ASSESSMENT OF CURRENT ENERGY CONSUMPTION PRACTICES, CARBON EMISSION AND INDOOR AIR POLLUTION IN SAMAGAUN, MANASLU CONSERVATION AREA, NEPAL

A Dissertation Submitted to the
Central Department of Environmental Science
For the Partial Fulfillment of M.Sc. Degree in Environmental Science,
Institute of Science and Technology, Tribhuvan University, Kirtipur,
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LETTER OF RECOMMENDATION

This is to certify that the dissertation entitled **"Assessment of Current Energy Consumption Practices, Carbon Emission and Indoor Air Pollution in Samagaun, Manaslu Conservation Area, Nepal"** prepared by **Ms. Rajani Suwal, Roll no. 6379,** as a partial fulfillment of the requirement for the completion of Master's Degree in Environmental Science has been carried out under my supervision and guidance. The work performed and results presented in this dissertation are original and has not been submitted for any other degree. Therefore I recommend her work for the approval.

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Letter of Acceptance

This Dissertation presented by **Ms. Rajani Suwal**, Roll no 6379**, e**ntitled **"Assessment of Current Energy Consumption Practices, Carbon Emission and Indoor Air Pollution in Samagaun, Manaslu Conservation Area, Nepal"** has been accepted as a partial fulfillment of the requirement for the final year of the Master's degree in Environmental Science.

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Declaration

I, Rajani Suwal hereby declare that the piece of work entitled "**Assessment of Current Energy Consumption Practices, Carbon Emission and Indoor Air Pollution in Samagaun, Manaslu Conservation Area, Nepal",** presented herein is genuine work, done originally by me and has not been published or submitted else where for the requirement of a degree program. Literature and data works done by others and cited within this dissertation has been given due acknowledgements and listed in the references.

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Abstract

Nepal is one of the lowest energy consuming countries in the world. More than 85 percent of its total energy comes from traditional biomass energy such as forests, agricultural residues and by-products from crops. Due to increasing per capita energy consumption, natural resources are being depleted with heavy emission of GHGs in the atmosphere which is supposed to be the cause of global climate change. The main objective of the study was to study the current energy consumption practices, to estimate the particulate matters and carbon emission from the current practices and to recommend the most suitable renewable energy technologies. The field work was based on primary and secondary data with design methodology were used. Firewood burning was found to be the major sources of energy used for cooking purposes in the Samagaun. The use of this traditional fuel leads to the different environmental issues like deforestation, indoor air pollution and ultimately affecting on human health.

From the results, we can say that traditional cooking stove (TCS) user is found to be in dominant number then improve cooking stove (ICS) user. The total amount of firewood used per day by TCS users are 2135kg/day whereas ICS users are 349kg/day. The average amount of firewood consumed by traditional and improve cooking stove user per day is 62.79 kg and 43.63kg respectively. The per capita/year firewood consumption of TCS and ICS user are 4401.9kg/per person/year and 3266.7 kg/per person/ year respectively. The calculation shows that per capita firewood consumption for TCS user is 1.3 times more than ICS user. The per capita/year carbon emission of TCS and ICS user is 8055.47 kg CO_2e per capita/year and 5978.15kg CO_2e per capita/year correspondingly. This calculation shows that ICS emits 1.3 times less CO_2 in the atmospheric environment than the TCS. And the average mean particulate concentration at normal atm. condition for traditional cooking stove was found to be 2866µg/Nm^3 and for improved cooking stove it was found to be 1333µg/Nm^3 both of which far exceed the national standard of 230µg/m^3TSP.

Based on the study, metallic improved cooking stove could be recommend as the best alternative energy technology in the study area.

Keywords: Climate change, Fuel wood, Greenhouse gas, ICS, Renewable energy, TCS and TSP

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Rajani Suwal

Table of Contents

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AEPC	Alternative Energy Promotion Centre
AGECC	Advisory Group on Energy and Climate Change
ARI	Acute Respiratory Infection
ARRPEEC	Asian Regional Research Programme in Energy Environment and Climate
CBS	Central Bureau of Statistics
COPD	Chronic Obstructive Pulmonary Diseases
CFDP	Community Forestry Development Project
CO	Carbon monoxide
CO_2	Carbon dioxide
ESAP	Energy Sector Assistance Program
FAO	Food and Agriculture Organization
FGD	Focused Group Discussion
GHGs	Greenhouse Gas
GoN	Government of Nepal
GOs	Government Organizations
GJ	Gega Joules
HHs	Households
IPCC	International Panel on Climate Change
ICIMOD	International Centre for Integrated Mountain Development
ICS	Improved cooking Stove
ICSPs	Improved cooking Stove Programs
kg	Kilogram
LPG	Liquefied Petroleum Gas
MoST	Ministry of Science and Technology
MCA	Manaslu Conservation Area
masl	Meter above the sea level
mg/m^3	Milligram per Meter Cubic
MT	Metric Tons
NGOs	Non-Government Organizations
NHRC	Nepal Health Research Council

NAST	Nepal Academy of Science and Technology
NTNC	National Trust for Nature Conservation
NRs	Nepalese Rupees
PM	Particulate Matter
ppm	Particle per Minute
RAWSEP	Residents against Wood Smoke Emissions Particulates
RECAST	Research Centre for Applied Science and Technology
SNPBZ	Sagarmatha National Park Buffer Zone
Sq.Km	Square Kilometer
TWA	Time Weight of Average
TCS	Traditional Cooking Stove
TSP	Total Suspended Particles
UNICEF	United Nation International Children's Emergency Fund
UNDP	United Nations Development Programme
$\mu g/m^3$	Microgram per Meter cubic
VDC	Village Development Committee
VER	Voluntary Emission Reduction
WECS	Water and Energy Commission Secretariat
WWF	World Wildlife Fund

CHAPTER I
INTRODUCTION

1.1 Background

Energy is the center of economic, environmental and developmental issues in today's world. Clean, efficient, affordable and reliable energy services are indispensable for global prosperity. Developing countries in particular need to expand access to reliable and modern energy services to reduce the poverty and to improve the health of their citizens by increasing productivity, enhancing competiveness and promoting economic growth. Current energy systems in this world are inadequate to meet the needs of poor people and are jeopardizing the achievement of the Millennium Development Goals (AGECC, 2010).

About one billion people in Asia depend on biomass as their main source of energy (Thapa 2006). Nepal is one of the highest traditional fuel consuming countries in Asia because of its high dependency on traditional biomass fuels, mostly firewood, limited extent of charcoal and crops and animal residues (Bhattarai, 2003) and 88 percent of people in Nepal live in rural areas (Shrestha, 2004).From the total energy requirements of the country, the rural areas account for 80 percent, mainly used for cooking (Shrestha, 2004). Almost all rural energy consumption (98%) is from traditional biomass resources, such as fuel wood, agricultural residues and animal dung. Accessibility to the electric grid by rural people is very limited, while LPG gas and kerosene oil in the high altitude and remote areas are relatively costly due to the high cost of transport. Therefore, people living in remote areas depend heavily on forest resources to meet their demand for cooking energy. In high altitude areas fuel wood is needed for cooking and space heating; the amount increasing with the increase in the altitude and decrease in the temperature. This results in continuous forest degradation, nutrient depletion from soils (by burning agro waste and cow dung), low agricultural outputs and soil erosion. Together, these aspects result in a further reduction of accessibility to fuel wood (Shrestha, 2004).

