Chapter 17

Livestock as a Household Energy Source in the Mountains: Traditional Practices and New Opportunities

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Introduction

Livestock play an important role in the mountain economy. They contribute to the livelihood of mountain communities by providing milk, meat, muscle power (for ploughing and transportation), and dung. Dung is used both as manure and as a source of energy for cooking. The use of dung as a cooking fuel is increasing as a result of the decreasing availability of fuelwood, twigs, and bushes and lack of access (both physical and monetary) to other options for producing energy like fossil fuels or renewable energy technologies. This situation is being exacerbated by the present drop in the number of livestock in response to the increasing pressure on the limited resources. This means that an even greater proportion of the available dung is being used for cooking, even though this affects farm productivity. Research reports indicate that any increase in the number of livestock in the fragile ecosystem of the mountains would lead to overuse of forest biomass resources and negative environmental consequences (Singh 1998; Tulachan and Neupane 1999).

There is, however, a technological option that enables dung to be used both as a fuel and as fertiliser – the biogas digester, which produces both biogas fuel and manure, is a well tested technology. At present, however, this technology is only used extensively in low lying mountain areas (below about 1,500m) because of the inherent temperature limitation. The optimum temperature for production of biogas is 33ºC, production seizes if the temperature falls below 10ºC. There are various possibilities for maintaining the temperature above 20ºC when ambient temperatures are low, however, for example using solar thermal technologies, or burning some of the biogas or other fuel to prepare hot water to be fed into the biogas digester (Monga and Ramana 1992). There are a few examples of these technologies in operation within the Hindu Kush-Himalayan (HKH) region. Before an effort is made to popularise any of these options, more detailed research needs to be done into the application of biogas technology in cold climates. If biogas digesters can be made technologically and economically feasible at higher altitudes, then it will be possible to meet both the energy and the manure requirements of mountain farmers without compromising the use of dung for one or the other.

Patterns of Energy Use in the HKH Region

Cooking and heating are the main household energy needs (Figure 17.1) in the HKH region (Rijal 1999). A variety of traditional cooking and heating stoves fired by fuelwood, twigs, or dung are used in mountain households. In higher altitude mountain areas, the demand for space heating is greater than for cooking in terms of the useful energy requirement. A typical example is that of Nepal. In the mountains 32% of the useful energy required by the household sector is used for cooking and 56% for heating, compared with 40% for cooking and 36% for heating in hill areas (Rijal 1999). Lighting energy needs are met by kerosene, or electricity where it is available. The final energy consumption of different types of fuel in four countries of the HKH region is shown in Figure 17.1.

Cottage industries (such as agro-processing, charcoal production, potteries, bakeries, blacksmiths, sawmills, carpenters' shops, and village workshops) need energy for lighting, process heat, and motive power. In general, wood is used to provide process

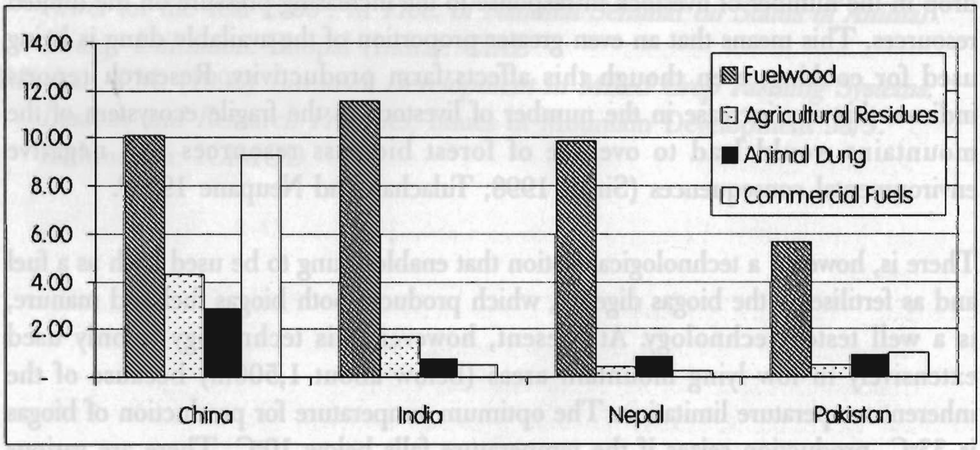

Figure 17.1: **Final energy consumption in selected countries of the HKH region, FY 1994/95**

