on the farm productivity as well as soil quality. Reduced application of farmyard manure decreases soil microbial activities, soil carbon and ultimately the farm productivity.

The National Living Standards Survey (2003/2004) of Nepal shows that 10.33 per cent of the total households in the country are using dung cake as the primary cooking fuel. Considering 4.25 million households in the country (population census 2001), 0.44 million households are using dung cake as the main cooking fuel. Only 2.38 per cent of

the households (0.10 million) are using biogas that is generated out of the animal dung with no loss to plant nutrients. The biogas plant is technically feasible, financially viable and environmentally cleaner to convert animal dung into biogas. The clean fuel biogas is used for cooking and slurry obtained from the biogas plants used for manuring crops. In spite of such distinct benefits, many farmers are still using dung cake and not adopting biogas technology. One can argue that this is due to lack of capital among the poor. But, credits are available from institutional sources for establishing a biogas plant by individual household. The government is providing a subsidy of NPR5,000 per plant in the study areas under clean development mechanism (CDM) of the carbon trade. This subsidy comes to be about 20 per cent of the total costs of the installation of a biogas plant.

This reluctant behaviour of the farmers in terai (plain) areas can be attributed to their traditional practices and inadequate information about the private and social costs of dung cake burning in addition to the loss of plant nutrients. Planers and policy makers are also not fully aware about the full range of costs of burning dung cake. The study quantifies the increased demand for chemical fertilizers due to dung cake fuel burning among the rural poor and also explores the factors affecting the household decisions to use dung cake against biogas as the cooking fuels. The major research questions are: does dung cake burning increases the need for purchase of chemical fertilizers? If yes, by how much? Do farmers know this fact? Why the farmers are still using dung cake fuel for cooking? What is the chemical fertilizer cost of dung cake burning in the country?

Theoretical underpinnings

Application of chemical fertilizers that succeeded in green revolution in 1960s failed to bring sustained benefits due to damage of soil quality in many areas. Use of chemical fertilizers has ecological implications and the burden on the farm budget. This requires a judicious blend of chemical fertilizers with organic manure (Ghosh, 2004). The organic manure comes from composting of herbaceous or soft plant materials and farmyard manure from animals, later being the major source. The smallholder farmers are joint producers and consumers. Application of the organic manure in crop production is governed by production theory whereas the consumption of dung cake fuel is governed by consumption theory. A rational farmer desires to maximize his crop production as well as the utility from the dung cake fuel consumption. There are several logics to explain why some farmers prefer to use more of the animal dung for cooking purpose. First, the crop production has longer gestation period than the use of dung cake for cooking. The farmers with higher discounting prefer to use the dung for cooking purpose than in the crop production. Moreover, not whole of the dung produced is burnt, but that applied to the crop is generally residual in nature. Second, the dung cake for cooking has day-to-day need whereas the need for farmyard manure is only during the planting season. Third, the soil damaging effects of the chemical fertilizer is long term and not generally visible to the farmers in the short run. Fourth, environmental effects of the chemical fertilizers such as ground water pollution, surface water pollution and green house gas emissions are externalities to the farmers. Lastly, health effects of the smoke from the dung cake are generally little known to the less educated rural households. Socio-economic, farm characteristics and information available affect the decision of the farmers to burn or not to burn the dung. Externally, relative price of cooking fuel and chemical fertilizer are also expected to affect the decision of the farmers. The relative price of the fuel and fertilizer is sensitive to the

government policies on tax and subsidies and reliable information are necessary for efficient rates of taxes and subsidies.

Methodology

The study was conducted in Southern plain area (commonly known as terai) of a tiny Himalayan country Nepal in South Asia. In Nepal, the proportion of the households burning dung cake as the main fuel for cooking is higher in Southern plain areas as compared to those in middle and high mountains in the North. Among the regions in the plain areas (terai), the problem is more concentrated and serious in over a dozen districts bordering to India, namely, Morang, Sunsari, Saptari, Siraha, Dhanusha, Mahottari, Sarlahi, Bara, Parsa, Nawalparasi, Rupandehi, Kapilvastu and Dang out of 75 districts in the country (CBS, 2004). These districts are main rice-wheat producing areas of the country. The plain areas are also recognized as the food grain basket of the country. The problem of dung burning is found to be more severe in Kapilvastu district due to larger proportion of the households using dung cake fuel.

