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# BIOMASS PRODUCTION AND THE CONSERVATION OF ENERGY THROUGH IMPROVED COOKING-STOVES IN NEPAL

Kayeswor Man Sulpya

*MIT Series No. 12*

1991

International Centre for Integrated Mountain Development

# BIOMASS PRODUCTION AND THE CONSERVATION OF ENERGY THROUGH IMPROVED COOKING-STOVES IN NEPAL

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**June, 1991**

**International Centre for Integrated Mountain Development (ICIMOD)**

**Kathmandu, Nepal**

# PREFACE

This paper was prepared for, and presented at, the Seminar on 'Rural Energy and Related Technologies' held in Kathmandu from 26 to 28 March, 1991, in collaboration with the Agricultural Development Bank of Nepal and the Water and Energy Commission Secretariate of His Majesty's Government of Nepal.

This paper traces different aspects of the development of ICS technology in Nepal and identifies factors that are important in order to achieve an increased use of this technology in conserving energy in the domestic sector.

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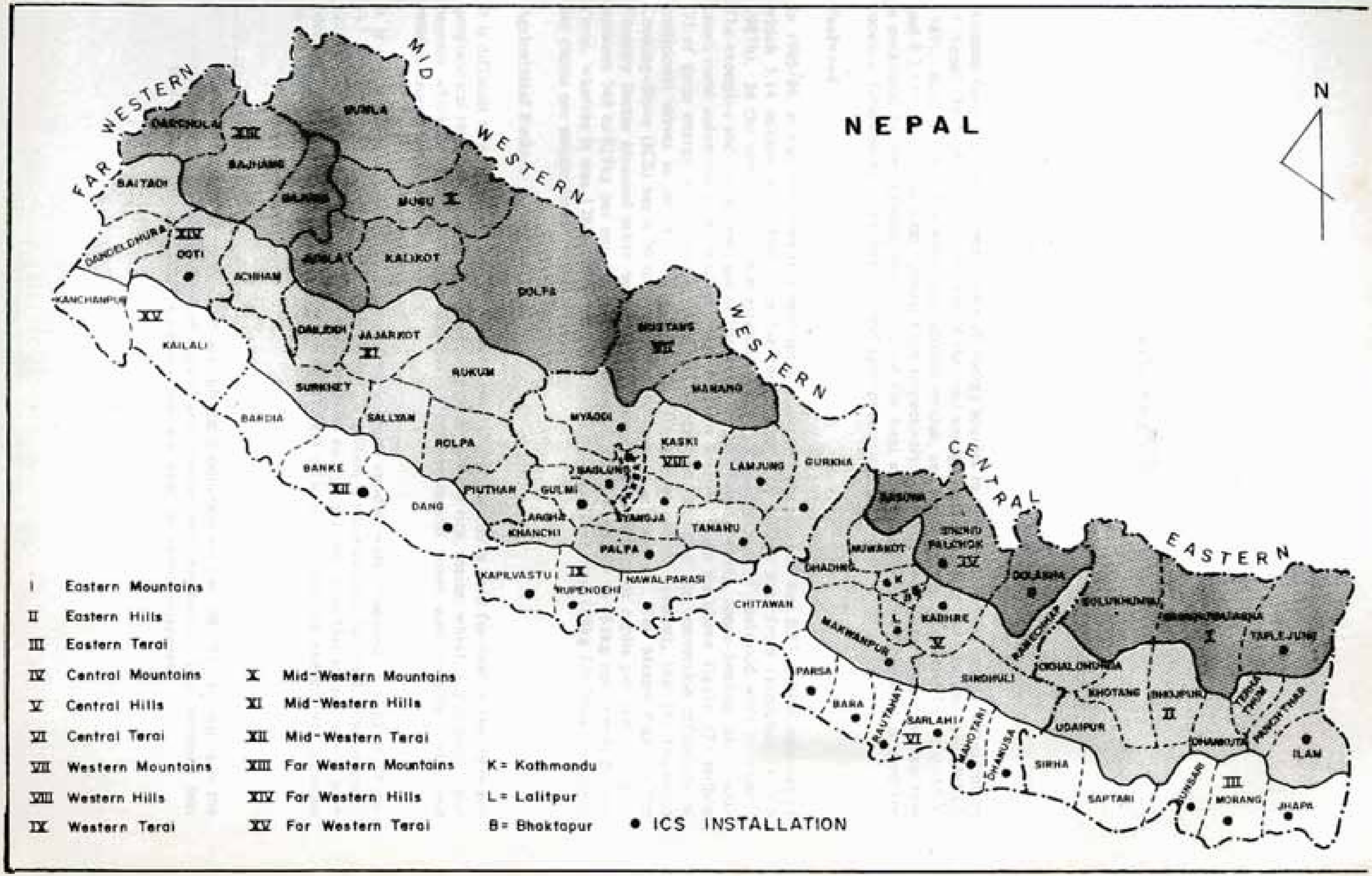

NEPAL
N
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
I Eastern Mountains
II Eastern Hills
III Eastern Terai
IV Central Mountains
V Central Hills
VI Central Terai
VII Western Mountains
VIII Western Hills
IX Western Terai
X Mid-Western Mountains
XI Mid-Western Hills
XII Mid-Western Terai
XIII Far Western Mountains
XIV Far Western Hills
XV Far Western Terai
K = Kathmandu
L = Lalitpur
B = Bhaktapur
• ICS INSTALLATION

# INTRODUCTION

Biomass fuels are predominant forms of energy sources in the total national energy consumption of Nepal. In 1988/89, 95.1 per cent of the total energy needs were met by biomass fuels (WECS 1989), and, of these, fuelwood, agricultural residue, and animal dung accounted for 75.9, 10.9, and 8.3 per cent of the total biomass fuels respectively. A major proportion of this biomass fuel is consumed by the domestic sector. Out of the total energy consumed, 95 per cent is used for cooking, followed by space-heating, and agro-processing.

**Fuelwood**

In 1985/86, it was estimated that the supply of accessible fuelwood was 6.27 million tons out of which 5.14 million tons came from the forests and 1.13 million tons from farmlands (WECS 1987b). In the same year, it was estimated that 10.8 million tons of fuelwood were consumed. The excessive and unregulated use of fuelwood for household cooking, space-heating, and wood-based rural industries accelerated destruction of the forests. From the above figure, 181 million GJ of gross energy was obtained which, at 10 per cent, assumed the conversion efficiency of traditional stoves to be 18.1 million net GJ. (It may be noted, however, that the Improved Cooking-Stove (ICS) has a 20 to 30 per cent conversion efficiency). The Master Plan for the Forestry Sector assumed urban household consumption to be 248kg per capita per year, ranging between 548 to 829kg per annum in the mountains and between 474 to 483kg per annum for the *Terai*, whereas it was 176kg for Kathmandu, 144kg for Lalitpur, and 128kg for Bhaktapur on a per capita per annum basis (Shaikh 1989).

**Agricultural Residue**

It is difficult to estimate what proportion of agricultural residue is used for fuel in the different geographical regions of Nepal. Residues include those from rice, maize, wheat, sugar, millet, and bagasse which can be grown in a number of agro-ecological zones with varying yields and residue/crop ratios (New Era 1990).

It is estimated that 12.47 million tons of agricultural residue were produced in 1985/86 (Table 1).[1] Assuming that one-sixth of the residue (2.1 million tons) was used for fuel, discharging a uniform heat value of 12.6 GJ per ton, the gross energy derived from this source would have been 26.2 million GJ. Assuming only a five per cent efficiency in use, the energy used amounts to 1.3 million GJ.

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1. The latest available statistics on agricultural production are for 1987/88. According to the statistics, 13.46 million tons of agricultural residue were produced. It is assumed that one-sixth of the residue (2.24 million tons) was used for energy purposes.

**Table 1: Production of Agricultural Residue**

| Agricultural Residue | Mountain Region '000 T | Hill Region '000 T | *Terai* Region '000 T | Nepal (Total) '000 T |
|---|---|---|---|---|
| Rice husk | 15.3 | 146.98 | 538.85 | 701.13 |
| Rice straw | 183.6 | 1763.70 | 6466.20 | 8413.30 |
| Rice barn | 3.1 | 29.40 | 107.77 | 140.23 |
| Maize cobs | 21.1 | 177.57 | 63.31 | 262.14 |
| Maize stalks | 140.4 | 1183.80 | 423.40 | 1747.60 |
| Wheat straw | 51.3 | 361.38 | 633.85 | 1046.50 |
| Bagasse | 0.4 | 9.40 | 157.71 | 167.50 |
| Jute stick | 0.0 | 0.00 | 1.22 | 1.22 |
| Total | 415.2 | 3672.21 | 8392.51 | 12479.62 |

Source : WECS; Energy Sector Synopsis Report 1985/86, 1987b.