heat in facilities such as forges, potteries, and bakeries, although in the HKH region of China coal is used extensively for this purpose. Motive power requirements are met by electricity, diesel, and kerosene, where available, or else by human or animal labour using mechanical equipment. Fuelwood is widely used in agro-based facilities such as those for crop drying. The bulk of energy inputs for land preparation, cultivation, post-harvest processing, and transport related to agriculture are in the form of human and animal labour. In the mountain areas, the degree of mechanisation and of use of commercial fuels is generally low.

In general, per capita consumption of energy is lower in the hills and mountain areas of the HKH than the country average. At the same time, the percentage of the per capita energy consumption derived from fuelwood is substantially higher than in each country as a whole. For example, in India fuelwood contributes 66% of the total energy requirement in the HKH region compared to 47% in the whole country (Rijal 1999). These figures reflect the fact that in general the mountain regions are marginalised in terms of access to commercial fuels and are heavily dependent on fuelwood. This situation is worsened by the low level of efficiency of utilisation of these fuels and the creation of health hazards – particularly for women who are the managers, producers, and users of energy at the household level.

Overall, the patterns of energy use in the HKH Region show the following trends (Rijal 1999).

- Biomass fuels dominate the energy scene, with fuelwood being the principle source of energy.
- The household sector is a major consumer of energy.
- Energy demand is increasing as a result of agricultural diversification and intensification, rural industrialisation, and increasing tourism.
- Energy use in mountain households varies with the household size, altitude, ethnic group, income and expenditure, land holding, livestock holding, and the number of cooking/heating stoves employed.
- The requirement for heat energy, primarily for cooking and heating, is higher than that for energy for shaft power as an input to a production process.
- The demand for fuelwood exceeds the sustainable supply, and thus the process of destruction at the margin is a common phenomenon in a large part of the region.
- The cost of energy extraction is increasing.
- The availability of fuelwood is and the time taken for its collection is increasing.
- Continuous unsustainable use of fuelwood from the forest forces rural people to use 'other' biomass fuels, further degrading the environment.
- Access to and availability of energy technologies are improving, but as yet not sufficiently to show a reduction in human (particularly of women) drudgery.

There are no readily available substitutes for biomass fuels in rural mountains. Nor is there any widespread use of energy saving devices to increase the efficiency of biomass fuel use. As a result the mountain's gross biomass energy consumption is reflected in a low useful energy utilisation (less than 20% energy efficiency). The complementary nature of the energy mix, especially in mountain households, shows limited scope for interfuel substitution. The choice of particular energy forms to provide the desired energy services in the mountains is, and will continue to be, based on the availability of and access to particular energy resources and technologies at affordable prices. Thus biomass fuels are and will remain the mainstay of energy sources in the mountain areas in the foreseeable future. The contribution of fuelwood amounts to more than 80% of the total energy requirement in the HKH regions of Nepal and Bhutan, 66% in India, 52% in Pakistan, and 29% in China (Rijal 1999).

There is evidence of increasing use of 'other' biomass resources (agricultural residues, animal dung) as fuels as a result of the decrease in the supply of fuelwood (Table 18.1). The present trend indicates that the use of agricultural residues and animal dung as sources of energy is on the rise in the HKH region. This clearly reflects the ongoing stress on forest resources. At the same time the transition from biomass to commercial energy forms is slow in mountain areas, as a result of both monetary and non-monetary factors and of the lack of suitable technological options, except in some major urban settlements.

Table 17.1: **Population, forest area, and consumption of biomass fuels in the HKH region, FY 1994/95**

Area/Location[1]	Population (millions)	Forest area (million ha)	Annual per capita consumption of biomass		
			Fuelwood (kg)	Agricultural residues (kg)	Animal dung (kg)
HKH, China	19.7	23.6	760	460	321
Eastern Mountains, India	14.7	15.2	758	135	73
Western Mountains, India	18.3	5.6	635	81	88
Eastern Nepal	11.8	2.7	565	47	97
Western Nepal	8.6	6.2	691	26	49
Northern Mountains, Pakistan	22.3	18.5	290	54	87
Western Mountains, Pakistan	6.7	34.7	607	5	87

Source: Rijal 1999

[1]The eastern mountains in India include Sikkim, Darjeeling, and the North East Region of India; the western mountains include Uttarakhand, Himachal Pradesh, and Jammu & Kashmir; Eastern Nepal includes the eastern and central development regions; Western Nepal includes the west, mid-west and far-west regions; the western mountains of Pakistan include Balochistan; and the northern mountains include the North West Frontier Province, Federally Administered Tribal Areas, and Azad Jammu and Kashmir.