The study was conducted using primary data collected from a sample of 331 households from six Village Development Committees (VDCs)[1] in Kapilvastu district (Figure 1). The VDCs were selected purposively to find households using biogas, and those using the dung cake, in the same village under similar setting to facilitate the precise comparison. Household was the ultimate sampling unit. Two sampling frames were constructed – one for the households using dung cake as the main cooking fuel and another for the households using biogas as the main cooking fuel. The biogas using households were obtained from four biogas companies[2] working in the district. The information on the dung cake users were obtained from key informants in the sample VDCs. From each sampling frame 50 per cent of the households were selected using systematic sampling with random start. Thus, we got

Figure 1.
Study area

175 dung cake user households and 156 biogas user households for the survey. The rice and wheat productivity and use of chemical fertilizers were surveyed for each of the sample household.

The household survey was conducted using well-structured pre-tested questionnaire. The questionnaire, among others, included modules on fuel use, demographic structures, socio-economic conditions, chemical fertilizer application and crop productivity. The survey was implemented for six weeks by a team of trained enumerators.

The basic assumption for the analysis is that in the attempts to maximize utility, given the full information, the households choose a combination of fuels that maximize their utility from cooking services from fuel efficiency within the budget and other resource constraints. Considering this fact, method of mean differences was used to estimate the difference in chemical fertilizer consumption by dung burning and biogas user households. In addition, an ordinary least square (OLS) model was fitted to assess the effect of dung cake burning on demand for chemical fertilizers adjusting for other confounding factors:

$$Fj = \alpha + \beta D + \sum_{i=1}^{n} \gamma iXi + \varepsilon \tag{1}$$

The quantity purchased of chemical fertilizers (*Fj*) where $j = 1$, 2 and 3 for nitrogen, phosphorus and potash fertilizers, respectively, was regressed with dung cake burning (*D*) and socio-economic variables that include number of adult livestock reared, land operated, non-agricultural income, gender of the household head, and education and occupation of the household head.

Likewise, the household survey data were used for fitting a probit model to identify the factors affecting the household decision to use dung cake as the cooking fuel against biogas fuel. The following probit model was estimated:

$$\Pr(dungfuel = 1) = \alpha + \beta iXi + \varepsilon \tag{2}$$

where, Pr (dungfuel = 1) is probability score of using dung cake as the main cooking fuel. The explanatory variables *Xi* include number of cattle *(Bos indica),* number of water buffaloes *(Bubalus bubalis)*, family size, land holding, distance to the nearest forest, ethnicity, household income, and male and female education (measured as the average years of schooling).

Results

The results are presented in two sub-sections, namely, purchase of chemical fertilizers and the factors affecting the household decisions to use dung cake fuel. The discussions are made together after the presentation of the results.

Purchase of chemical fertilizers

The annual purchases of urea and diammonium phosphate (DAP) are significantly higher among the dung cake burning households as compared to those among biogas using households (Table I). However, the purchase of potash fertilizer is not significantly different among these two groups of the farmers. Other factors likely to affect the amount of chemical fertilizers purchased are dealt later in this section.