1.1.1 Energy consumption pattern in Nepal

Nepal's energy resources are presently classified into three categories namely the traditional, commercial and alternative or renewable energy by National Planning Commission in1995. Traditional energy resources include fuel wood from forests and tree resources, agricultural residues coming from agricultural crops and animal dung in the dry form. Traditional energy resources can, of course, be termed as biomass energy resources since it only covers the bio materials for energy purpose. Energy resources coming under the commercial or business practices are grouped into commercial energy resources that particularly include the coal, grid electricity and petroleum products. Biogas, solar power, wind and micro level hydropower are categorized into the alternative energy resources in Nepal (WECS, 2010). Such resources are considered as the supplement of conventional energy resources. The total energy consumption in the year 2008/09 was about 9.3 million tons of oil equivalents (401 million GJ) in the country out of which 87 percent were derived from traditional resources, 12 percent from commercial sources and less than 1percent from the alternative sources (WECS, 2010).To date, most efforts to develop alternative energy in Nepal have focused on the supply of energy through large-scale hydropower projects for urban areas. These efforts have largely ignored the fact that the rural population will continue to rely on natural resources for their energy needs for a long time to come. Exploring renewable energy resources and technologies which could be used by rural people is critical to changing this situation. Substituting renewable technologies for fuel wood use would help to reduce deforestation and greenhouse gas emissions (AEPC, 2009/2010).

The alternative option available to mitigate the wood fuel burning is the Improved Cooking Stove (ICS), which is implemented in only small percentage of households. A history of ICS development program in Nepal dates back to 1950s with the introduction of some Indian models. Since then, a number of Improved Cooking Stove Programs have been promoted in rural communities of Nepal. A variety of stove designs with different dissemination strategies are promoted both by the government and the non-government organizations. During 1980s, interest and efforts were revived when the National Planning Commission included ICS in an attempt to address the pressing fuel wood problem. The government's concern for fuel wood conservation was also reflected with the inclusion of ICS dissemination efforts as an important component of FAO assisted Community Forestry Development Project in 1981.

In early 1990s, Research Center for Applied Science and Technology modified stove design that can be built completely from cheap readily available local materials which have been promoted by various organizations to complement these efforts. Alternative Energy Promotion Centre/Ministry of Science and Technology executed National ICS Program with the support of Energy Sector Assistance Program. In 1999, the National ICS Program was implemented in the middle hills of Nepal through the experienced NGOs and GOs (Bhattarai *et al.*, 2009).

1.1.2 Fuel wood and indoor air pollution

The burning of fuel wood, dung cakes, straw and agricultural residue creates many hazardous particles, since cooking is usually done indoors this can lead to severe health problem (Smith, 2006). The particles in smoke can go deep into the lungs and these particles alone or combination with other air pollutants can cause acute respiratory diseases such as lung cancer, asthma, chronic bronchitis and irreversible damage to air sacs to those who are in contact with the smoke (Miller, 2004). In Nepalese society there is a gender specific problem in cooking, always female have to cook for their family members, so female are more vulnerable to air pollution (Tamrakar, 1998). Indoor air pollution, especially smoke generated from burning solid biomass fuel in kitchens, is a major environmental health issue in Nepal. According to Pradhan (2009), biomass fuels such as animal dung, crop residues and wood, which are considered the most polluting fuels, lie at the bottom of the energy ladder, and are used mostly by the poor people in Nepal. Global health at the University of California at Berkeley, sounded the alarm that solid fuels, on which almost half of the world's population rely for cooking and heating, account for about 2 million deaths every year when burned in open fires or traditional cook stoves (Smith, 2008).According to Smith, women and young children in the developing countries get exposure to indoor air pollution due to household fuels. They inhale the indoor smoke that contains a range of health-damaging pollutants, such as small particles and carbon monoxide, and particulate pollution levels may be 20 times higher than accepted guideline values, which links the diseases of acute lower respiratory infection, low birth weight, pneumonia, tuberculosis, cancer and Chronic Obstructive Pulmonary Diseases etc (Smith, 2008).

Importantly, the system dynamics assessment found that the Sagarmatha National Park Buffer Zone (SNPBZ) forests are affected by an increasing demand for fuel wood (occurring due to tourism growth), as one of the main sources of energy. Selected forests show an average reduction of 38 percent in forest biomass from 1992 to 2008(Salerno *et al.,* 2010). This shows that the business-as-usual scenario is unlikely to result in the preservation of the current forest status; in fact, such preservation would require 75 percent of fuel wood to be replaced with alternative energy sources. At the same time, 75 percent reduction of firewood use, 80% reduction of dung use would reduce indoor carbon monoxide (CO) concentrations to the standard limits for CO exposure set by the World Health Organization (Salerno *et al.*, 2010).

This study reviews the status of biomass as a source of household energy and indoor air pollution in Nepal. The current statistics show that about 89 percent of total energy is consumed in residential sector is largely for cooking and heating purpose (Lohani, 2011). The major sources of residential energy are fuel wood (86.5%), animal dung (6.5%) and agricultural residue (3.7%), which clearly indicates a huge demand for biomass as household energy in the country. Several studies have shown that particulate matter (PM10) concentration on cooking place was about 8000µg/m^3 against the national standard of 120µg/m^3 in 24 hours average time (Lohani, 2011). Similarly, the total suspended particle (TSP) was about 8,800µg/m^3 against national standard of 230µg/m^3, 21 ppm of carbon monoxide (CO) against national standard of 9 ppm in 8 hour average was found (Lohani, 2011).

1.1.3 Rural Energy development programme in Nepal

The rural population in Nepal is highly dependent on traditional bio fuel for heating and cooking. This form of energy however, is a threat to the environment and the health of the population. Supported by UNDP in 1996, the Rural Energy Development Programme is seeking to promote renewable energy sources by building small hydropower and solar heating (cooking stoves) systems to provide reliable, low-cost electricity to a large number of isolated, rural communities. The programme was subsequently scaled up via the national Hydropower Development Policy of 2001, which focused on rural development via low-cost hydropower systems. The lessons learned from this programme helped formulate Nepal's National Rural Energy Policy in 2006 and its subsequent national five-year plans. This programme has aim to connected 59000 households to micro hydropower installations, constructed 317 new micro hydropower plants with 5.7 megawatts of installed capacity and installed nearly 15000 improved cooking stoves, 7000 toilet-attached biogas plants, and 3200 solar home heating systems. By the end of 2012 modern energy services will have been made available to almost a million people in remote rural areas of the country and15 percent of Nepal's electricity will be generated from micro and mini hydropower plants (UNDP, 2013).

1.1.4 Forest Ecosystem Services

Forests are important ecosystems, delivering benefits that go far beyond the supply of the extracted products, such as timber and fiber, fuel wood, woody biomass for energy and the non-wood forest products. These provisioning services are often considered to be the main forest ecosystem services. However, the provisioning services depend on soil formation, photosynthesis, and nutrient cycling, which are so-called supporting services, provided by the forests. Furthermore, forests play a key role in carbon sequestration, protecting water quality and clean air and in helping to regulate climate, floodwaters, disease, waste, and water quality, thus providing regulating services. In addition, forests reduce air-pollution by filtering, intercepting and trapping windborne particulate matter (FAO, 2005). In many regions, but especially mountainous areas, the single most important value of forests may be protection of soil and water, and the prevention of flooding, avalanches and landslides (FAO, 2005).

Forest resources have the potential to make a major contribution to development by meeting basic needs in energy as well as other forest products, by contributing to food security, by sustaining industries which provide employment and income, and by maintaining environmental stability. But if this potential is to be fully realized, uncontrolled exploitation must be replaced by appropriate management of the entire forest production chain, from the establishment through to the maintenance and harvesting of forest crops to processing, marketing and fuel use in the home and elsewhere. The domestic stove, as a key element of the end-use of forest products, plays an important part in this process (Boy, 2000).

1.2 Rationale of study

The world population is increasing at alarming rate. This increases the demand of the energy accordingly. At the present context this will certainly concentration the pressure on fossil fuel to obtain the increasing demand of energy. But such use of energy based on fossil fuel not only decreases their stock for major environmental degradation. Lack of practice of using Renewable energy technologies (RETs) depending on the traditional energy resources and depletion of forest resources are also the major causes of under development of the country and main cause of abrupt energy crisis. Besides many remote villages of Nepal, where people are deprived of clean energy supply although energy supply is not an interest of their priority list.