The physiographic distribution of agricultural residue production is 67.2, 29.4, and 3.4 per cent for the *Terai*, hill, and mountain regions respectively. Rice straw accounts for about 67.2 per cent of the total agricultural residue supply (Sharma 1986).

**Animal Dung**

Animal dung is the third type of indigenous energy source. Based on a study conducted by the Agricultural Statistics' Division of the Ministry of Agriculture there were about 15.5 million livestock units (LSU) in Nepal in 1985/86 (New Era 1990). Dung produced in the hill and mountain regions is mostly used for composting, but in the *Terai* it is used for fuel in the form of dung-cakes and dung-sticks that are made by mixing it with straw and jute sticks. There are estimated to be 4.8 million head of livestock in the *Terai*. Assuming that 45 per cent of the dung production is lost during grazing, only 2.2 million tons of dung are available for fuel in the *Terai* Region (New Era 1990).

**Biomass-based Energy Technology**

Exploitation of the forests for fuelwood, fodder, and timber, along with the agricultural demands of the growing population have placed forests under heavy pressure, reducing forest cover, and thus damaging the environment. As a result, current rural, household energy supplies and consumption patterns are of serious concern. Lack of fuelwood increases the proportion of crop by-products and animal dung used for fuel, thus constraining their use as fodder and as organic inputs for soil improvement.

In order to overcome scarcity as well as to improve biomass use a change in balance between the biomass energy consumed by the domestic and other productive sectors is essential (Fig. 1). There are three possible approaches to achieving this change in balance.

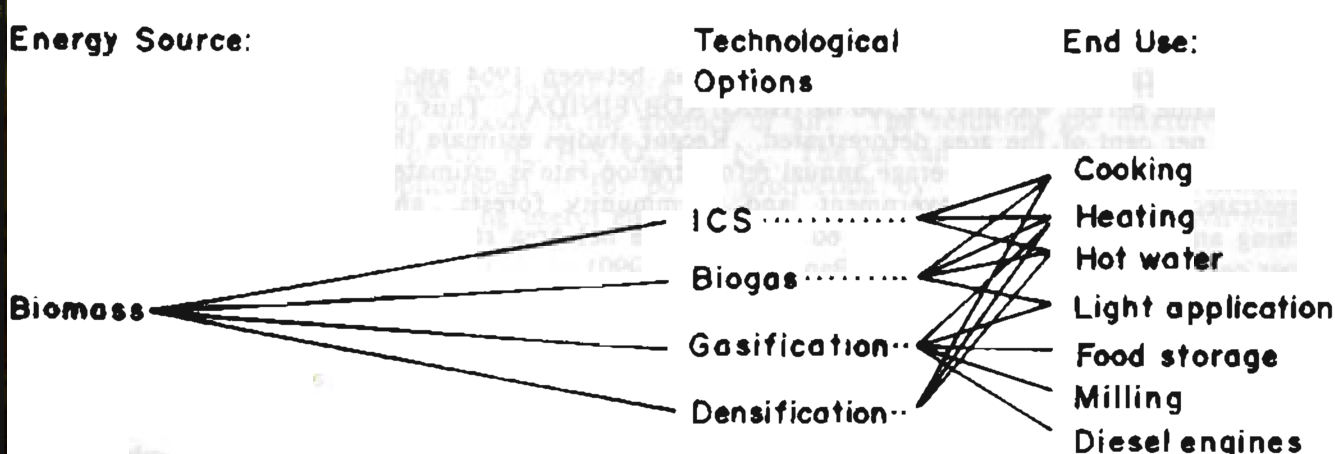
1. Increasing the domestic and industrial biomass fuel resource base through:

    - o bioenergy plantation programmes and
    - o domestic and industrial use of agricultural residue and animal waste through densification, biogas production, and thermo-chemical gasification processes.

2. Switching to non-biomass fuels.

3. Conservation of biomass through improved cooking-stoves.

**Fig. 1: Technological Options and End Use of Biomas**




Source: Author's compilation

**Bioenergy Plantation Programme**

Fuelwood supplies could be increased by efficient management of the existing natural forests, agro-forestry practices, and on-farm plantations. The Master Plan for the Forestry Sector (MPFS) recorded intensive and enriched planting of over nearly 100,000 ha by the end of 1986, half of which were under community forestry projects. However, in the absence of a proper monitoring system, it is difficult to assess the survival rate and the status of growth (New Era 1990). Sagarnath Plantation Project has a target to plant trees on 10,000 ha of land over a period of 10 years on a high, sustained yield basis. The main objective was to plant fast growing exotic species of eucalyptus (*Eucalyptus camaldulensis*) for fuelwood, the indigenous Sissoo (*Dalbergia sisso*) for timber (main stem), and the rest for fuelwood.

In view of the rapid deterioration of forest resources and the scarcity of fuelwood, bioenergy plantation programmes should be given prime importance. This type of activity generates local labour employment. Its main objective should be to produce bioenergy rather than industrial wood. Therefore, the selection of species is significant and the species should have the following characteristics:

- high biomass yield,
- high calorific value,
- rapid growth,
- good copiccing (regeneration after harvest),
- easy to establish,
- high adaptability,
- need for little aftercare, and
- nitrogen-fixing ability as well as the ability to provide steady fuelwood supplies.

There is also a lot of scope for producing charcoal which can replace fossil fuel. It is observed that, in Thailand, the regeneration of forests resulted from increased plantation to obtain raw material for charcoal. This type of plantation helps to increase domestic and industrial biomass fuel.

The area of natural forest decreased by 570,000 ha between 1964 and 1985. Reforestration during the same period was only 69,200 ha (HMG/ADB/FINIDA). Thus reforestation took place on only 12 per cent of the area deforestrated. Recent studies estimate the annual deforestation rate as 44,000 ha whereas the average annual reforestration rate is estimated to be only 7,900 ha. Reforestrated areas include government land, community forests, and private plantations. Assuming an effective survival rate of 60 per cent, the net area reforestrated amounts to only 10.7 per cent of the deforestrated area (Banskota et al. 1990).

**Densification of Biomass Residue**

Large amounts of biomass residue are produced in Nepal as a result of forestry activities, timber production, and agro-industrial processes. These residues (sawdust, rice husks, straw, wild bushes, bagasse, maize stalks, etc) are available in a form that makes them unsuitable (because of their combustible characteristics) or impractical (because of transport costs) for domestic and/or commercial use.

Residue can be converted into briquettes or pellets of different shapes and sizes by densification processes and can then be used as fuel in various end use devices. In processing, a homogeneous material with a real density of approximately 1,000 - 1,400 kg/m$^3$ and a bulk density of 500 to 800 kg/m$^3$ is produced. Ideally, the briquettes are not hygroscopic, do not swell in water, and do not crumble during combustion or gasification.

Briquettes are made by simple densification or by a partial pyrolysis-cum-densification process. The partial pyrolysis-cum-densification process is neither technically sound nor viable from an economic and financial point of view (WECS 1988). Most entrepreneurs in Nepal have ceased to produce briquettes by the partial pyrolysis-cum-densification method, because the dies and extruders are subject to wear and the pyrolyser needs repairing about once a month. This is because the pyrolyser is continually subjected to a temperature of 300°C. Because of reaction to the friction of internal husks and to direct external heat, the pyrolyser is subject to continual deterioration. Production of tar inside the pyrolyser also creates problems, and breakages in the power transfer chain are common (WECS 1988). Also some consumers in Kathmandu complained that these briquettes crumbled during transportation. Based on a patent from the Indian Institute of Technology (IIT) Delhi, two licensees constructed a total of 70 carbonised briquetting plants throughout India; most of which were privately funded. After sixty of these plants ceased to operate, IIT withdrew the licensing rights from these manufacturers (University of Twente 1990).

It is clear from Table 1 that apart from maize cobs and stalks, the maximum quantity of agricultural residue is produced in the *Terai*. Sharma (1986) estimated that the Central Development Region was where the maximum amount of all types of residue, apart from jute sticks, were produced. Data from the Ministry of Industry show that there are about 27 briquetting factories registered for installation in Nepal. Of these, 13 are to be located in the Central Development Region, while seven are to be located in the Western Development Region (WECS 1988). According to the Eighth Plan, Energy Resource Development Section (WECS) Report, 7 rice husk densification plants were installed by the private sector. Their annual production was about 3,500 tons. These are located in the *Terai* and in the Kathmandu Valley.

**Biogas**

Anaerobic digestion (biogas production) is a process through which organic matter is converted into methane and carbon dioxide in the absence of air. The resulting gas mixture may also contain small quantities of Co, $H_2$, $H_2S$, $O_2$, and $N_2$. The gas can be used for direct combustion (cooking or heating applications) or for power production by means of internal combustion engines. Apart from producing useful energy, the system can also contribute to environmental hygiene.

Compared to other sources of bioenergy, the anaerobic digestion method has three advantages.