	Test statistics	Unit	Mean for biogas users ($n_1 = 156$)	Mean for dung cake users ($n_2 = 175$)	Mean difference ($n = 331$)	Significant
1	Urea purchased	Kg/hh	86.41	128.44	−42.03***	0.005
2	DAP purchased	Kg/hh	74.75	102.06	−27.31**	0.022
3	Potash purchased	Kg/hh	6.02	7.14	−1.12	0.252
4	N applied in rice	Kg/ha	44.10	66.00	−21.90***	0.000
5	P applied in rice	Kg/ha	31.17	45.39	−14.22***	0.000
6	K applied in rice	Kg/ha	4.49	6.16	−1.67	0.135
7	NPK applied in rice	Kg/ha	79.85	117.63	−37.79***	0.000
8	Rice yield	Kg/ha	3,865.13	3,625.47	239.66	0.121
9	N applied in wheat	Kg/ha	34.76	54.07	−19.30***	0.001
10	P applied in wheat	Kg/ha	25.12	34.93	−9.81***	0.004
11	K applied in wheat	Kg/ha	3.09	4.22	−1.12	0.186
12	NPK applied in wheat	Kg/ha	62.97	93.21	−30.24***	0.001
13	Wheat yield	Kg/ha	1,877.95	2,041.03	−163.08	0.141

Note: hh stands for household
Source: Field Survey (2009)

Table I.
Mean differences of chemical fertilizer applications and crop yields between biogas users and dung cake burning households

Nitrogen and phosphorus applied in rice and wheat crops through chemical fertilizers are significantly higher among the farmers using dung case fuel as compared to those using the biogas. However, rice and wheat yields are not significantly different between the biogas users and dung cake users. One can raise a genuine question that why the crop yields are not higher among dung cake burning households in spite of the higher quantity of the chemical fertilizers purchased.

The variables used for modelling the household demand for chemical fertilizers are presented in Table II. The farmers generally purchase urea and DAP. They purchase potash in small amount. The farmers purchase nitrogen at the rate of 66 kg/ha and phosphorus at the rate of 42 kg/ha per annum. Purchase of potash is only 4 kg/ha. As the chemical fertilizers are not generally stored at home for the following year, the amount purchased can be treated as the amount applied. Thus the annual application of the chemical fertilizers is at 38:20:2 kg/ha of NPK (nitrogen, phosphorus and potash). The chemical fertilizers purchased by these households are generally used in rice and wheat crops. The general recommended dose of chemical fertilizers for rice in the country is 90:60:40 kg/ha NPK whereas that for wheat is 80:60:40 kg/ha NPK. It means the application of chemical fertilizers is much lower than the recommended dose. This may be due to the reason that the chemical fertilizers are not manufactured in Nepal and imported fertilizers are not readily available in the market.

In all, 53 per cent of the sample households are dung cake users and rests are biogas users. Users of other fuels are not included in the sample. The farmers on an average have 2.64 adult cattle and buffaloes. Calves and small ruminants having little contribution in dung production are not included in this statistics. The average operational land holding of the sample households is 0.76 ha per household, almost equal to the national average of 0.70 ha. The farmers earn on an average NPR70, 000 per household (1US$ = NPR72) from non-agricultural sources, the major one being the remittance from their family members working in India, Malaysia and Gulf countries. Due to heavy outmigration of the males 48 per cent of the sample households are female headed. Due to expected simultaneity bias, agricultural income is not included

	Variable name	Description	*n*	Mean	SD	Minimum	Maximum
1	N	Purchase of chemical fertilizers in terms of nitrogen (kg/ha)	331	66.03	87.52	0	786
2	P	Purchase of chemical fertilizers in terms of nitrogen (kg/ha)	331	41.92	57.78	0	611
3	K	Purchase of chemical fertilizers in terms of nitrogen (kg/ha)	331	3.97	9.08	0	60
4	Dung burning	Dung cake burning farmers (1) as against biogas users (0)	331	0.53	0.50	0	1
5	Livestock	Number of adult cattle and buffaloes kept by the farmers	331	2.64	0.99	0	15
6	Land	Operational land (ha)	331	0.76	0.99	0	10.2
7	Non-agri income	Income from non-agricultural sources (NPR 1,000)	331	69.85	102.69	0	970
8	Gender	Male headed households	331	0.52	0.50	0	1
9	Education of head	Education of household head (years of schooling)	331	5.06	4.86	0	16
10	Occupation of head	Agriculture as the main occupation of the household head	331	0.45	0.50	0	1

Table II.
Descriptive statistics

Source: Field Survey (2009)

in the model – quantity of the chemical fertilizer consumption also affects the level of agricultural income. Average schooling of the household head is five years. The main occupation of 45 per cent of the household heads is agriculture and second largest category is housewives. Though, it is clearly understood that price is the major determinant of the demand for the chemical fertilizers, it was not possible to fit the price in this cross-sectional model due to lack of variability among the price variables for the farmers residing in the same or nearby villages.