Availability of Dung and Present Use

Studies in selected areas of the HKH have shown that the total dung produced would be sufficient to meet 35 to 64% of the total primary energy requirement in the different areas (Table 17.2). However, not all dung is physically available for energy production as most of the animals are not stall-fed. The common practice in mountain areas is to graze animals outside (pasture/grazing land, inside forests, in open spaces, and sometimes on fields with no crops growing), thus dung is scattered in open spaces and not easily available, although in areas where there is a high demand for dung for fuel, low-income households do collect dung from the fields. It is thought that overall 60% or more of the dung produced is effectively available for use. The primary use of dung is for farmyard manure, but because of the decreasing availability of fuelwood and twigs, an increased amount is being used for cooking.

Table 17.2: Dung production and its present use in selected areas of the HKH Region, FY 1994/95

	Total dung production (GJ per capita)	% of total primary energy requirement
Nepal	7.5	59
Uttaranchal, India	7.0	41
Himachal, India	9.3	35
Bhutan	7.2	64

Note: Based on Livestock Data from the Agricultural Sector Database prepared by MFS, ICIMOD

Table 17.3: Dung availability in selected areas of the HKH Region, FY 1994/95

	Dung availability per capita (kg per year)
Nepal	689
- Terai	543
- Hills	794
- Mountains	938
Uttaranchal, India	645
- Low Hills	372
- Mid Hills	798
- High Hills	946
Himachal Pradesh, India	849
- Low Hills	733
- Mid Hills	981
- High Hills	602

Source: Rijal 1999

There is a substantial variation in dung availability among the different agroclimatic areas in the HKH region (Table 17.3). Dung availability per capita is generally, if not always, higher in mountain areas than in the Terai or the hills. In most places, the availability of dung per capita is decreasing, however, as the human population is growing faster than the livestock population. This is partly the result of the decrease in available fodder associated with deforestation as well as of lack of animal feed in remote mountain areas.

The percentage of dung used as fuel in some typical areas is shown in Table 17.4. The values indicate that the share of dung as fuel increases with a decrease in the availability of fuelwood. For example, the share of dung is about 16% of total energy consumption in eastern Nepal compared with 5% in western Nepal, where the per

Table 17.4: Percentage of dung used as fuel in selected areas of the HKH region	Per cent of dung used as fuel
Eastern Nepal	16
Western Nepal	5
Uttaranchal, India	8
Himachal, India	6
Source: Rijal 1999	

capita area of forest is more than three times higher (Table 17.1).

Figure 17.2 shows a diagrammatic representation of the trends over time in the availability of fuelwood and animal dung, the forest area, the human population, and the total energy requirement in the mountain areas of the HKH. There is a clear need for a properly designed intervention package to avoid the development of a big energy deficit and the concomitant problems both for people and the environment. Wide-scale introduction of biogas technology could be one of the options, however there is a need first to adapt the technology to make it a feasible option in the higher altitude mountain areas.