- o It converts wet organic substances into useful energy,
- o produces biogas from all types of organic waste (with the exception of lignin), and
- o produces a slurry which is a better fertiliser than the manure feedstock.

More than 5,700 biogas plants have been installed in more than 50 districts of Nepal (Pokharel and Yadav 1991).

**Gasification**

Gasification is a thermo-chemical process in which biomass is converted into a combustible gas that can be either used for direct combustion or as a fuel for internal combustion engines. At present, various types of biomass gasifiers have been adopted by manufacturers in both developed and developing countries. Some years ago, Research Centre for Applied Science and Technology (RECAST) also designed and developed a wood and charcoal gasifier. National Structure and Engineering (Pvt.) Ltd. also developed some biomass gasifiers. The gasifier designed by RECAST was the down-draught type which is designed for operation with charcoal (Shrestha 1983). However, the efficiency of the gasifier and the composition of the gas were not mentioned.

Successful use of this technology was reported in Indonesia, when a 15kW wood gasification system was successfully operated for over 4 years (Susanto 1988). This system supplies electricity to about 300 houses on a daily operating basis from 5 to 11 p.m. A small gasification system capable of developing up to a 10kW shaft power output, using producer gas generated from rice husk, was developed in Thailand by Coovaltanachai in 1988. For the hill regions in Nepal, this type of gasification system can be used for electricity generation as well as for replacing diesel engines in rice mills.

**Switching to Non-biomass Fuel**

In urban areas, consumption of kerosene and eletricity for domestic purposes has been increasing rapidly. Transition from the use of traditional fuel to modern commercial fuel can be of considerable significance in the domestic energy consumption pattern. In particular it widens the range of possible responses open to the consumer under the pressure of increasing fuelwood scarcity. On the one hand, it brings many benefits - it helps to contribute to the over-exploitation of biomass resources - but it adds greatly to the pressures on scarce resources of capital and foreign exchange.

The best alternatives to fuelwood are kerosene and electricity which are economically more feasible in comparison to the high price of fuelwood in the local market (Table 2). Notwithstanding, where fuel supplies are predominantly non-commercial, the potential for fuel switching is minimal.

Table 2 also shows the technological option of end use devices and economic comparison of different types of fuel with respect to the type of stove and its efficiency. The thermal efficiencies are calculated by means of the boiling water test. Taking into account the conversion efficiencies, the total rupees spent per MJ of useful heat is calculated. By comparing the useful heat generated, if the price of fuelwood is less than Rs 1.50 per kg, the ICS will be financially economical to use. There are other factors that justify continued support for the cooking-stove programme. These are: significant advances in technical know-how in stove design, positive responses from users, better knowledge of the constraints in the existing programme, and greater access to information exchange. With this in mind, the Master Plan for the Forestry Sector has recommended the continuation of the ICS programme, and, recently, USAID/Nepal chose to support it.

**Table 2: Economic Comparison of Different Types of Fuel by Stove Type**

| Technology Options | Fuel Type | Average Stove Power kW | Efficiency % | Conversion Factor | Purchased Rs/unit | Fuel Rs/MJ | Useful Heat Rs/MJ |
|---|---|---|---|---|---|---|---|
| Insert Stove | fuelwood | 4.4 ± 0.2 | 21.5 ± 1 | 16.5 MJ/kg | 2.5 Rs/kg* | 0.151 | 0.70 |
| | | | | | 1.4 Rs/kg | 0.084 | 0.39 |
| | | | | | 0.8 Rs/kg | 0.048 | 0.22 |
| *Tamang* Stove | fuelwood | 6.2 ± 0.5 | 24.7 ± 1 | 16.5 MJ/kg | - | - | 0.61 |
| | | | | | | | 0.34 |
| | | | | | | | 0.19 |
| Improved Two-ring Mud Stove | fuelwood | 6.6 ± 0.3 | 26.7 ± 1.5 | 16.5 MJ/kg | - | - | 0.56 |
| | | | | | | | 0.31 |
| | | | | | | | 0.18 |
| Improved One-ring Mud Stove | fuelwood | 3.4 ± 0.4 | 22.7 ± 2.5 | 16.5 MJ/kg | - | - | 0.66 |
| | | | | | | | 0.37 |
| | | | | | | | 0.21 |
| Burner Stove (small size) | kerosene | 1.5 ± 0.0 | 56.5 ± 1.2 | 36.3 MJ/lt | 8.5 Rs/lt | 0.344 | 0.41 |
| Wick Stove (small size) | kerosene | 1.4 ± 0.0 | 49.3 ± 1.5 | 36.3 MJ/lt | 8.5 Rs/lt | 0.232 | 0.47 |
| Local Electric Heater | electricity | .8 ± 0.0 | 62.0 ± 0.0 | 3.6 MJ/kWh | 1.2 | 0.333 | 0.53 |

Source: 1. Devtec 1989.
2. Sulpya 1984.
3. RECAST 1987.

Note: A 24cm diameter *dekchi* (flat pot) was used for the test 15 minitues simmerging without lid after boiling was done throughout the test.

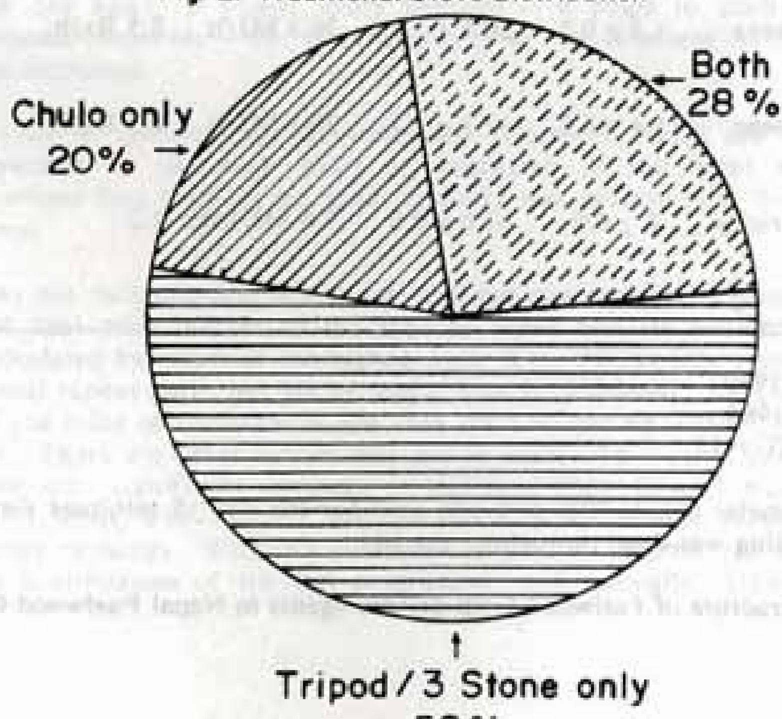
* Pricing structure of fuelwood from private agents to Nepal Fuelwood Corporation.

# CONSERVATION OF BIOMASS THROUGH IMPROVED COOKING-STOVES

## Background

To meet domestic energy requirements, various technological options have been discussed. However, the development and dissemination of these technologies in rural areas are very limited. Therefore, rural people are forced to burn lower quality fuels such as twigs, branches, crop residue, animal dung, and even weeds or grasses. The situation is worsened by the use of inefficient cooking-stoves, resulting in a high consumption of fuelwood. According to a survey conducted by RECAST in selected villages, over 90 per cent of the people in one village used tripods, while only 7 per cent used tripods in another village. Home-made mud stoves (*Chulo*) were common in the second village and about 50 per cent of them had a single ring and the other 50 per cent had two. Another survey conducted by the Community Forestry Development Project (CFDP), covering a wider hill area of Nepal, showed that about 52 per cent of the households in the hill areas used tripods or three stones for cooking while 20 per cent used '*Chulo*', and the rest used both types of stove (Fig. 2).

Fig. 2: Traditional Stove Distribution




Source: Community Forestry Development Project (CFDP)

The need for ICS was realised and promotion of the same became one of the most important components of the fuelwood management programme. The use of improved cooking-stoves (ICS) can save 18 to 42 per cent of fuelwood use (Shakya 1985 and Sulpya 1984).

**History of ICS Development**

The history of the ICS is not new in the Nepalese context. The development of ICS can be divided into three phases. The first phase started in the 1950s by introducing "*Magan Chula*" which originated in India. At that time, the village development services, "*Gramin Vikash Sewa*", started promoting ICS in some areas of Nepal. The programme was aimed at uplifting the living conditions of the people and reducing exposure to smoke. However, the programme lacked a scientific approach in terms of design, promotion, and testing. The programme was unsuccessful in terms of wider dissemination because of easy accessibility to the forest nearby as well as the low price of firewood.