The results of regression analysis show that using dung cake fuel significantly increases the demand for chemical fertilizers (Table III). On an average, purchase of chemical fertilizer is higher by 21 kg-N among the dung cake fuel users than among the biogas users. This estimate is obtained after correcting for confounding factors affecting the consumption of chemical fertilizers. For example, per hectare increase in

		Coefficient	SE	*t*	Significant ($p > \|t\|$)
1	Dung burning	20.99***	8.61	2.44	0.015
2	Animal	−1.50	2.59	−0.58	0.562
3	Land	42.97***	4.37	9.84	0.000
4	Non-agri income	−0.03	0.04	−0.80	0.426
5	Gender	12.89	9.40	1.37	0.171
6	Education of head	0.30	0.92	0.32	0.748
7	Occupation of head	27.79***	9.04	3.07	0.002
8	Constant	7.96	11.65	0.68	0.495

Table III.
Factors affecting the purchase of nitrogen fertilizers

Notes: $n = 331$. $F(7, 323) = 20.57$; probability $> F = 0.000$; adjusted $R^2 = 0.293$; root MSE = 73.57.
*,**,***Significant at 10, 5 and 1 per cent levels, respectively
Source: Field Survey (2009)

land size increases nitrogen fertilizer demand significantly. It is logical that larger the farm size larger is the demand for chemical fertilizers. Household head taking the agriculture as the main occupation purchases nitrogen fertilizers by 28 kg-N. Number of animals, non-agricultural income and education of the head, however, do not affect the purchase of chemical fertilizers.

Similarly, burning dung cake as fuel increases the demand for phosphorus fertilizers by 11 kg/ha-P (Table IV). Other confounding factors are farm size and occupation of the head. Other factors like number of animals, income, gender and education do not affect the demand for phosphorus significantly.

However, the demand for potash fertilizer is not affected by the use of dung cake as fuel (Table V). Land size and occupation of the household head affect the demand for potash fertilizers instead. Increasing a head of adult animal decreases the demand for potash significantly.

The biogas user farmers are getting same level of crop yield even with less use of chemical fertilizers. This can be attributed to the use of organic matter in crop production from avoided burning. The dung slurry after the use in biogas is used in farming whereas the dung burnt as the dung cake is reduced to a mere ash. The small amount of the ash after burning the cake is, however, rich in potassium, a plant nutrient, but other major nutrients like nitrogen and phosphorus are lost. It seems that

		Coefficient	Standard Error	t	Significant ($p > \|t\|$)
1	Dung burning	11.36**	5.59	2.03	0.043
2	Animal	0.20	1.68	0.12	0.906
3	Land	29.61***	2.84	10.44	0.000
4	Non-agri income	−0.03	0.03	−0.96	0.339
5	Gender	3.63	6.11	0.60	0.552
6	Education of head	0.83	0.60	1.39	0.166
7	Occupation of head	17.90***	5.87	3.05	0.002
8	Constant	0.64	7.56	0.08	0.932

Notes: $n = 331$. $F(7, 323) = 22.81$; Probability $> F = 0.000$; adjusted $R^2 = 0.316$; root MSE = 47.78.
*,**,***Significant at 10, 5 and 1 per cent levels, respectively
Source: Field Survey (2009)

Table IV.
Factors affecting the purchase of phosphorus fertilizers

		Coefficient	SE	t	Significant ($p > \|t\|$)
1	Dung burning	0.70	1.04	0.68	0.499
2	Animal	−0.82***	0.31	−2.62	0.009
3	Land	1.68***	0.53	3.19	0.002
4	Non-agri income	−0.01	0.01	−1.45	0.148
5	Gender	−1.52	1.14	−1.34	0.183
6	Education of head	0.14	0.11	1.23	0.220
7	Occupation of head	2.15**	1.09	1.97	0.050
8	Constant	4.14***	1.41	2.94	0.004