Viewing these perspectives in the study area, this reports has been prepared via conducting the survey prepare the energy profile. So as to investigate existing facility in the village, socio-economic condition of the villages and potential energy resources use to uplift quality of life of the villagers. This can in turn contribute to the poverty alleviation, to promote the use of alternate energy at its best possible viability depending upon the location and available resources. Use of alternative energy in accordance to the approach of sustainable development should be the priority as it is an indicator of true prosperity. The actual implementation of the energy assessment will primarily benefit those who spend most of their time for firewood collection, and suffer from various respiratory diseases due to the use of traditional energy resources. So this scenario creates the need for the optimum use of alternative energy so that we can abide by the principal of sustainable development.

1.3 Objectives

Research in Manaslu Conservation Area, an isolated region in the foothills of the Himalayas, will assess the role of renewable energy technologies for reducing fuel wood consumption and reducing greenhouse gas emissions. The study aims:

- To study current energy consumption practices in rural households.
- To estimate the particulates matter (PM) from the current practices.

- To compute the carbon emission from the current practices and
- To recommend the most suitable renewable energy technologies.

1.4 Scope of the study

Major energy demand in developing countries like Nepal is supported by biomass, chiefly by fuel wood in the rural households for their daily life. The high dependency on fuel wood has caused the deforestation at an alarming rate which is leading towards the ecological and climatic hazards. Nepal, with no adequate natural reserves of coal, petroleum and natural gases has to depend on other countries to meet the demand of such commercial fuels and also the alternative forms of energy had not been implemented due to the geological structure of the earth, remoteness, inaccessibility and low economic of the people. Mostly in the remote area people depend on fuel wood from forest for their cooking and other purposes which will causes the forest degradation. The higher and alarming rate of forest degradation is causing loss of biodiversity, change in local climate, working as hazard catalyst, disasters and natural calamities and slowly threatening the human lives.

In this scenario, there is a need to explore new locally available renewable energy resources and technologies which are feasible for the area such as Samagaun in Manaslu Conservation Area where human development is less and as in Nepal where there are not sufficient research carried out to identify the energy generation and consumption in the local level. Hence this study was carried out to identify the alternative source rather than current energy for increasing their livelihood.

1.5 Limitation of the study

1.5.1 This survey is limited to four wards of Samagaun VDC only other remaining two wards could not be surveyed due to different technical constraints such as time and resources.

1.5.2 Although, language translator (Tibetan to Nepali) was hired during the interview. Some information might have been lost during the process of understanding the questions by the translator, asking it and writing the answers of the respondents.

1.6 Overview of contain

The final form of this report is limited in seven chapters along with additional references and annexes.

Chapter I is the introductory and informatory section which includes background of the study. Further, this chapter includes rationale of study, objectives of the study, scope of the study and limitation of study.

Chapter II includes reviews of the literature.

Chapter III covers methodology followed by research design, data collection methods, nature and sources of data and methods of results presentation etc.

Chapter IV deals with study area with site description and map of the study area.

Chapter V shares the findings of the study where the results are presented along with estimation of total GHG emission from current energy consumption, the amount of firewood consumption, Particulate matter finding and its effect to the respondents.

Chapter VI includes the comparison of the results with discussion.

Chapter VII deals with conclusions of the study and recommendations based on the results findings.

CHAPTER II
LITERATURE REVIEW

2.1 History of rural energy in Nepal

Nepal is in the early stages of electrification (1998), with only about 15 percent of the population connected to an electricity supply. The residential and industrial sectors accounted for 39 percent and 41 percent respectively of the total electricity consumption. The load factor (ratio of average demand to peak demand) is low (i.e. 50% in 1996) because of the relatively high share of residential demand for lighting. Electricity consumption in Nepal is expected to grow at 12 percent per annum during 1996-2010. Power sector development accounted for 8-20 percent of the total development outlay of the country during 1985-95, and is heavily dependent on foreign capital. Improvements in energy efficiency are considered to be one of the major options available for the mitigation of greenhouse gases (Bjorklund and Chadwick, 2004)

Energy is a prerequisite for the survival, development, and economic welfare of human beings. Various energy sources have been explored by human society to fulfill energy needs. However, biomass, especially wood, still constitutes a primary energy source in rural areas of developing countries (Nepal 2008). For example, in the Himalayan mountain region, fuel wood is one of the principal sources of energy for cooking, space heating, and water heating in rural households (Rijal, 1999).

The Indian stove models, the Hyderabad and Magan Chulo, were the first Improved Cooking Stove, introduced in Nepal, during the 1950s. In the 1960s, an agro-engineering workshop in the Department of Agriculture developed a mound-based stove model, which was disseminated through the mid-1970s, a number of NGOs and GOs (Peace Corps, Women Training Centre, RECAST, and UNICEF) were involved in ICS research and dissemination of the Lorena stove model. Unfortunately, lack of funding led to stagnation in stove dissemination. In the 1980s, GoN/The National Planning Commission addressed the fuel wood consumption issues in its sixth five year Plan, and together with the introduction of Community Forestry. GoN initiated dissemination of ceramic pre-fabricated stove, supported by FAO and UNDP. Shrestha (2004) reported that the ceramic inserts proved inappropriate to most areas of Nepal, since they were often breaking during long and complicated transportation in hill areas.

The energy consumption pattern by source between 1993/94 and 2002/03 shows that the energy consumption is dominated by traditional sources, which accounted for about 87 percent of the total energy consumption in 2002/03, although its percentage of total consumption has been slowly declining (ICIMOD, 2006). Of the traditional sources, fuel wood accounted for 89 percent, agricultural residues for 4 percent, and animal waste for 6 percent. Fuel wood contributed 75 percent of the total energy consumed in 2002/03(ICIMOD, 2006). This indicates the pressure on the traditional sources, primarily on the forests.

A case study undertaken by Sherpa (2009) in Upper Mustang found that energy demand of 3.1 kg per person/day, totaling up to 6,123.6 metric ton/ year. There is high demand for energy mainly for cooking and heating purpose, mainly because of its cold weather and tourism activities, which is met by very scarce natural resource, now affected by the fast changing weather patterns. Only 18% of this energy demand is met by bio fuels like *caragana*, remaining being met by livestock dung. However, livestock dung is needed for many purposes, viz. fuel, and agriculture productivity and pasture cultivation. If the livestock dung is used for fuel energy, there is less manure left for agriculture, and even lesser for pasture regeneration (Sherpa, 2009).

2.2 Fuel wood consumption by traditional cooking stove

With close to 90 % of the total national energy consumption biomass (wood, dung) is by far the most important primary energy source in Nepal. Nearly two third of the biomass is used for cooking. Unfortunately, the traditional utilization of firewood and dung for cooking in mud stoves or simple three-stone stoves is characterized by low fuel efficiency and inadequate venting of smoke resulting in high levels of indoor air pollution with severe health implications especially for women and little children who spend between 2-7 hours per day in the kitchen. The inefficient use of biomass also contributes to the increasing deforestation and forest degradation in parts of the country (NEEP, 2013).

A study of traditional agro ecosystem conducted by Singh and Sundriyal (2009) to understand status of fuel wood and fodder in central Himalayan village found that the total fuel consumption is 418.86MT and the annual fuel availability is 211.03MT, there is a deficit of 207.83 MT. Total available fodder is 281.76MT but the total consumption is 402.72MT so there is a deficit of 207.83 MT (Singh and Sundriyal, 2009).