**Phases of Stove Development in Nepal**

| 1950 | 1960 | 1970 | 1980 | 1990 |
|---|---|---|---|---|
| **First Phase:** Socioeconomic and health aspects | | **Second Phase:** Technical/scientific aspects | **Third Phase:** Technical/scientific, health, and socioeconomic aspects | |

The second phase started in the early 1970s and focussed on improving fuel efficiency. Technological know-how about large mud stoves with a number of rings, known as the *Lorena* Stove, came from South America (Guatemala). The Women's Training Centre of Nepal was involved in training women in the construction of *Lorena* Stoves. The main objective during this period was to find a solution to the fuelwood crisis and accompanying deforestation. The dissemination of these stoves was slow because of lack of scientific and critical application. In the late seventies, RECAST became involved in the improvement of these stoves and renamed them Nepali *Chulo*.

The third phase, which began in the early 1980s, was taken up by research and development (R&D) and laboratory-based work. This included a detailed assessment of cooking-stove performance, standardised procedures for testing, and design methodologies to obtain higher performance and efficiency. The *Lorena* Stove was replaced by ceramic Insert and Double Wall Stoves. These cooking-stoves were designed by RECAST under a contract with the HMG/UNDP/FAO Community Forestry Development Project (CFDP). Large-scale distribution was carried out by the CFDP. After some years, with support from UNICEF, the ceramic cooking-stoves and the New Nepali *Chulo* were also introduced through the Agricultural Development Bank, Nepal (ADB/N), the Small Farmers' Development Project (SFDP), and the Women's Development Division (WDD) through their Production Credit for Rural Women (PCRW) Programme. Thousands of these stoves were distributed. Some modifications to ceramic Tata Energy Research Institute (TERI) models were made, especially on the second ring and its size (Fig. 3). Distribution was limited and confined only to the field trail. As in the first phase, socioeconomic issues once again occupied the centre-stage of activities. ICS production was reviewed and planned for a self-propelling distribution process.

Later the *Tamang* Stove (Improved Village Stove) was introduced. It consisted of a mud-brick or mud-stone ICS with an iron tripod which was driven into the combustion chamber to form a better foundation. It is a two-ring stove with a chimney (ceramic or mud-block). The stove can withstand excessive force, such as that exerted during cooking maize porridge. The chimney was modified for easy cleaning.

Taking into account the social context of stove construction, one-ring and two-ring stoves were introduced. These stoves were built by making metal moulds with locally available materials such as the clay and agri-residues used to make local mud stoves (Sulpya 1990). The moulds were to maintain standard dimensions. The stove is chimney-less, but in the two-ring model the chimney can be fixed on afterwards with minor on-site modifications.

**Types of ICS and Their Theoretical Potentials**

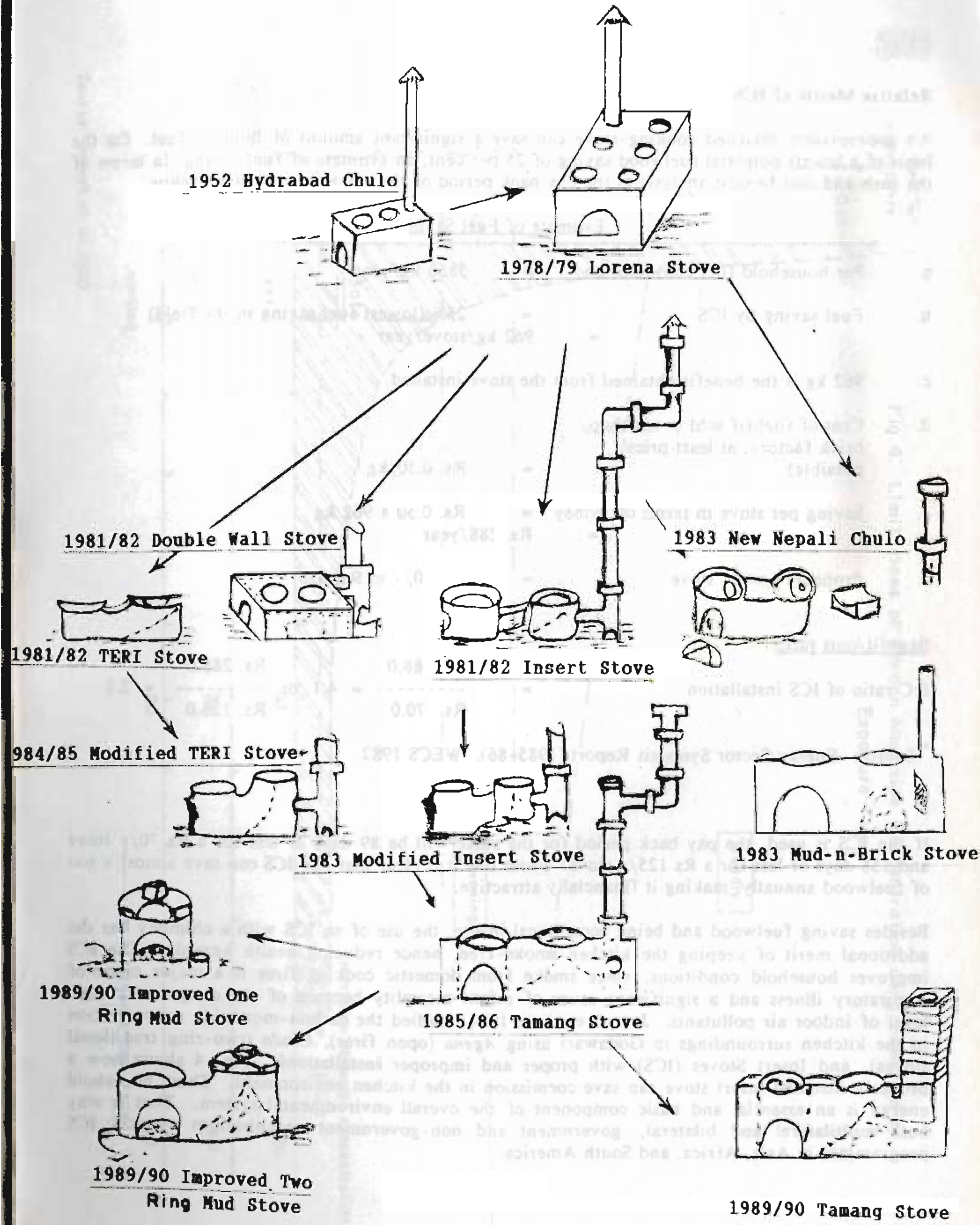
There are various types of ICS, namely, the Insert Stove, the Double Wall Stove, the Modified TERI Stove, the New Nepali *Chulo*, the *Tamang* Stove, the Mud-n-brick Stove, the Single-ring and the Two-ring Stoves, and the Metallic Stove. The efficiency of stoves varies from 21.5 to 26.7 per cent in field conditions (RECAST 1984, 1987, 1988) (Fig. 3 and Table 2), while the performance efficiencies of the new Nepali *Chulo* and the Metallic Stove are not known. Potential fuelwood savings range from 25.6 per cent to 40 per cent over the 16 per cent fuel efficiency of the traditional stove. MPFS projected that the number of ICS in use would increase to 290,500 in 2001 and 753,500 in 2011, covering 9.2 per cent of all households in 2001 and 20.8 per cent in 2011 with a subsequent annual growth rate of 10 per cent. If the ICS programme was accelerated to reach 70 per cent in the Seventh Five Year Plan, fuelwood saved would still be only 2.4 per cent in 2000/01 and there would be a 5.8 per cent fuelwood demand in the Middle Mountains, Siwaliks, and the *Terai* by 2010 (Table 3).

**Table 3: Projected Fuelwood Savings from ICS ('000 t)**

| Zone | 1985-86 | 1990-91 | 1995-96 | 2000-01 | 2005-06 | 2010-11 |
|---|---|---|---|---|---|---|
| **Moderate Programme** | | | | | | |
| Mid-Mountains | 9 | 43 | 59 | 81 | 110 | 151 |
| Siwaliks | 2 | 10 | 14 | 20 | 29 | 41 |
| *Terai* | 10 | 50 | 72 | 104 | 150 | 215 |
| Total | 21 | 103 | 145 | 205 | 289 | 407 |
| % of consumption | 0.1 | 0.8 | 1.0 | 1.3 | 1.8 | 2.3 |
| **Accelerated Programme** | | | | | | |
| Mid-Mountains | 9 | 61 | 95 | 149 | 234 | 366 |
| Siwaliks | 2 | 14 | 23 | 37 | 61 | 100 |
| *Terai* | 10 | 70 | 116 | 192 | 317 | 524 |
| Total | 21 | 145 | 234 | 378 | 612 | 990 |
| % of consumption | 0.1 | 1.2 | 1.7 | 2.4 | 3.8 | 5.8 |

Source: Master Plan for the Forestry Sector, HMG/ADB/FINIDA, 1988.