Notes: $n = 331$. $F(7, 323) = 2.91$; probability $> F = 0.006$; adjusted $R^2 = 0.039$; root MSE = 8.91.
*,**,***Significant at 10, 5 and 1 per cent levels, respectively
Source: Field Survey (2009)

Table V.
Factors affecting the purchase of potash fertilizers

the farmers by their experiences for generations know these facts and increases the purchase of chemical nitrogen and phosphorus to maintain the crop yield and do not increase the purchase of potash. Burning the dung cake increases the need for purchase of nitrogen and phosphorus fertilizers to maintaining the same level of crop productivity. It is not immediately clear why the large chunks of the rural farmers burn dung cake fuel for cooking their food and purchase chemical fertilizers instead directly purchasing the cooking fuel such as biogas or liquid petroleum gas. Next section attempts to answer this question using household level data.

Factors affecting the household decisions to use dung cake fuel

Why the people still use dung cake for cooking their food is a big question yet to understand fully. The study analysed the primary household data to answer this question.

Probit analysis using dichotomous dependent variable dung cake (1 for using dung cake fuel and 0 for using biogas) explains the factors affecting the use of dung cake fuel. The results show that increase in the number of cattle increases the use of dung cake fuel whereas an increase in the number of buffaloes decreases the use of dung cake fuel (Table VI). More precisely, every unit increase in cattle increases the probability of using dung cake fuel by 8.5 per cent, whereas every unit increase in buffalo decreases the probability of using dung cake fuel by 5.0 per cent. This is because buffalo-dung is softer than cow dung and more suitable for feeding in biogas plant than for the preparation of the dung cake. Moreover, buffaloes are reared by better off farmers who have higher affordability to the biogas.

Another important factor to increase the use of the dung cake fuel is the distance from the household to the nearest forest. Every kilometre increase in the distance of the household to the boundary of the nearest forest increases the probability of using dung cake fuel by 2.1 per cent. This is because of the shortage of fuelwood in the villages that are farther away from the forest. Similarly, tribal households have 30 per cent more probability of using dung cake fuel than the non-tribal households. It means the practice of burning dung cake fuel is mostly tradition bound in interior villages away from the forest.

As expected, an increase in household income significantly decreases the use of the dung cake fuel. Education is another strong factor variable that decreases the use of

	Variable	Coefficient	Marginal effect (dF/dx)	SE	Z	$p > \|z\|$	95 per cent confidence interval	
1	No of cattle	0.214***	0.085***	0.071	3.020	0.002	0.075	0.352
2	No of buffalo	−0.125**	−0.050**	0.060	−2.080	0.037	−0.242	−0.007
3	Family size	0.017	0.007	0.037	0.460	0.642	−0.056	0.090
4	Land holding	−0.037	−0.015	0.098	−0.380	0.705	−0.229	0.155
5	Distance to forest	0.052***	0.021***	0.018	2.920	0.004	0.017	0.087
6	Tribal ethnic groups	0.758***	0.295***	0.186	4.080	0.000	0.394	1.122
7	Household income	−0.002*	−0.001*	0.001	−1.660	0.097	−0.005	0.000
8	Male education	−0.110***	−0.044***	0.030	−3.670	0.000	−0.168	−0.051
9	Female education	−0.242***	−0.096***	0.041	−5.950	0.000	−0.321	−0.162
10	Constant	0.688**		0.331	2.080	0.037	0.040	1.337

Notes: $n = 331$. LR $\chi^2(16) = 201.24$ ($p = 0.000$); log likelihood = −128.27; pseudo $R^2 = 0.440$. *,**,***Significant at 10, 5 and 1 per cent levels, respectively

Source: Field Survey (2009)