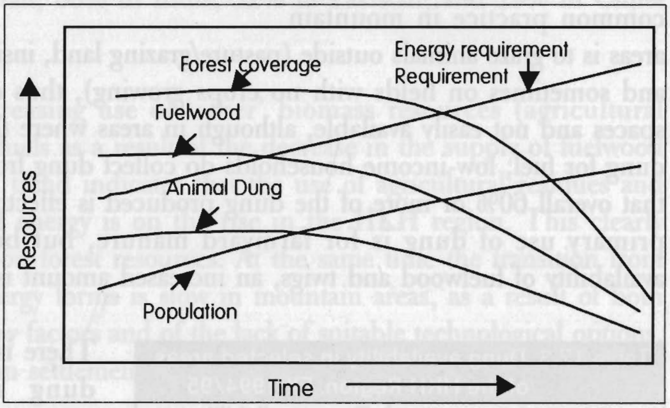

Figure 18.2: **Trends in resource availability in mountain areas of the HKH**

Technological Options for Providing Energy in Mountain Areas

Given the reduction in the traditional sources of fuel for energy and the increase in energy requirements in mountain areas, it is necessary to consider alternative means of energy supply. In general, decentralised energy systems offer an advantage compared with centralised energy options, given the nature of the energy services required and the remoteness of the areas. There are a variety of renewable energy technologies (RETs) available that could be considered based on the area-specific availability of energy resources and energy services. These include mini- and micro-hydropower, various solar technologies, and biogas production – the option considered here.

Biogas technology provides a way of meeting the fuel requirements of mountain communities without losing the benefits of farmyard manure; it obviates the problems associated with the competing use of animal dung for farmyard manure and fuel. At the present levels of dung production per capita (Table 17.2), more than 25% of the total energy requirement could be met from biogas. Not only is the fertiliser value of the dung retained, the slurry from biogas plants can actually be superior to farmyard manure (IT 1979; Rijal 1998), and the slurry can be used to enhance the composting of dung and agricultural residues.

Biogas technology

Biogas is produced by anaerobic digestion of organic wastes and water, thus an airtight digester is a prerequisite. The digestion process ferments the organic materials in the presence of a natural mixed bacteria culture and produces gaseous products and a liquid effluent. The gas consists of a mixture of methane (50-60%), carbon dioxide (30-40%), and other gases including hydrogen, nitrogen, and hydrogen sulphide. Biogas is colourless and non-toxic but the hydrogen sulphide gives it a slightly pungent smell. The yield rate of biogas is temperature-dependent, the optimum temperature being 33°C. The gas is mainly used for cooking and lighting and sometimes as a fuel for internal combustion engines. The mixing ratio of diesel to biogas is theoretically 20:80, although users frequently report a ratio of 40:60. The effluent is used as a wet or sun-dried fertiliser and has a better nutrient content than green manure. The digestion process reduces the level of pathogens within the dung and may therefore generate public health benefits (Rijal 1998). The two main types of biogas plant are the floating steel drum (Indian design) and the fixed dome model (Chinese design) (Rijal 1998).

The drum type consists of a two-chamber underground digester pit with a floating steel drum gasholder. Slurry is fed into the base of one chamber from the cemented inlet pipe. The gas rises and is collected inside the drum, the effluent overflows into the second chamber and the slurry is expelled through an outlet pipe which is at a lower level than the inlet pipe. The design was modified by the Khadi and Village Industries Commission (KVIC), India, to suit Nepalese conditions. In the modified design the pit is designed to taper down into the ground; gas is removed through a central guide pipe; and there is a two-compartment chamber design. The floating drum holds 60% of the daily rated gas output. The gas pressure, which is supplied by the weight of the drum, is 10 cm of water head. The gas drum has to be prefabricated in a workshop and carried to the plant site.

In the fixed roof or dome type model, the steel drum is replaced with a cement dome. As the gas forms, it pushes the slurry down forcing it into the input and outflow chamber. When the gas is used the pressure diminishes and the slurry flows back into the main pit. The plants have been modified slightly for use in Nepal. The major modification is the introduction of a fixed stirrer which breaks the crest on the surface of the slurry in the plant and thereby maximises gas production (Rijal 1998).

This model can be constructed at the site with locally available materials, except cement and GI pipe, so at present 80% of the biogas plants in Nepal are dome type (van Nes and Lam 1997).

After the biogas plant is installed, the owner has to feed the digester with the required quantity of dung and water. The dung is collected from the livestock stall and poured into a dung mixing pit. An equal amount of water is added and the two mixed by hand or foot until no lumps are left, since the pressure of lumps could reduce gas production. Continuous feed type plants need to be fed daily with the amount of dung and water required for the particular capacity. In general, approximately two buffaloes or three cows produce sufficient dung for a four cu.m biogas plant, which produces sufficient gas to fill the cooking needs of an average (six person) family.