Fig. 3 ICS Technology Development in Nepal



**Relative Merits of ICS**

An appropriatly designed cooking-stove can save a significant amount of biomass fuel. On the basis of a lowest potential fuelwood saving of 25 per cent, an estimate of fuel saving, in terms of the cash and cost benefit analysis as the pay back period of the stove, is calculated below.

<u>Estimate of Fuel Saving</u>

a. Per household fuel consumption = 3850 kg/year*

b. Fuel saving by ICS = 25% (lowest fuel saving in the field) = 962 kg/stove/year

c. 962 kg is the benefit obtained from the stove installed.

d. Cost of fuel (if sold to tea shop, brick factory, at least price possible) = Rs. 0.30/kg

e. Saving per stove in terms of money = Rs. 0.30 x 962 kg = Rs. 288/year

f. Probable cost of stove = Rs. 70/- to Rs. 125/-

<u>Benefit/cost ratio</u>

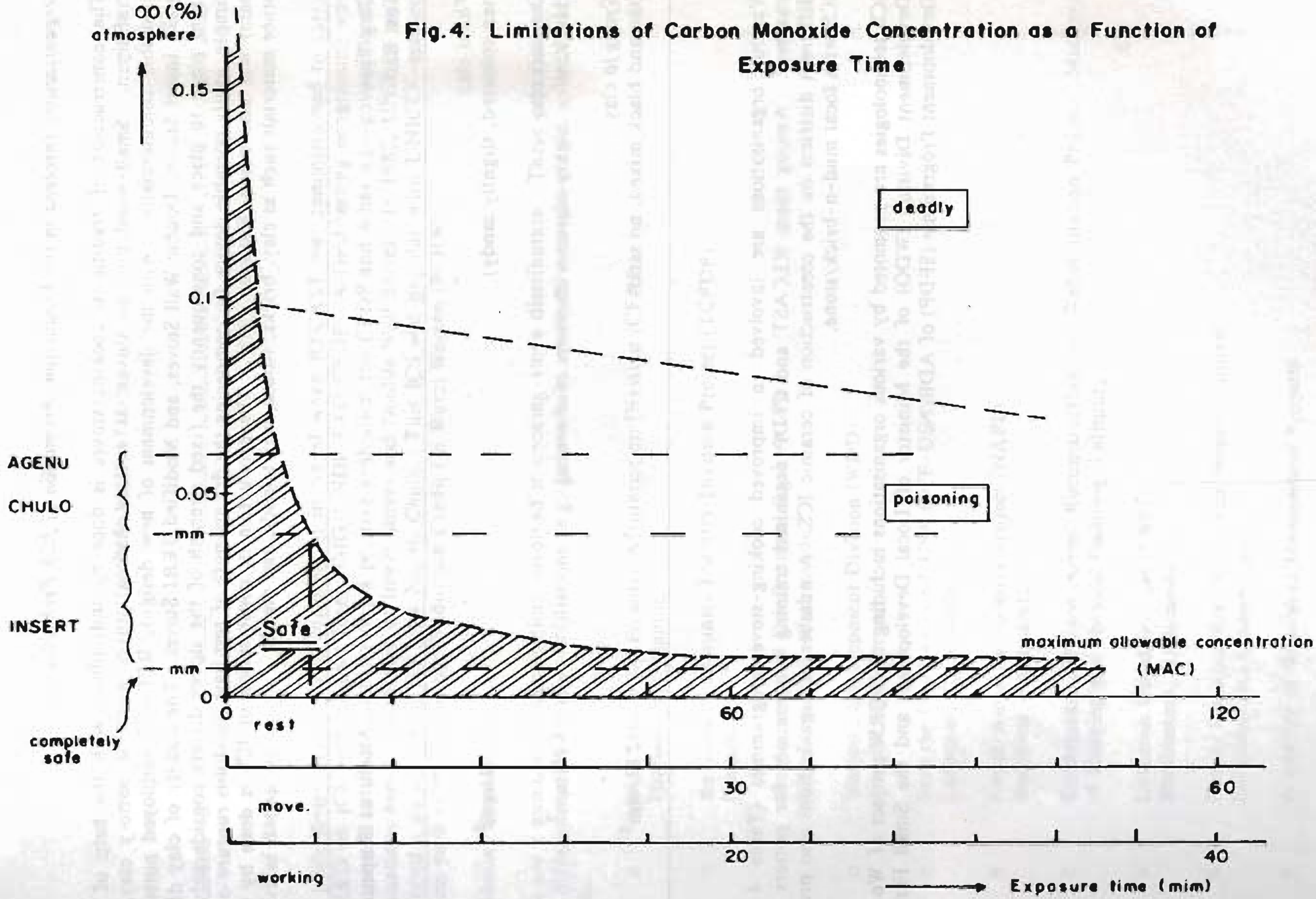
B:C ratio of ICS installation $= \frac{\text{Rs. } 288.0}{\text{Rs. } 70.0} = 4.1$ or $\frac{\text{Rs. } 288.0}{\text{Rs. } 125.0} = 2.3$

* Source: Energy Sector Synopsis Report (1985-86). WECS 1987.

If the ICS is used, the pay back period for the stove will be 89 days or less for a Rs 70/- stove and 158 days or less for a Rs 125/- stove. From this it is clear that one ICS can save almost a ton of fuelwood annually, making it financially attractive.

Besides saving fuelwood and being economical in use, the use of an ICS with a chimney has the additional merit of keeping the kitchen smoke-free, hence reducing health hazards. The ICS improves household conditions, since smoke from domestic cooking fires is a major cause of respiratory illness and a significant cause of infant mortality because of the dangerously high level of indoor air pollutants. Joseph et al. in 1984 studied the carbon-monoxide concentration in the kitchen surroundings in Godawari using *Agenu* (open fires), *Chulo* (two-ring traditional stoves), and Insert Stoves (ICS) with proper and improper installations. Fig. 4 shows how a properly installed insert stove can save coemission in the kitchen environment. Thus, household energy is an essential and basic component of the overall environmental system. That is why both multilateral and bilateral, government and non-government organisations support ICS programmes in Asia, Africa, and South America.

Fig. 4: Limitations of Carbon Monoxide Concentration as a Function of Exposure Time




Source: Joseph et. al. 1985.

*Organisations Involved in the Production/Promotion of ICS Technologies*

The construction of traditional cooking-stoves is done by individuals with the help of local craftsmen. Small-wood burning stoves, as well as charcoal stoves made of pottery clay, are available commercially. With the development of new designs, RECAST employed potters to make Insert Stoves, Double Wall Stoves, and Modified TERI Stoves. The quality of clay differs from place to place and consequently the fixed strength of the stoves differs considerably. A simple, easily portable device for comparing the dry strength of test bars (modulus rupture of test bars) was also made (Hausner 1985). The production or construction of ICS is done by using other materials such as clay, bricks, stones, iron tripods, and metals.

| Clay Type | Modulus Rupture of Test Bars |
|---|---|
| *Thimi* clay (tan coloured, slightly sandy) | 11 $N/mm^2$ |
| *Damauli* clay (black, silty, highly plastic with traces of dixenite) | 5 $N/mm^2$ |
| *Syangja* clay (tan and black mixed, no sand) | 12 $N/mm^2$ |

Various organisations are involved in improved cooking-stove programmes (Table 4 next chapter). Among them RECAST and CFDP organised training programmes for potters from different districts on the construction of ceramic ICS. A number of organisations also produce ICS with local mud-n-brick/stone.

ICS technologies are promoted by various organisations including the PCRW project of Women's Development Division (WDO) of the Ministry of Local Development and the Small Farmers' Development Programme (SFDP) of ADB/N.

# DISSEMINATION

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## Historical Background

Mass scale distribution of ICS commenced in Nepal when RECAST was commissioned to carry out R&D on ICS with support from HMG/UNDP/FAO/CFDP. A field testing programme was implemented in 1982, and following a positive evaluation the CFDP and other non-governmental organisations began distribution of Insert Stoves and Double Wall Stoves. In 1982, UNICEF also developed a ceramic ICS, the New Nepali *Chulo.* This ICS was popular with UNICEF-assisted projects such as SFDP and the Production Credit for Rural Women (PCRW).

*Distributing Organisations*

There are a number of organisations involved in cooking-stove distribution. These organisations have different administrative affiliations (e.g. government, private, non-government, etc), and include:

- o the Community Forestry Afforestation Division (CFAD)
  Hattisar, Kathmandu,
- o the *Terai* Community Forestry Division Project (TCFDP)
  Hetauda,
- o the Agricultural Development Bank (ADB)
  Ram Shah Path, Kathmandu,
- o Women's Development Division (WDD)
  Jawalakhel, Lalitpur,
- o Save the Children Fund/USA (SCF-USA)
  Lazimpat, Kathmandu,
- o Nepal-Australia Forestry Project (NAFP)
  Baneswar, Kathmandu,
- o Earthquake Affected Areas' Reconstruction and Rehabilitation Project, Ministry of Housing and Physical Planning, Lalitpur,
- o Lutheran World Services (LWS)
  Bhatbhateni, Kathmandu,
- o Family Planning Association and Parasite Control,
  Lainchaur, Kathmandu, and
- o A number of Watershed Management Projects.