Table VI.
Factors affecting household decision for use of dung cake as cooking fuel in Kapilvastu district

the dung cake fuel. Female education has much stronger effect on reducing the dung cake fuel than male education. Every year increase in the male schooling decreases the probability of using dung cake fuel by 4.4 per cent whereas that due to one year increase in female schooling decreases the probability of dung fuel use by 9.6 per cent. This is because the cooking in the study area is generally done by women. It can be inferred that education is a strong variable to switch from the dung cake fuel to the biogas. The probit function estimated is strong and explains 44 per cent of the variations in the fuel choice. The family size of the household and the land holding size are not found to affect the choice of the dung cake fuel for cooking significantly.

The analysis of the factors affecting the dung cake fuel use shows that the practice can be reduced by educating people particularly women and intervening through income generating activities. Tribal communities need more supports for altering the practice of dung cake burning. As the distance to the forest increases the dung cake burning, plantation of trees in village level barren lands can also reduce the burning of dung cake. Support to keep buffaloes should go side by side with the supports for biogas promotion.

It means the habit of using dung cake fuel is explained more by the situational contexts like geographic areas, livestock farming, demographic structure and education. No doubt the household income is a strong factor affecting the choice.

Discussions

Use of the dung fuel increases the demand for nitrogen (N) and phosphorus (P) by 20.99 and 11.36 kg per household in nutrient terms, respectively. This requires 36.17 kg of urea (after adjusting for the N content from DAP) and 24.17 kg of DAP for just maintaining the crop yield. Considering the survey year price (2009) of chemical fertilizers, the additional costs incurred by the farmers on purchasing chemical fertilizers just to compensate the loss of nitrogen and phosphorus due to burning of animal dung comes to be NPR1,562 per household. For comparison, one bottle of liquid petroleum gas (14.2 kg) costs NPR1,400. As a bottle of the gas is not enough for a year, the poor are rational to burn dung fuel and buy fertilizer or food instead.

Considering that 0.44 million farmers are using dung fuel in Nepal, the additional demand for the chemical fertilizers come to be 15,916 tonnes of urea and 10,635 tonnes of DAP costing NPR398 million and NPR289 million, respectively. It means the nutrient cost alone of the dung cake burning in Nepal is to the tune of NPR687 millions. The problem is multiplied by the fact that the chemical fertilizers are not readily available, the quality is not generally assured and the farmers do not have adequate knowledge of proper application of the chemical fertilizers.

In addition, the chemical fertilizers provides only the major nutrients (NPK) and micronutrients get depleted in the soil where organic manure is not added. Studies in African countries show that dung as an energy source is the major contributor to reduced agricultural productivity from land degradation (Bojö and Cassells, 1995). Health costs of burning dung cake, drudgery faced by women and children, environmental costs of the chemical fertilizers, green house gas emissions from dung burning, fertilizer production and application are additional costs of dung cake burning. Considering recent policy of the government to provide price subsidy on chemical fertilizers, the burning of dung cake also increases the burden of subsidy to the government treasury. Though the fertilizer subsidy is aimed for increasing crop production, a part of it is bound to go for compensating the loss of plant nutrients due to dung burning.

Several other issues are reported with the burning of dung fuel and use of chemical fertilizers. The dung cake has low combustion and heat efficiencies. One kilogram of dung cake gives combustion 230 kcal and the same amount of dung can produce 0.184 m^3 of biogas with a heat of combustion of 520 kcal. Thus, using biogas plant increases combustion efficiency by 126 per cent. Moreover, dung cake is burnt at 11 per cent heat efficiency in an open *chulla* whereas the biogas is burnt at an efficiency of 60 per cent in a standard burner (Jash, 1990).

As the chemical fertilizers are not produced within the country, the increased use of imported chemical fertilizers implies increased dependency on exhaustible fossil fuels and increased trade deficit. As the import of chemical fertilizers is done only by the public sector, handling and price subsidy involve large sum of money leading to budget diversion, deficit and even suspected moral hazards.