The study by Maih *et al* (2009) showed that family size, income, amount cooked and burning hours significantly affected the amount of wood fuel used per family per year. Taking into account different family sizes, the study observed that 4.24 tone firewood were consumed per family per year. The study showed that 42 percent of families used only biomass fuel, 5 percent used liquefied petroleum gas (LPG) and 53 percent used kerosene along with biomass fuels. The main source of biomass fuel was homestead forests (40%). It has been figured out that the incomplete combustion of biomass in the traditional cooking stove poses severe epidemiological consequences to human health and contributes to global warming (Maih *et al*., 2009).

The study carried out by Silwal (2011) in Syafrubasi reported that 67 percent of HHs were using traditional cooking stove and 25 percent of HHs were using improved cooking stove. The total energy consumption of the VDC was 57870.67 GJ per year. 88 percent of the total energy comes from biogas energy (firewood) and 10 percent of total energy comes from non-biomass including kerosene, electricity and LPG in the Syafrubesi VDC. The average per capita energy consumption of the VDC was 23.11 GJ. The per capita biomass fuel consumption was 20.71 GJ whereas the per capita non biomass fuel was 2.32 GJ per year. It shows that the biomass fuel consumption is higher than non-biomass fuel consumption. The total firewood combustion of the biomass fuel of the VDC was found to be 3095.25% tons per year which produce 4698.58 tons of GHGs and might have consequences on environment (Silwal, 2011).

2.3Fuel wood consumption by improved cooking stove

During the initial years of improved stoves distribution (late 70’s and early 80’s), the empirical evidence on the efficiency gains related to the effective usage of these artifacts was mainly anecdotal or restricted to laboratory tests, where it was shown that some stove designs were more efficient than the traditional "open fire" stove (Gill, 1985).

In rural Guatemala, stove users were requested to cook with their improved stoves for a week, and then to cook with a traditional open fire stove for another week. These households were closely monitored by program technicians, firewood was freely provided to them and they were explicitly asked not to modify their cooking habits. Their findings indicate that improved stove usage significantly reduces firewood consumption by approximately 60% (Boy, 2000).

Over the past few decades, improved firewood cooking stoves have been massively distributed around the world, mainly with the purpose of decreasing firewood consumption among rural households. The impact of an improved stove design distributed in the Northern Peruvian Andes on firewood consumption was estimated. Improved stove usage appears to reduce firewood consumption by approximately 46% in the study area (Adrianzen, 2013).

The study by Poudel (2010) in Chekampar side of MCA showed that using improved stoves reduced per capita firewood consumption by 620.5 kg per capita/year, household firewood savings by NRs71357.5 per capita/year. The carbon emissions of traditional cooking stoves user is more than ICS user by 1135.51 kg per capita/year. Out of 61 households, 45.90% HHs reported that they had respiratory and optical problem whereas 54.09% HHs reported they had not suffered from respiratory and optical problem. Improved stoves users agreed that, ICS have many advantages over the traditional one (Poudel, 2010).

2.4 Indoor air pollution

According to a comparative study conducted by Reid *et al.* (1986), the mean personal exposure to Total Suspended Particles (TSP) in traditional (*agena*) cooking stoves and improved stoves is 3.92 and 1.13 mg/m^3, respectively. Similarly, mean personal exposure to CO in traditional stoves and improved stoves was found to be 380 and 67 ppm, respectively. This implies that improved cooking stoves reduce indoor TSP concentration by around 70% and CO concentration by 80% compared with traditional stove (Ried *et al*., 1986).

Pandey (1997) identified the highest rates of chronic bronchitis in Jumla. After many years of study, the Nepal Health Research Council (NHRC 2004) found that the prevalence of ARI among children aged below 5 was 38% (11 of 29 examined in Jumla). Comparing ARI by binary fuel types, children with unprocessed fuel in the kitchen had a higher prevalence (59%, 10 of 17) as compared with children with processed fuel in the kitchen (33%, 1 of 3). Bates *et al.* (2005) confirmed that the use of solid fuel in indoor stoves is associated with an increased risk of cataracts in women, who do the cooking

The indoor air pollution increases the risk of chronic obstructive pulmonary diseases and acute respiratory infection in childhood, the most important cause of death among children five year of age in developing countries. Evidence also excites of associations with low birth weight, increase and prenatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer, cataract and specifically respect of the use of coal with lung cancer. Exposure to indoor air pollution may be responsible for nearly two million excess deaths in developing countries and for some 4 percent of the global burden diseases (Nigel *et al.,* 2000).

The first ever carbon financing project in Nepal was verified in the voluntary market that will pave a way to accessing carbon financing at the grass root level through an appropriate benefit sharing mechanism. A total of 7,500 biogas plants have been installed by WWF Nepal under the Gold Standard Voluntary Emissions Reduction Project in 2010. The final verification report concluded that the emission reductions for 2007 and 2008 were 12,125 tons of CO_2equivalents (2,685 biogas plants).

The time weight of average (TWA24hrs) respirable dust level was measured by gravimetric sampler range from 13 to 2600μg/m^3 in the rural setting and 3 to110μg/m^3in the urban setting. The co- located photometric and gravimetric devices indicate that the side pak personal aerosol monitor device required a calibration factor of 0.48 and 0.35 for rural and urban data whereas Dust Trak devices required of 0.31 and 0.35 for rural and urban setting in correct for the particle size and density of the biomass smoke. Those involve in domestic work in rural Nepal are expose to average respirable dust concentration of -1400μg/m^3 which equate to more than the current

UK limit for respirable dust (4000µg/m^3). The mostly women are the high exposure to the respirable dust concentration and these expose are likely produce respiratory illness (Kurmi *et al.,* 2008).

According to Lohani (2011) biomass is a key source of residential energy providing around 85% from the fuel wood alone. Many Nepalese still use traditional cooking stoves that produce lots of smokes causing a high degree of indoor air pollution. Special women and children are exposed to indoor air pollution since most time they live inside the house or work in the kitchen. Some result suggest that above 8000µg/m^3TSP and 82ppm CO had been found in a kitchen where traditional stoves were used which far exceed the national limit of 230µg/m^3 TSP and 9ppm CO.

2.5 National policies and action plan on renewable energy

Renewable Energy Technologies have increasingly received due attention in periodic plans since the Seventh Plan (1985 -1990) where, for the first time, a targeted approach amongst other policy measures was established for its development. The Eighth Plan (1992 - 1997) envisaged the need for a coordinating body for large- scale promotion of alternative energy technologies in Nepal and the Alternative Energy Promotion Centre (AEPC) thus established as an executing body.

The Ninth Plan (1997 - 2002) formulated long term vision in the science and technology sector which has the fundamental goal of rural energy systems developed as to increase employment opportunity through gradual replacement of traditional energy with modern energy. Renewable Energy Subsidy- 2000 and the Renewable Energy Subsidy Delivery Mechanism- 2000 were formulated and implemented to realize the objectives set out in the plan (NPC, 1991). The Tenth Plan (2002 - 2007) gave priority to suitable and relatively smaller size systems. It also encouraged research on expansion of biogas systems in the Himalayan region and towards reducing the cost (NPC, 2007).

CHAPTER III
STUDY AREA

3.1 Background of study area

The Manaslu Conservation Area is in Gorkha District in the Western Development Region. The district has 69 VDCs. The project area comprises seven VDCs-Samagaon, Lho, Bihi, Prok, Chumchet, Chhekampar and Sirdibas in the northern part of the district. The manaslu conservation area lies in 28^o 20' - 28^o 45' latitude and 84^o 29' - 85^o 11' longitude. All the VDCs except the Sirdibas are bordered with China (Tibet) on the northern side. The elevation of the area ranges from 1,400m to 8,163masl. The major peaks in the project area are Manaslu Himal (8,163m) which is highest peak lies in the Samagaun VDC. The village Samdo lies north of the Manaslu Himal. Other major peaks are Himalchuli (7,893m),Shringi Himal (7,187m), Langpo (6,668m) and Saula (6,235m).The major rivers in the area are BudhiGandaki, Syar, Daroudi and Chepe, besides this the area is endowed with several attractive waterfalls. The major passes in the MCA are Larke (5,205m) and Gyala (5,375m).The Kalchuvan Lake in Prok, Birendra Lake in Samagaun are the important places and attractions to the tourists in the area.