Technological innovations for biogas plants to be used in mountain areas

Biogas plants with a metal gasholder (Indian type) are not suitable for mountain areas because of the high transportation cost involved. In contrast, fixed dome biogas plants (Chinese type) can be constructed in inaccessible hill areas. The masonry dome lies below the soil surface, which helps reduce temperature fluctuations within the digester. Dome type biogas plants can be found operating in hill areas up to 1,500m.

At higher altitudes, where the temperatures are lower, it is necessary to develop some method of temperature enhancement to ensure that a suitable temperature is maintained inside the biogas digester. This is a prerequisite to popularising biogas plants in the mountains (Dhar and Sharma 1987). An attempt has already been made in China where there are a number of biogas plants operating in low temperature conditions in which animal excreta is mixed with hot water prior to being fed into the digester (Monga and Lakhanpal 1988; Monga and Ramana 1992).

There are several possibilities for enhancing the temperature inside the digester. Some of the suggested modifications are shown in Figure 17.3. Firstly, the biogas digester pit can be insulated using locally available materials (such as agricultural or plant residues) packed in plastic bags so that the desired temperature can be maintained inside the digester without fluctuation.

Secondly, construction of a solar greenhouse on top of the dome structure would help to increase the temperature of the digester. It could have the added advantage of helping farmers diversify the production of cash crops.

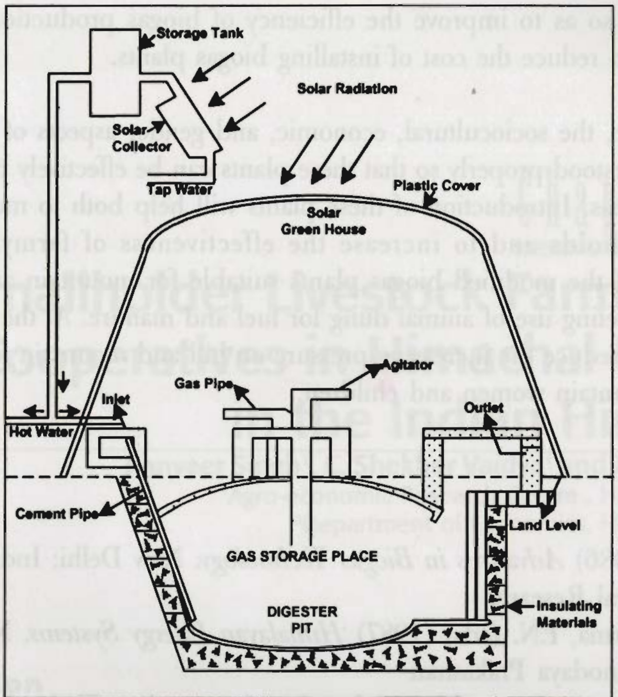

Figure 17.3: **Modifications to a Biogas Plant for Use in Mountain Areas**

Thirdly, mixing the dung with hot rather than cold water would enhance the temperature inside the digester. Hot water could be obtained by installing a solar water heater (which are relatively inexpensive) and/or burning a small amount of biogas. Mixing of some of the slurry coming out of the biogas plant with the input material would also help to enhance the temperature.

These are a few of the modifications that could help maintain the desirable temperature within the biogas digester. Which are needed and the extent would depend primarily on the temperature profile of the specific location. In cold climatic conditions, all of these suggested modifications may be necessary, whereas in other places one or two modifications could be sufficient to attain the desired temperature.

Future Research Agenda

There is a need to carry out on-site research and demonstrations in selected mountain areas to examine the suitability of the various options suggested for biogas technology. A field demonstration should be carried out on the manure value of the slurry so that the beneficiaries can derive maximum benefit from the organic manure. The type of biogas plant linked to a sanitary latrine should be demonstrated and promoted to improve the hygiene in mountain households. R&D activities should be strengthened so as to improve the efficiency of biogas production under cold conditions and to reduce the cost of installing biogas plants.

At the same time, the sociocultural, economic, and gender aspects of biogas plants need to be understood properly so that these plants can be effectively popularised in the mountain areas. Introduction of these plants will help both to meet the energy needs of households and to increase the effectiveness of farmyard manure. Popularisation of the modified biogas plants suitable for mountain areas will help reduce the competing use of animal dung for fuel and manure. At the same time, it will also help to reduce the increasing pressure on hill and mountain forests and the drudgery of mountain women and children.

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