Before the development of biogas technology and with a limited knowledge on environmental problems of dung burning and application of chemical fertilizers, economic return of using dung as fuel was estimated to be three times the returns from using dung as manure (Aggarwal and Singh, 1984). But, later on it is widely accepted that chemical fertilizers cause pollution leading to unsustainability of agriculture. The chemical fertilizers applied to the farm have both on site and off site pollutions. These inorganic fertilizers impair the capacity of the soil to retain nutrients and actually deplete the stock of nutrients which occur naturally in the soil and their runoffs pollute water constituting a danger to human health (Bala *et al.*, 1992). Studies recommend to revisit the traditional methods of chemical-based agriculture and to look for a judicious blend of chemical fertilizer with organic manure (Ghosh, 2004). Recent development of organic agriculture and increasing demand for organic food have further increased the scope for diverting animal dung from the fuel to the farm manure.

Among the factors increasing the use of the dung cake fuel, distance to the nearest forest has important implication to afforestation. Similar results were obtained in Ethiopia (Mekonnen and Köhlin, 2008) where households with more trees were less likely to burn the dung. Increasing income and education have strong effects on reducing the dung burning. The negative effect of household income on dung burning support the hypotheses that poverty plays important role in degrading the natural resource base (Shively and Pagiola, 2004; Teklewold, 2011) and poor are less likely to invest in environmental conservation (Holden *et al.*, 1998). The farmland of the poor is getting further degraded reducing the productivity and ruining their future.

Conclusions

The study quantifies amount of chemical fertilizer required to compensate the loss of plant nutrients due to dung cake fuel use. It also identifies the factors affecting the household decisions to use dung fuel instead of alternative fuel available in the villages. The study econometrically finds the effect of various factors in household decision to purchase different quantity of the chemical fertilizers. Dung cake fuel use is found to increase the demand for chemical fertilizers significantly. It also estimated the additional costs required to buy the chemical fertilizers by the rural poor people and at the national level. The additional direct cost is NPR687 million per year.

The study also assessed the factors affecting the use of dung cake fuel by the poor. It analysed the factors affecting the use of dung cake fuel for cooking food and found that tribal people in rural areas largely depend on dung fuel. The income is found to be strong variable at local level. The education, particularly female education, is the strong variable that can reduce the use of dung cake fuel. The results will be supportive

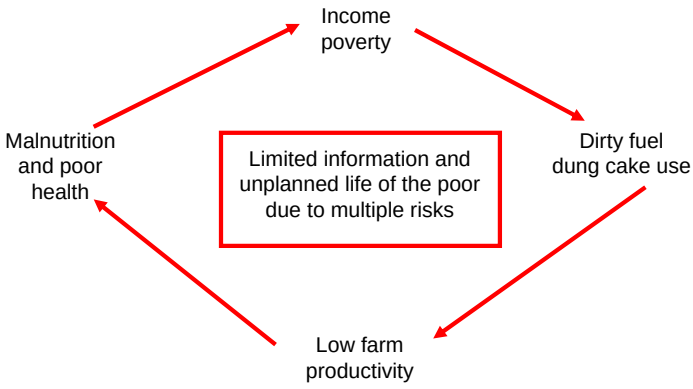

Figure 2.
Poverty fuel and health vicious circle

to the policy makers for designing fertilizer policy, household energy policy and agriculture policy. Creating awareness of the pollution from the fertilizer and health costs of dung cake fuel among the rural people particularly the tribal people can reduce the use of this dirty fuel improving the health of the people, increasing the productivity of the farm and reducing the emission of green house gases (Figure 2). Possible policy instruments can be subsidized cooking fuels, improved stoves for burning wood fuel and heat use efficiency, and promotion of biogas plants among the rural poor.

Notes

1. The sample Village Development Committee were Gajehada (Biogas 24 households + dung fuel 46 households), Motipur (80 + 5), Niglihawa (5 + 52), Badganga (10 + 5), Hathausa (18 + 38) and Kopuwa (19 + 29).
2. The four biogas companies working Kapilvastu district were Rastriya Biogas Company, Bhrikuti Biogas Company, Public Biogas and Tribeni Biogas in the order of influence.