The Samagaun (Figure 2) is lies at $28^0$34'58.6"N, 84^0 38'28.2"E situated at the height of 3390masl.Samagaun is surrounded by High Mountain and traversed by BuddhiGandaki River. Sama VDC is situated on the flat land and consists of two settlements i.e. Sama and Samdo. And the bio-climatic zone varies from sub-tropical to nival with various ecosystems as micro-habitats.

Figure 1: Samagaun VDC (Source: Google earth 2012)

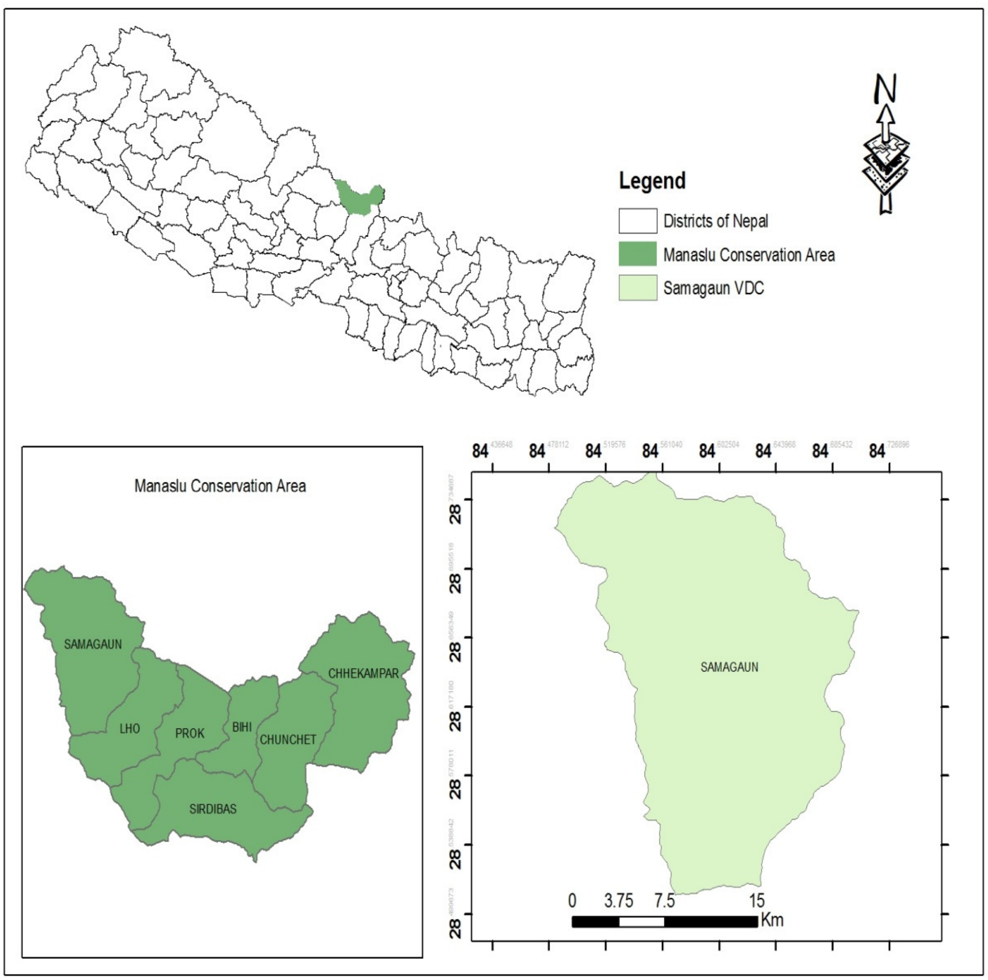

Figure 2: Study Area in Manaslu Conservation Area

3.2 Socio-economic and biophysical condition

3.2.1 Population

According to population census by CBS 2011, the total population of Samagaun VDC is 604 with 197 individual households. The average family size is 4.4. The total population of male and female is 281 and 323 respectively. It has the total area of 333.09sq.km. The main ethic group in the region is Bhotia. And most of the people in the regions are Buddhist with a rich cultural heritage. There are several small and large monasteries (gumba) in the area where Lamas are very influential in promoting social and conservation values by developing and enforcing certain rules.

3.2.2 Education

There are two primary schools, one is Samdo primary school in Samdo village and one is Gaurishankar primary school in Samagaun village. Literacy rate is less than 2 percent only monks and nuns are literate. It might be due to various reason likes farness of school, children are not getting opportunity to have higher classes after the primary school and lack of teacher in their school.

3.2.3 Occupation

The people's means of existence is mostly marginal agriculture, animal husbandry and seasonal migration for labour and trade during the winter months. The main crops grown in the area are naked barley, buckwheat, and potatoes. Besides this, livestock and seasonal trades of yarsagomba are also practiced. Livestock like Joppa (male yak) and Jhomu (female yak), cows, horses etc. are used. According to KMNTC 1998 counting there are 7 Cow/Bull, 823 Yaks, 635 Joppa, 301 Chyangra and 243 Horses in Samagaun.

3.2.4 Land distribution

Samagaun VDC covers 333.09sq. Km area of which agriculture land covers 0.31 percent, Forest land cover 1.36 percent, Scrubland cover 0.23 percent, Grassland cover 16.4 percent, River/riverbed cover 2.78 percent, Snow/glacier cover 18.24 percent, Lake/pond cover 0.08 percent, and Barren land cover 60.59 percent (KMTNC, 1998).

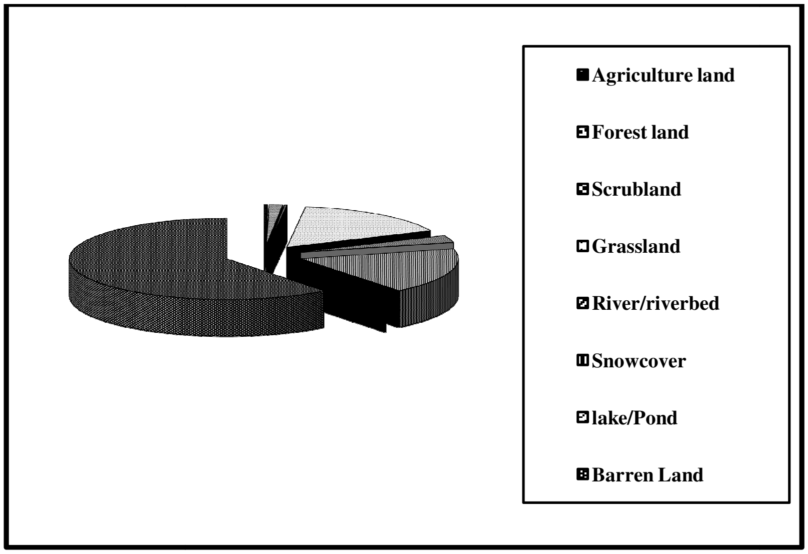

Figure 3: Land distribution of Samagaun VDC

3.2.5 Health and sanitation

The health and sanitation situation in the Samagaun was analyzed from the direct observation and also obtained during the HHs survey. HHs was interviewed about presence or absence of toilet & drinking water facilities. From the survey it was found that the health and sanitation condition was very poor. Each of the sub health post is managed by one health worker with limited medicines in the health post. Besides, traditional healing practices are also prevalent in the area.

3.2.6 Energy use

Samagaun VDC is totally depending upon the fuel wood for the energy need particularly for the cooking, preparation of animal food and heating purposes. The entire household used to fulfill their energy demand from the fuel wood. About 90 percent of the household used the traditional type of cooking stove only few have improved cooking stoves. Electricity is the other energy source which is used for the lighting. And the renewable sources of energy are solar, micro hydropower etc.