Some organisations, such as the Community Forestry Development Project (CFDP), the Resource Conservation Utilisation Project (RCUP), Integrated Hill Development Project (IHDP), CARE/NEPAL, the Tinau Watershed Management Project, and the Red Cross have discontinued distribution of ICS.

**ICS Models Selected for Distribution**

Different models of the ICS are currently available, for example, Insert Stoves, Double-Wall Stoves, New Nepali *Chulo*, Tamang Stoves, Mud Brick Stoves, One-ring and Two-ring Mud Stoves, and Two-ring Metal Stoves with top rings. Distribution is carried out through various organisations supported by FAO, USAID, UNICEF, the European Economic Commission (EEC) the Australian Government, and a number of other donor agencies. RECAST distributed a number of stoves in its project areas, but the largest distributor is the CFDP; it distributed stoves in 12 out of its 29 districts. More than 60 thousand ICS are distributed throughout the country.

According to the Water and Energy Commission Secretariat (WECS), by 1986/87 the total number of ICS installed was 44,946 (Table 4). However, lack of proper coordination among distributing agencies renders it difficult to assess the number of ICS. According to the TCFDP, more than 18,000 ICS have been distributed - 2,000 of which have been distributed by SCF/USA.

**Table 4: ICS Distributing Agencies: Performance Indicators**

| Organisations | Stoves Installed Up to 1986/87 | Target Up To 1989/90 Cumulative | ICS Models | Concentrated Area (Geographical Distribution) | User Input |
|---|---|---|---|---|---|
| CFDP (UNDP/FAO) | 22,136 | 30,000 | Insert Stove, *Tamang* Stove | Mid-hills and Mountains | Minimal |
| RCUP (USAID) | 1,001 | 2,000 | Double wall New Nepali *Chulo* | Mid-hills | " |
| TCFDP (EEC) | 9,610 | 20,000 | Insert Stove | *Terai* | " |
| N/AFP (Australian Govt.) | 2,400 | 4,500 | Insert Stove Mud-n-brick stove | Mid-hills Mountains | " |
| ADB/N (UNICEF) | 4,100 | 10,000 | New Nepali *Chulo* *Tamang* Stove | Mid-hills *Terai* | " |
| CWSP | 1,699 | 3,500 | Insert Stove | NA | " |
| Others | 4,000 | - | - | NA | " |
| Total | 44,946 | 70,000 | | | " |

Source: WECS Report 1988.
Note: NA - Not Available

The distribution was not planned properly, taking geographical regions into account. From 1982/83 to 1986/87, the same ceramic Insert Stoves and the New Nepali *Chulo* were distributed widely from the *Terai* to the mid-hills and mountains. Later *Tamang* Stoves were installed by the CFDP, Family Planning and Parasite Control Project, Action Aid, the SFDP, and the PCRW Project in the mid-hills, and distribution is continuing while SCF-USA and NAFP are distributing simple mud-n-brick or mud-n-stone stoves with chimneys in the mid-hills. In Rautahat, the TCFDP is launching a pilot stove programme with non-chimney stoves, single-ring mud stoves, and two-ring mud stoves with metallic grates.

*Distribution: Approach and Strategies*

The Seventh Five Year Plan targetted the distribution of 160,000 ICS under the alternative energy development programme. Various organisations were involved in meeting the target, through different extension strategies. The strategies involved varied from free distribution, subsidised distribution, and sale.

Depending upon the types of organisation involved, training programmes were arranged for installers and promoters before distribution in the target areas. Under the Forest Department, Community Forestry Development Projects (Hills and *Terai*) organised regular training programmes for installers. Two promoters per district have been engaged to promote, monitor, and plan for distribution. Recruitment is usually local. Ceramic ICS are produced in different areas by the districts and transported to the local headquarters of their respective organisations. Transportation from the project area to the user's house is paid for by the user. Promoters then arrange with the installers for installation.

Under the Forestry Department, the distribution of ICS is free. Within any one organisation, there are different approaches to distribution (Sulpya 1989). For instance, in Chitwan District (during the 1988 survey) it was found that the former *Panchayat* was responsible for stove distribution. Each *Panchayat* received 18 to 27 stoves, at the rate of 2 to 3 stoves per ward and stoves were distributed by lottery. Many people were disappointed because they did not receive one. In Dhanusa District, on the other hand, stoves were distributed on a first come first served basis, and in Rupandehi District, the responsibility for stove distribution was placed with the District Forestry Office, and applications were received for a period of up to 3 months only.

SCF-USA installs the ICS, charging a minimum of Rs 10/- to Rs 40/- for women who are taking informal literacy classes.

The Nepal-Australia Forestry Project discontinued the free distribution of ceramic Insert/New Nepali *Chulo* cooking-stoves for a period of time and later, with the help of RECAST, distributed mud-n-brick/stone stoves, with mud-block chimneys constructed on site. The cost of this stove is negligible as it is made out of locally available materials.

*Deficiencies in the Approach to Distribution*

Over the past few years, the ICS were widely distributed by a number of organisations involved in development activities. Distribution was target-oriented and failed to examine the approach in a holistic perspective thereby becoming trapped in artificially defined disciplinary boundaries (Sarin 1989). Although promotion of ICS is one of the most important components of fuelwood management programmes, in most cases the programmes were run without properly assessing needs or surveying geographical regions. Defects in distribution are also because of the lack of proper monitoring, lack of feed-back and lack of technical back-up units. There was also a lack of proper coordination among the R&D and distributing organisations who failed to tap the technical know-how of R&D. Most projects distributed one or two types of ceramic ICS only to the mountains, hills, and the *Terai*. Some projects still continue to distribute ceramic and other types of ICS in their project areas.

## ADOPTION AND TECHNOLOGY PROMOTION CASES

The overall acceptance of ICS was low (WECS 1987). As observed during various surveys, it differed from organisation to organisation. Table 5 shows the adoption rate of ICS.

**Table 5: Adoption Rate of ICS**

| Survey Conducted by Organisation/ Private | Number of Households Surveyed | Percentage of Use | Cooking-stove Models | Survey Area by Geographical Region | Comments |
|---|---|---|---|---|---|
| CFDP 1984 | 538 | 70 | Insert Stove | Mid-hills | after 1 year of installation |
| ADB/N 1985 | ? | 80 | New Nepali *Chulo* | ? | " |
| RCUP | ? | 70-75 | Double Wall | Mid-hills | " |
| UMN | ? | 40 | New Nepali *Chulo* | " | after 3 years of installation |
| RECAST 1986 | 40 | 100 | *Tamang* Stove | " | after 1 year of installation |
| CFDP 1986 | 499 | 63.5 | Insert Stove | " | " |
| Sulpya 1989 | 226 | 58 | Insert Stove | *Terai* | after 1 & 2 years of installation |
| WECS 1987 | ? | 10-30 | ? | Mid-hills | ? |

Source: Introduction of Improved Stoves for Domestic Cooking in Nepal, CFDP 1984.
Five Energy Workshops, WECS 1985.
Improved Cooking-Stoves for Domestic Cooking in Nepal, RECAST 1987.
A Study on the Impact and Effectiveness of Insert Stoves in the *Terai*, Sulpya 1989.
An Evaluation of Alternate Energy Technologies in Nepal, WECS 1987a.

**Further Field Observation**

Defective construction was also observed at ceramic ICS production sites. They were not produced as specified in the laboratory, and, as a result, high fuel consumption was likely. In most cases, ceramic ICS were purchased without examining them for cracks. In Badhikhel, Bhaktapur District, stoves with structural defects and which were incomplete were delivered from the potter and installed in several households. After a few months of operation, the stoves ceased to function. This had a negative impact on the national ICS programme. One case observed in Rautahat District was that of a chimney cap that sunk completely into the chimney pipe. In Doti District, the diameter of the chimney pipe was hardly 7 cm and the body of the stove looked like a round-bottomed cooking pot.

A majority of the people complained that the ceramic ICS was only suitable for a small-sized family. The stove was fragile and many users who had ceased to use their stoves complained of cracks in the combustion chamber, although some stoves were in use after minor repairs at home. It was suggested that the wood-feeding outlet (entrance door) should be on the side so that the stove would take up less space and the second ring would receive sufficient heat for cooking.

Apart from the ceramic ICS, *Tamang* Stoves were also installed in some areas. These stoves can be locally constructed with locally available materials such as mud-brick/mud-stone iron tripods, and with very little training. The chimney can be made by using mould. In some areas it was observed that the stoves were constructed with massive walls, low baffles, and unusually large wood feeding-outlets.