References

Aggarwal, G.C. (1989), "Judicious use of dung in the third world", *Energy*, Vol. 14 No. 6, pp. 349-52.

Aggarwal, G.C. and Singh, N.T. (1984), "Energy and economic returns from cattle dung as manure and fuel", *Energy*, Vol. 9 No. 1, pp. 87-90.

Ange, A.L. (1994), *Integrated Plant Nutrition Management in Cropping and Farming Systems – A Challenge for Small Farmers in Developing Countries*, Food and Agriculture Organization, Rome.

Bala, B.K., Satter, M.A. and Biswas, B.K. (1992), "Utilization pattern of animal draft power and Cow dung in Bangladesh", *Bioresource Technology*, Vol. 41 No. 1, pp. 1-8.

Bojö, J. and Cassells, D. (1995), "Land degradation and rehabilitation in Ethiopia: a reassessment", AFTES Working Paper No. 17, World Bank, Washington, DC.

CBS (2004), *Monograph: Agriculture Census Nepal 2001/02*, National Planning Commission, Central Bureau of Statistics, Kathmandu.

Ghosh, N. (2004), "Reducing dependence on chemical fertilizers and its financial implications for farmers in India", *Ecological Economics*, Vol. 49 No. 2, pp. 149-62.

Holden, S.T., Shiferaw, B. and Wik, M. (1998), "Poverty, market imperfections and time preferences: of relevance for environmental policy?", *Environment and Development Economics*, Vol. 3 No. 1, pp. 105-30.

Jash, T. (1990), "Loss of fertilizer and fuel value of dung cake", *Energy*, Vol. 15 No. 9, pp. 831-2.

Mekonnen, A. and Köhlin, G. (2008), "Biomass fuel consumption and dung use as manure: evidence from rural households in the Amhara Region of Ethiopia", Environment for Development, Discussion Paper Series EfD DP 08-17, Goteborg, April.

Pant, K.P. (2010), "Health costs of dung cake fuel use by the poor in rural Nepal", SANEI Working Paper No 10-14, South Asian Network of Economic Research Institutes, Dhaka.

Pant, K.P. (2012), "Cheaper fuel and higher health costs among the poor in rural Nepal", *AMBIO: A Journal of the Human Environment*, Vol. 41 No. 3, pp. 271-83.

Sansoucy, R., Jabbar, M.A., Ehui, S. and Fitzhugh, H. (1995), "The contribution of livestock to food security and sustainable development", Keynote paper, Wilson, R.T., Ehui, S. and Mack, S. (Eds), Livestock Development Strategies for Low Income Countries, Proceedings of the Joint FAOIILRl Roundtable on Livestock Development Strategies for Low Income Countries, ILRl, Addis Ababa, 27 February-2 March 1995, Food and Agriculture Organization International Livestock Research Institute, Nairobi, pp 9-22.

Shively, G.E. and Pagiola, S. (2004), "Agricultural intensification, local labor markets and deforestation in the Philippines", *Environment and Development Economics*, Vol. 9 No. 2, pp. 241-66.

Teklewold, H. (2011), "Farming or burning? Shadow prices and farmer's impatience on the allocation of multi-purpose resource in the mixed farming system of Ethiopia", paper presented, EAAE 2011 Congress Change and Uncertainty Challenges for Agriculture, Food and Natural Resources, August 30-September 2, Zurich, available at: http://ageconsearch.umn.edu/bitstream/116080/2/Teklewold_ Hailemariam_ 138.pdf (accessed 23 August 2012).

Waithaka, M.M., Thornton, P.K., Shepherd, K.D. and Ndiwa, N.N. (2007), "Factors affecting the use of fertilizers and manure by smallholders: the case of Vihiga, Western Kenya", *Nutrient Cycling in Agroecosystems*, Vol. 78 No. 3, pp. 211-24.

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