CHAPTER IV
MATERIALS AND METHODS

4.1 Research framework

First of all, survey was designed and questionnaire and interview schedule was developed. The natures of data were both quantitative and qualitative form. Qualitative data were collected through questionnaire survey, focus group discussion, key informant interview and observation. Quantitative data were carried out by measuring the indoor air pollution using the medium vol air sampler (model no. APM 821, Envirotech Instruments Pvt. Ltd.). A random sampling technique was adopted to collect data. After data collection it was analyzed by using various statistical tools and techniques for final report preparation (Figure 4).

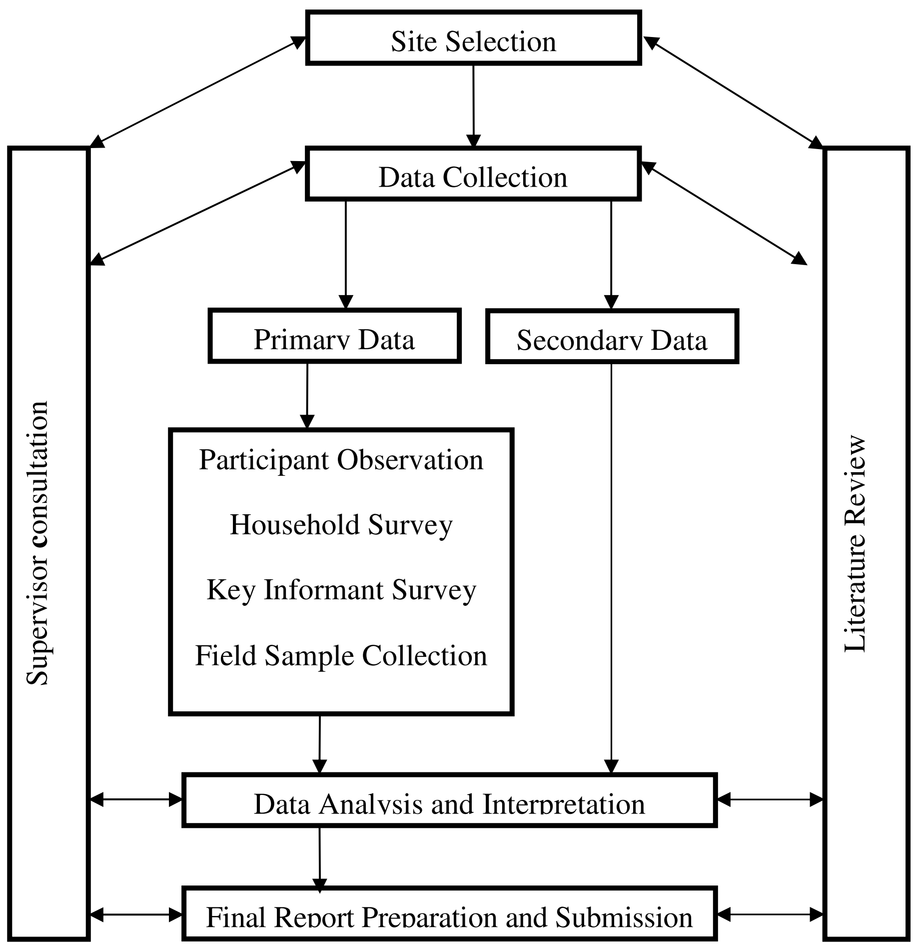

Figure 4: Chart of research framework

4.2 Data collection techniques

4.2.1 Methods of Primary data collection

Primary data were collected with structured schedule interview from the sampled households and indoor air pollution was measured by the air sampler instrument in which each three household from traditional and improved cooking stove user were carried out.

4.2.1.1 Sampling method

Sample survey was carried out to get the information from each household. A random sampling was used for data collection. The number of household for survey was selected ensuring at least 25% sample from total population. Among the 166HHs in Samagaun Village, 42 HHs were randomly selected (Annex 1).

4.2.1.2 Household survey

Among 197 households of the study area, 42 households were taken from 25% of the total households within the VDC and structural household questionnaires survey (Annex 2) were carried out for informative data collection which covers the detail information of both the traditional energy practices and commercial energy too. The household list was acquired from the office of Manaslu Conservation Area, Philim. And the data was collected by random sampling technique.

4.2.1.3 Key informant interviews

Interviews were carried out with key informants of the study area that helps to find out the various type of energy use. The key informants were those persons who have been living there for long period of time and have a great deal of knowledge in energy use. And the information was drawn from elder persons mostly village leader and some teacher of local school too.

4.2.1.4 Focus Group discussions

Discussion was conducted by gathering all the local committee member, concerned stakeholders of the VDC. The major stakeholders who were involved in FGD include teachers, forest users groups, social workers, local politicians, farmers, and Mother

Group (Ama Samuha). It helps to get the information about the past and present dependency on forest for the firewood, health condition of the local.

4.2.1.5 Direct observations

Many of the relevant information which supported the study were obtained from the direct observation and photograph collection on site during the field survey. Important observations were noted and noticeable changes were marked by direct observation and eye inspection method for the indoor air pollution condition, sanitation condition and health related issues was drawn out during the field survey.

4.2.2 Secondary data collection

Secondary data for study were collected from various publications including project reports dissertation reports, books, journal, government policies, NGOs, INGOs and electronic materials were collected and studied together to get the additional information,

4.3 Methods of data interpretation

To compute Carbon Dioxide emissions the conversion of firewood from dry weight of CO_2 is based on Intergovernmental Panel on Climate Change (IPCC), 1996 revised report on Guideline for national Greenhouse Gas Inventory (the conversion rate of 1kg firewood emit1.83 kg of CO^2eqv.) and Smith et al. 2000.Average weight of one kg of fuel wood was determined by weighing each bundle of firewood from the sampled households with the help of spring balance.

And to quantify the total amount of particulate matter in ambient air, medium vol air sampler was used. The sampler consists of a vacuum pump calibrated to draw in a fixed volume of air. The air passes through a filter that acts as a barrier to particles. The average concentration of particulate matter was calculated by step-by-step calculation of ambient particulate concentration (Annex 3)**.**The collected data from the survey had been processed and analyzed using SPSS v.16 statistical tools like Correlation etc. Also, Microsoft Excel was used to produce graphs and figures to use in the text.

CHAPTER V
RESULTS

5.1 Ethnicity, age and family size of respondents

The major ethnic group in this region is of Bhotia (Tibetan origin), nevertheless, they would like to call themselves as Lamas. The average age of the respondents was 45 years. The male and female percentage of the respondents was 62 percent and 38 percent respectively. Majority of the households have family size between 5-7 individuals.

5.2 Types of cooking stove used

Out of 42 households, 81 percent used the traditional type of cooking stove and 19percent used the improved type of cooking stove. The study shows that the traditional type of cooking stove user is in a dominant form than the improve type of cooking stove user which was shown in following figure:

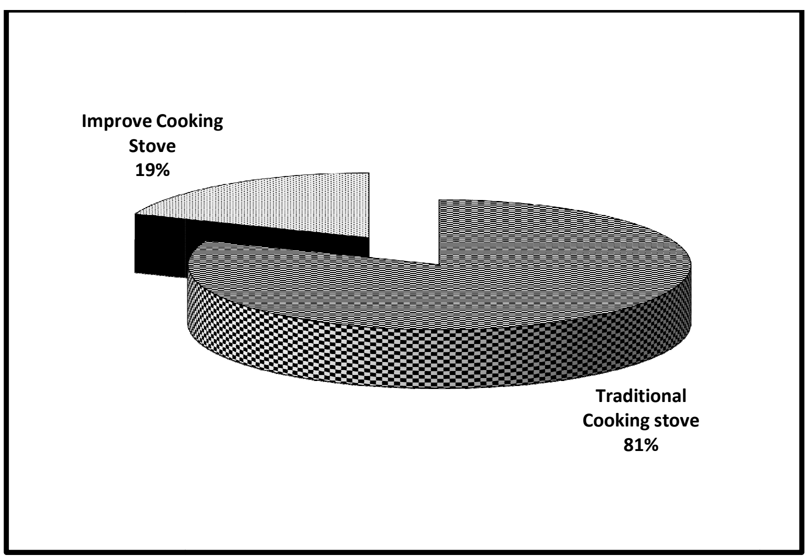

Figure 5: Types of cooking stove used

5.3 Energy for cooking

Entire respondents use traditional energy resources for cooking purpose except agricultural by product/waste. Respondents do not use agricultural-residue for cooking purpose as there is no other option for fertilizers and pesticides inside the VDC. Forest is the main sources of energy for cooking their food in their daily life.