Wood (1987) estimated that only 70 per cent of the installed stoves were used in the first year, 60 per cent in the second, 40 per cent in the third, and 20 per cent in the fourth year, with no stoves being used beyond four years. As reported, the life of the ceramic stove varies from two to four years (Pradhan and Rijal 1988). Some projects have recorded better performances than others.

In a number of regional countries, where ICS programmes are also being conducted, evaluation results indicated that acceptance rates in India were below 50 per cent during the early years of the national stove programme (FAO 1988). In some NGO programmes where training has been very thorough, users played a major role in the field testing and modification of the stove, and, where extensive monitoring was carried out, acceptance rates were greater than 70 per cent. In Indonesia, over 60 per cent use was reported, while, in Sri Lanka, the level of acceptance was recorded as over 80 per cent.

# 5

# FIELD CASE STUDIES

## Case Study 1

In 1985, RECAST installed 50 *Tamang* Stoves in Hokse Village, 25 minutes walk from Palanchock Bhagawati in Kabhre District. Because of the iron quadripod used in the stove construction, people found it suitable for cooking their staple food or *dhindo* (maize porridge). During the construction of the stove, the iron quadripod was driven into the ground to give a firmer foundation so that it could withstand the force exerted while stirring cooking *dhindo*. At the time of installation, a large number of villagers were, however, asking for such stoves. At that time there were 40 stoves in one area of Hokse Village alone, making it easy to study the impact and effectiveness of the distributed stoves. However, after six months the *Pradhan Pancha* came to RECAST with an application for 62 *Brahmin* and *Chettri* households which were willing to pay Rs 60/- per stove and from 200 *Tamang* households which were willing to pay Rs 20/- to Rs 30/- per stove. He also claimed that they had threatened not to vote for him and to smash the chimneys of the stoves already installed if *Tamang* Stoves were not installed in other villages and wards. This application was forwarded to the CFDP and then to MFSC, but no action was taken because it was claimed that Kabhre did not belong to the CFDP site.

The Family Planning and Parasite Control Project, based in Lainchaur, has a project at Panchkhal where they installed 13 *Tamang* Stoves in 1987 with the help of RECAST in an attempt to create demand in that area. After one month, 15 more stoves were installed. Later the demand grew and a policy of charging Rs 40/- per stove for those affiliated with the project and Rs 70/- for those not involved with the project was adopted. More than 200 stoves have been installed and installation continues.

In 1989, it was also observed in Hokse that some of the stoves (around 8) were removed from *Tamang* households and reinstalled in *Brahmin* and *Chettri* households; the installer was paid Rs 60.

## Case Study 2

In 1990, with the help of the Centre for Rural Technology (CRT) a training programme on ICS construction was organised by the ADB/N in Western Nepal under the Environmental Project. With grants from UNICEF, SFDP, and WDS, ICS are distributed free of cost. Recently, a policy of charging a certain amount of the cost to the users has been adopted. The charge differs from one place to another. An interesting approach adopted by the SFDP in Western Nepal involves paying the trained ICS installer (farmer) in full for a certain number of stoves; he then takes full responsibility for promoting and constructing *Tamang* Stoves. This approach initiated the privatisation of ICS production and distribution. Users are charged about Rs 40/- per stove. The chimney is constructed out of a mould of mud and brick and these installations have been successfully carried out in Palpa. Where proper construction has been lacking the CRT discontinued the programme for a period of time.

**Case Study 3**

During the 1988 survey, in three districts covered by the TCFDP, namely, Dhanusha, Chitwan, and Rupandehi, it was observed that 70 per cent of the Insert Stoves installed in 1986 were in use. The lowest use was in Dhanusha (34%) followed by Rupandehi (44%). In Chitwan District, 75 per cent of all the stoves installed in 1987 were in use. In Chitwan there were many complaints about unavailability and the use of 'source and force' in acquiring ICS.

It is learned that, some years ago, in Bharatpur in Chitwan District, Insert Stoves were installed at a cost of from Rs 135/- to Rs 150/- per stove by a private installer, Mr. Kopila, who had previously worked as an installer for the CFDP. More than 350 stoves were installed by him.

**Case Study 4**

In 1990, the TCFDP started a pilot stove programme in Judibela and Saruwatha villages of Rautahat District. These two villages are quite distinct from each other. Judibela lies to the north of Rautahat and fuelwood is collected freely from the nearby forest, while Saruwatha lies to the south of Rautahat where fuelwood is quite scarce and dung is the principal fuel used for cooking. The main objective in selecting these two villages is to determine the impact and effectiveness of improved local mud-stoves in both freely collected firewood areas and areas where firewood is scare.

It was observed that more than 100 improved single and two-ring mud-stoves without chimneys were constructed in Saruwatha Village, while in Judibela the response to improved mud-stoves was not enthusiastic. There, firewood is freely available but actually the villagers were more interested in different sized Insert Stove with chimneys. Through the local Nepal Red Cross, 50 Insert Stoves were installed. In Saruwatha, the improved mud-stoves were installed at the cost of Rs 5/- to Rs 20/- per stove. The TCFDP pays Rs 15/- for construction of the single-ring mud-stove and Rs 20/- for the two-ring mud-stove. The project also provides a metal grate worth Rs 8/-. The total cost per stove for the TCFDP is from Rs 23/- to Rs 28/-. It was observed that women who have received training are promoting the stoves which are a modified version of the traditional mud-stove. These stoves also helped to improve the suitability of kindling such as dung-sticks and agricultural residue. The stove is also portable and can be installed outside or inside depending upon the season; it also holds different sizes of cooking pots.

In the promotion of these cooking-stoves, two households were chosen for a kitchen performance test. A certain amount of fuel was given to cook a given quantity of food on the traditional stove for one day and on the improved two-ring stove for another day. It was found that in cooking the same amount of food (rice, potatoes, onion soup), the specific daily consumption of dung-sticks and soft wood was 1.16kg per head on the traditional two-ring stove whereas, on the introduced improved two-ring stove, it was 0.623kg. The perceived fuel saving was around 46 per cent; the improved single-ring mud-stove saved around 44 per cent.

**Further Field Observations**

A case was observed in Jumla in 1984, with a metallic stove having a 6.6m long metallic chimney and which consumed 37kg of fuelwood to cook a meal for 9 persons. The stove had no baffle but had a damper on the chimney; the cook, however, never used the damper to control the fuel. All the heat was directed into the second ring or into the chimney. The stoves were in the quarters of the Jumla Technical School.

Recently, a technical evaluation survey of the SCF-USA-installed mud-n-brick ICS with a ceramic chimney, at *Ilaka* No. 1 in Gorkha, was conducted. It was observed that the majority of stoves were not well installed and because of this the stoves did not perform well in terms of fuel saving. In most cases, the housewives themselves constructed the stoves according to instructions received, or by observing the installed stoves of their neighbours. In one village, out of 30 stoves distributed, only 10 stoves were installed.

**Lessons Learned from the Case Studies**

Acceptance of ICS depends upon the economic status of the people. If fuel supplies are predominantly non-commercial and fuel is available free of charge, the incentive for consumers to invest in ICS is minimal. Open fires (three stone/iron tripod), which are highly inefficient, or other simple traditional stoves are still being used by the majority of households. The governmental, non-governmental, and bilateral and multilateral organisations are still hoping for a large-scale introduction of energy efficient ICS in an effort to reduce the rate of deforestation and prevent the impending household energy crisis.

Lessons drawn from the case studies and field observations are highlighted in the following points.

- The priorities of rural women vary a great deal. Saving energy is not their top priority.

- Some stove designs are not based on women users' priorities.

- In many areas, particularly in areas with good agricultural production, agricultural residue and dung-sticks, rather than firewood, are the principal domestic cooking fuels.

- Traditional stoves used for cooking animal feed need to be replaced by ICS.

- Mass adoption of unifocal ICS needs to be replaced by broader-based development projects in which ICS are integrated as a component, e.g., improved kitchen conditions and sanitation, extra-income generation, biogas for lighting as well as cooking, kitchen gardens, and agro-forestry. Good examples can be taken from SFDP and WDD programme activities.

- Until now, the distribution of ICS has been either free or on a subsidy basis in rural areas. The distribution of ICS through commercial channels is more likely to succeed more rapidly in the monetised urban and semi-urban areas where fuelwood is purchased rather than collected.

**Organisation and Institutional Back-up Unit**

RECAST has been involved in R & D activities on cooking-stoves for several years. It can be considered as a pioneer in current ICS developments. As a result of R & D efforts, various models have been designed for the mid-hills and rural areas of the *Terai* and some of them are propagated by different distributing organisations. RECAST also acts as a technical back-up unit with involvement in training, refresher training, technical services, evaluation, analysis, field testing, and monitoring. From 1982 to 1984, regular interactions took place between RECAST and other cooking-stove distributing agencies. On request from such agencies, RECAST provides technical support for the effective implementation of the cooking-stove programme.