5.4 Source of firewood

The source of firewood for all the respondents in Samagaun VDC is from the protected forest area which is inside the Manaslu Conservation Area (MCA). The restriction on commercialization of firewood has resulted on making all the respondents dependent on the MCA to fulfill their domestic energy demand. Pangshar and Kermo are the two common forests near the Samagaun VDC where the entire respondents collect their daily domestic energy. They are not allowed to cut the tree from this forest, only dry fodder and timber are allowed to carry.

5.5 Species preference for consumption

The people of Samagaun VDC mostly preferred *Betula utilis* (Bhojpatra), *Rhododendron campanulatum* (Chimal) and *Juniperus* spp. (Dhupi) for cooking food. Similarly other species like, Langma and naked barley are also used for cooking purposes. Respondent said, due to easily availability they use *Betula utilis* the most for cooking.

5.6 Weight of per bundle of firewood in kilogram

The average weight of per bundle of firewood in Samagaun VDC was 40Kg (Annex 4). And its standard deviation of average mean was five.

5.7 Family size and types of stoves

Below tabulation of stove type and family size shows the number of TCS and ICS user with respect to family size. The total number of family size of TCS and ICS user was 177 and 39 respectively. The total number of family size is taken to calculate the per capita firewood consumptions of TCS and ICS user. Here we can found the maximum traditional stove user rather than improve stove user as shown below,

Table 1: Stove types of family size

Family Size	Stove type		Total
	Traditional Stove	Metallic Improved stove	
1	3	0	3
2	2	1	3
3	2	0	2
4	6	2	8
5	4	3	7
6	8	1	9
7	4	0	4
8	2	1	3
9	2	0	2
10	1	0	1
Total	34	8	42

Field Survey 2012

5.8 Firewood consumption

The average firewood consumption by TCS and ICS user per day was62.7kg and43.63kg respectively (Annex 5).At 5% level of significance ($\alpha = 0.05$), Z tabulated value is greater than Z calculated value. It shows that there is no significant difference between the firewood consumption in TCS and ICS. (Table 2)

Table 2: Result of z- test of firewood consumption between the TCS and ICS

Firewood consumption TCS(X_1) in kg	Firewood consumption in ICS(X_2) in kg	α	zcal. value	ztab. value
62.79	43.63	0.05	0.27	1.96

5.9 Per capita firewood consumption

The total amount of firewood used per day by TCS user was 2135kg/day whereas ICS users use 349kg/day. The average amount of firewood consumed by traditional and improve cooking stove are 62.79 kg/day and 43.63kg/day respectively.

The total family number of TCS and ICS user was 177 and 39 respectively. Now, per capita consumption of TCS and ICS user was 12.06 kg/per person and 8.95 kg/per person. The per capita/year firewood consumption of TCS and ICS user was 4401.9kg/per person/year and 3266.7kg/per person/year respectively. The calculation shows that per capita firewood consumption for TCS user is 1.3 times more than ICS user.

Table 3: Per capita firewood consumption

Type of stoves	Total no. of traditional cooking stoves user(n)	Total amount of firewood used per day in kg(N)	Average firewood consumption per kg/day(N/n)	Per capita firewood consumption (kg/per person)	Per capita/ year firewood consumption (kg/per person/year)
Traditional (TCS)	34	2135	62.79	12.06	4401.9
Improve (ICS)	8	349	43.625	8.95	3266.75

Field Survey 2012

5.10 Carbon emission

The per capita/year carbon emission of TCS and ICS was 8055.47kg per capita/year and 5978.15kg per capita/year correspondingly as shown in the following Table 4. The difference in amount of carbon emitted by TCS upon ICS was 2077.32kg per capita/year. This calculation shows that ICS emits 1.3 times less CO_2 in the atmospheric environment than TCS.

Table 4: Carbon emission

Types of stove	Per capita/year in kg firewood consumption (kg/per person/year) (X)	Carbon emission per capita/year in kg (X kg *1.83kg)	Difference amount of Carbon emitted per capita/year in kg
Traditional (TCS)	4401.9	8055.47	2077.32
Improve (ICS)	3266.75	5978.15	

Field Survey 2012

5.11 Particulate matter (PM)

The particulate matter was measured in both the traditional and improved cooking stoves. Both of this particulate matter was carried out in normal atmospheric temperature and pressure. And from the study it was found that in traditional cooking stove the TSP was found as 2866µg/Nm^3 and in improved cooking stove the TSP was found as 1333µg/Nm^3 both of which far exceed the National standard of 230µg/m^3

TSP (Annex 6).Here the improved cooking stove reduces about 54% of TSP than traditional cooking stove. (Table 5 and 6)

Table 5: Average particulate concentration in TCS

Initial Wt. (gm)	Final Wt. (gm)	Net Wt. (gm)	Time (min)	Average flow rate (lit/min)	Volume of air sampled (lit)	Average particulate concentration (gm/lit)	Average particulate concentration (µg/Nm^3)	Mean (TCS)
0.0003	0.003	0.003	1440	0.75	1080	0.000002731	2731.43	
0.0003	0.007	0.0063	1440	1.5	2160	0.000002914	2914.06	2866
0.0003	0.007	0.0068	1440	1.6	2304	0.000002952	2952.18	

Field Survey 2012

Table 6: Average particulate concentration in ICS

Initial Wt. (gm)	Final Wt. (gm)	Net Wt. (gm)	Time (min)	Average flow rate (lit/min)	Volume of air sampled (lit)	Average particulate concentration (gm/lit)	Average particulate concentration (µg/Nm^3)	Mean (ICS)
0.0003	0.001	0.0011	1440	0.75	1080	0.00000137	1370.25	
0.0003	0.002	0.0019	1440	1	1440	0.000001287	1287.13	1333
0.0003	0.002	0.0018	1440	0.95	1368	0.000001341	1341.11	

Field Survey 2012

Here in the indoor air pollution measures, the statistical analysis was carried out. At 5% level of significance ($\alpha = 0.05$), t- tabulated value is less than t- calculated value. It shows that there is a significant difference in total suspended particles between the TCS and ICS. (Table 7)

Table 7: Result of t- test of total suspended particles between the TCS and ICS.

Mean particulate concentration of TCS (X_1)	Mean particulate concentration of ICS (X_2)	α	t cal. value	t tab. value
2866	1333	0.05	17.30	2.78

5.12 Health problem by using firewood

From the people perception, we have found that traditional cooking stove have the significantly negative effect in their human health. As the traditional cooking stoves are equipped mostly in the rural household with open firewood with an unsuitable ventilation system which might cause the indoor air pollution. 67.5% of respondent reported that they are suffering by eye irritation by using the firewood for cooking purposes. Whereas 16.5% of respondent reported that they have suffered by cough, 10.54% of respondent reported that they are suffered by asthma and 5.46% of respondent reported that they are suffered by ARI. Mostly the women and children are highly affected because they spent their most of time near the kitchen.