**Factors Affecting the Adoption of ICS**

The ceramic ICS faced serious problems regarding its durability during transportation and also the availability of good clay deposits. The cooking-stove body was upgraded by conducting some tests for clay and by adding ceramic powder, fine sand, and talc. But these improvements were confined only within the laboratory, as the potters did not accept these mixtures for working on their traditional pottery wheels. As it is, the ceramic ICS tends to crack and break during thermal expansion and to contract during cooking. Some of the factors that affect the adoption of ICS are given below.

- o breakage of stove parts
- o blocked chimney
- o installed in wrong place and back draught
- o more time required to heat the second pot
- o not large enough for the family
- o need for space-heating during winter (cold season)

**Current Issues**

Various organisations have distributed and installed ICS in selected rural areas of Nepal. However, these are not suitable for all ethnic and geographical regions or for development regions. Economic stoves for cooking commercially in restaurants, army and police barracks, student hostels, and cottage industries (e.g., hand-made paper) are yet to be developed but thorough field investigations are necessary to optimise the designs. R & D work into further improvements is needed if wider acceptance of ICS is to be accomplished. For example, the ICS distributed by various organisations at present may comply with the appearance of improved models but not all of them have the same efficiency. The present models of ICS with ceramic chimneys, no doubt, are economical but in the high mid-hills and mountains, where space heating is achieved by burning wood during the cold season, these stoves are not as successful as open fires (*agenu* or iron tripod). In Nepalese society, long logs of fuelwood are widely used for cooking and short logs are hardly used at all. ICS has a smaller wood-feeding outlet in comparison to traditional stoves. Because of this it does not hold logs that are crooked in shape. Use of short sticks and logs will probably improve energy management during cooking and will help in the design of efficient cooking-stoves.

Because of non-uniformity in the distribution approach and the strategies of various distribution, expectations of free gifts of ICS, free installations, and free maintenance and repair (chimney pipe cleaning) have been raised. This has a negative impact even on those who are potential buyers.

There is, as yet, no institution with overall responsibility for ICS R & D and field implementation. Presently, ICS programmes are implemented through various organisations under the Ministry of Forest and Soil Conservation, the Ministry of Health, and the Ministry of Local

Development. The need to strengthen such institutions, with support and policy guidelines, has been felt. In terms of stove promotion, the current level of publicity has not attracted wide attention among potential users.

**Constraints and Opportunities for the Development of ICS Projects**

On the basis of the discussions presented above, the major constraints for the development of ICS programmes in Nepal can be listed as follows.

- ICS technology is a very complex one, especially in the context of Nepal. A single cooking-stove has to perform so many tasks; for example, fuel saving, space-heating, lighting, smoking for insect control, use of different sizes of pots, and preparation of different kinds of food, including maize and bread (*roti* - which has to be baked first on glowing charcoal). In addition to performing all these tasks the cooking-stove should be cost-effective.
- There is a lack of extensive and continuous research and this holds back the stove programme in terms of fulfilling users' needs.
- Interactions between researchers and extension agencies are negligible and hence, also, the subsequent transfer of technology.
- There is a lack of quality control on production sites, resulting in the production of low quality stoves. Stoves are also too heavy and fragile for transportation over rugged terrain. Distribution is also hampered by the lack of skilled installers.
- There is a lack of interaction between researchers and policy planners. This is one of the reasons why the necessary funds are not made available.
- Little effort is made to popularise the ICS at the village level. Except for a few villages, the promoters do not conduct promotional or maintenance visits and repairs are not carried out. The promoters felt they should be provided with transportation and a field allowance in order to work in the field.

Energy and environmental concerns are being given high priority attention in developing as well as in developed countries. Rapid deforestation has resulted in a significant loss of biomass productivity. Patterns of energy use are changing rapidly in urban, semi-urban, and even in rural areas in Nepal. As fuelwood prices rise, there is a growing tendency to use kerosene and even electric heaters. The problem for the rural poor is that they are unable to switch from biomass fuels because of the prohibitive costs of other forms of fuel. Thus, fuel conservation is the only option for the rural poor.

## 6

## OPTIONS FOR THE FUTURE

In future, in order to be more effective the ICS programme needs to be strengthened in four major areas - research and development, programme management, institutional arrangements and policies and programme improvement. Policy decisions and course of action under each area are suggested below.

### Cooking-stove Research and Development

Both chimney and non-chimney cooking-stoves should be designed for both cooking and space-heating and for use with a variety of biomass fuels. The design should be such that the cooking-stove plays an important role in maintaining clean and improved combustion.

Non-chimney stoves can be useful in the *Terai* Region where they can be used in thatched houses, as well as in the mountains where space-heating is needed. The stove should be made in such a way that the chimney can also be fixed on afterwards, if necessary, with only minor on-site modifications. This will also help to increase the present rate of production by a factor of 2.5.

In order to facilitate the use of different sizes of cooking pot, the ring should be shaped as an inverted cone so that it can hold various sizes of pot.

More research work is needed to improve/modify the traditional stove, ceramic stove, and even the *Tamang* Stove; they should be easier to construct, have mud-block chimneys, better combustion or clean combustion, and they should be fuel efficient.

Extensive field work should be carried out on stove testing, modification or optimisation of design on-site, and development and distribution strategies. Distribution can be improved by identifying priority zones where fuelwood scarcity is acute. The ultimate objective is to create a self-sustaining process of distribution.

The Government should provide for core and organisational support to R & D institutes as well as to distributing agencies, particularly the NGOs and voluntary organisations such as the Women's Organisation.

### Cooking-stove Programme Management

In the previous stove programme, mass-scale distribution was conducted by the District Forestry Offices. Most district office employees, including district forestry officers, felt that they did not know sufficient about improved stove technology for effective implementation of the programme. The same opinion is shared by other organisations where there is a lack of manpower and skill development. Training is needed for research, production, promotion, marketing, and management at various levels.

The ICS should be built by using moulds. This will help to produce standardised stoves that are laboratory approved and to maintain critical dimension. Use of locally available materials such as clay, stone/brick, and plant fibres as well as modification/improvement of the existing local stoves should be given more emphasis.

Testing and certification should be done prior to the distribution of ICS. In this case, RECAST can test the efficiency and certify the cooking-stoves.

Training should be given to local people in stove construction and promotion. The emphasis should be on women who are the ultimate users of ICS. The programme should include pilot project planning and management, impact assessment, and monitoring and evaluation of field programmes. It should also initiate private and market-oriented production of ICS in the future.

A regular monitoring and review system is necessary for the effectiveness of future efforts.

**Institutional Arrangements and Policy**

There should be clearly defined roles for government lead agencies and supporting agencies. As suggested in the national seminar on ICS in 1988, RECAST should play a lead role in the R & D work and the Ministry of Forest and Soil Conservation should be the lead national agency for the distribution of ICS. During the Fifth Energy Workshop, 1985, the role of WECS was identified as a national coordinator of ICS programmes. In order for WECS to fulfill this role, interagency cooperation and support, as well as coordination among policy-planners, decision-makers, and researchers is necessary.

The Stove Research and Development Action Plan (SRDAP) Committee, which was formed within RECAST and which is open to those involved in cooking-stove promotion, needs to be strengthened by provision of financial support. This committee is supposed to identify research needs and operate in close cooperation with implementing agencies.

ICS design, development, and field observations should be published in a newsletter, either separately or in an alternative energy newsletter, through a proper institution or the SRDAP Committee. For this, financial resources should be allocated.

Considering the topographical conditions, the transportation of ICS from one place to another is quite hazardous. Emphasis should be given to the production of ICS from locally available materials by using moulds and maintaining standard dimensions. Nepal Fuelwood Corporation (NFC) should provide short-sized logs. The use of short logs will improve energy management during cooking.

Women should be actively involved in stove energy programmes and receive training on distribution and on extension methods.

**Programme Improvement**

Based on the above discussions, it can be seen that the process for the development and sustained adoption of ICS is not short-term in nature. There is a need to gradually build up field experience, manpower, and continuous support over a number of years. A quick result with high impact, and/or an easy clear-cut solution, has not been experienced so far in any country using

ICS Technology.

The ICS Programme is really challenging but so far the focus has been only on fuelwood conservation. Through the introduction of ICS, other rural development aspects should be integrated into the programme; for example, kitchen improvement, sanitation, women's upliftment, income-generation, biogas, and agricultural processing. Experience gained from the SFDP and the PCRW projects of the ADB/N and WDD should be taken as an example. RECAST, in collaboration with the Women's Development Unit of Panauti, is implementing a similar type of programme with support from FAO's Regional Wood Energy Development Programme (FAO/RWEDP) Bangkok, and UNICEF, Nepal.

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