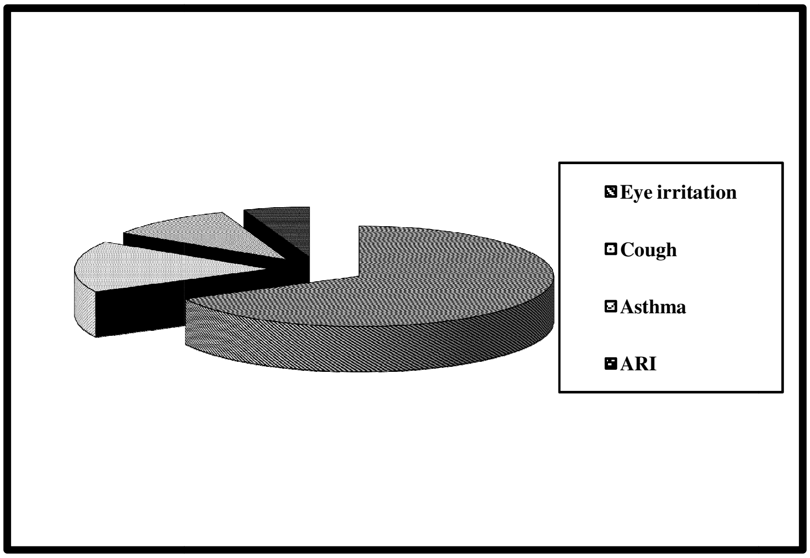

Figure 6: Health problems by using firewood

5.13 Lightening energy sources

Out of 42 household, all 42 families have the electricity and 13 households had both the solar and electricity. The supply of this electricity is from the local micro hydropower. The solar panels were donated by the Chinese government in 2067 B.S. in a few numbers by lottery system.

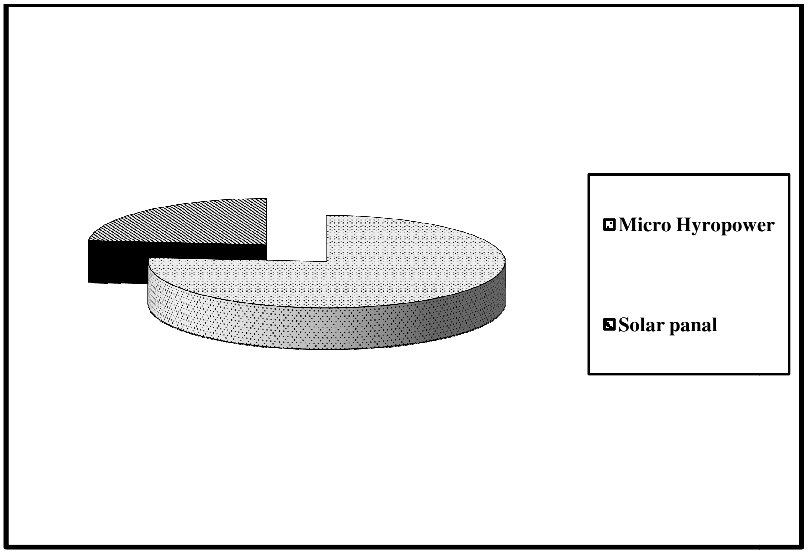

Figure 7: Lightening energy sources

5.14 Information about ICS

From the questionnaire survey, entire ICS user reported that the prime source of the information about the ICS was from their relatives/neighbor. Medias like radio/cable television/ newspaper are almost non-existent because of highly remoteness. There was no any regular supply of newspaper, magazines that would aware people about the ongoing issue and about the new technology in the market. Training/workshops on improved cooking stove were not conducted till date in the study area.

5.15 Duration of ICS installation

Among the eight respondents, four have installed in 2065 B.S. and two have installed in 2066 and 2067 respectively. People buy the ICS from the closer Tibetan markets rather than from the Nepalese markets. We have found that the ICS was installed in the hotel and lodges rather than in other.

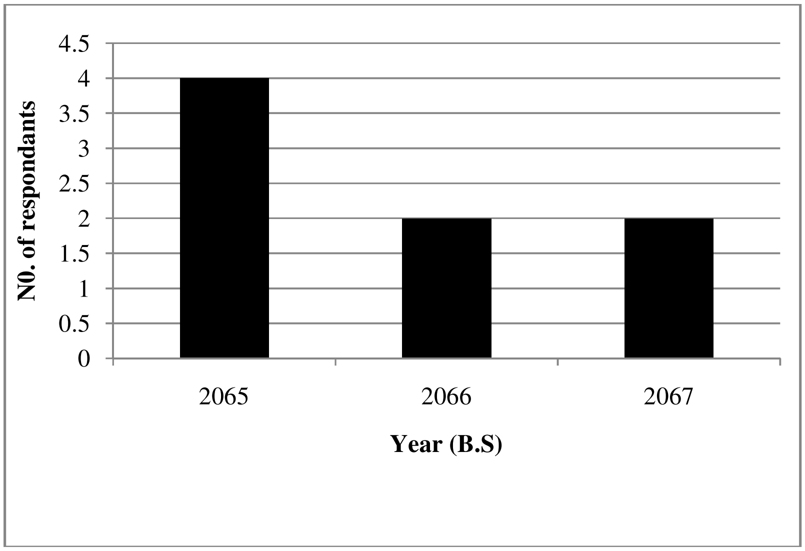

Figure 8: Duration of ICS installations

5.16 Cost of ICS

From the questionnaire, the average cost of ICS in Samagaun VDC is Rs. 11750 which ranges from Rs. 10000 as minimum to Rs. 13000 as maximum. They paid ICS themselves without the support of any external organization and governmental support.

5.17 National ICS program

The entire respondents in Samagaun VDC are unaware about the National ICS program. Also, during the focus group discussion everyone reported that they are unaware about National ICS program and subsidy program supported by the governmental organization.

5.18 People's perception on environmental problems

During questionnaire survey, about 81% of people were aware about environmental problems. Peoples are facing several environmental problems like loss of biodiversity, destruction of wildlife habit, lack of grazing lands, health hazards and Glacial Lake Outburst Flood (GLOF).

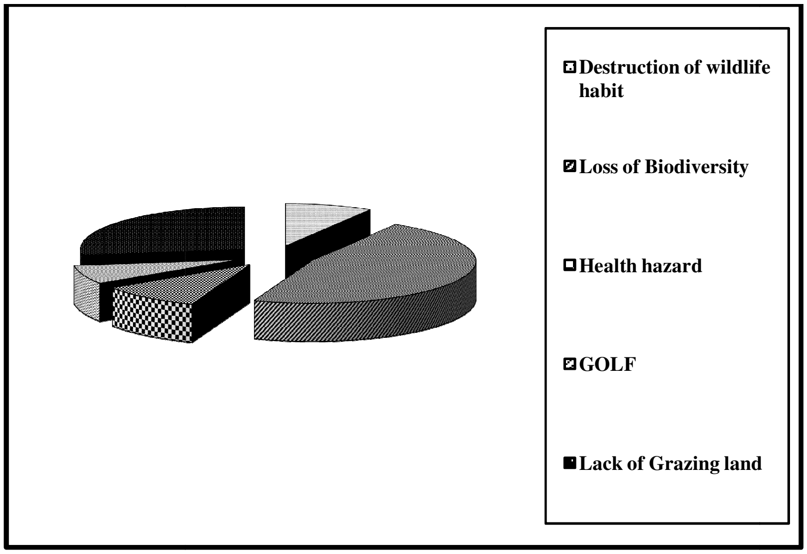

Figure 9: People’s perception on environmental problems

5.19 Willingness of people to use the alternative sources of energy

In a survey 81% of respondent shows that, they have willingness to use the alternative sources of energy. 64.8% of respondent are willing to use LPG, 20.9 % of respondent are willing to use Kerosene and 14.3% of respondent are willing to use ICS. They said that the main reason for willing to use this energy is due to energy efficiency, easy to use and doesn’t create any health problems.

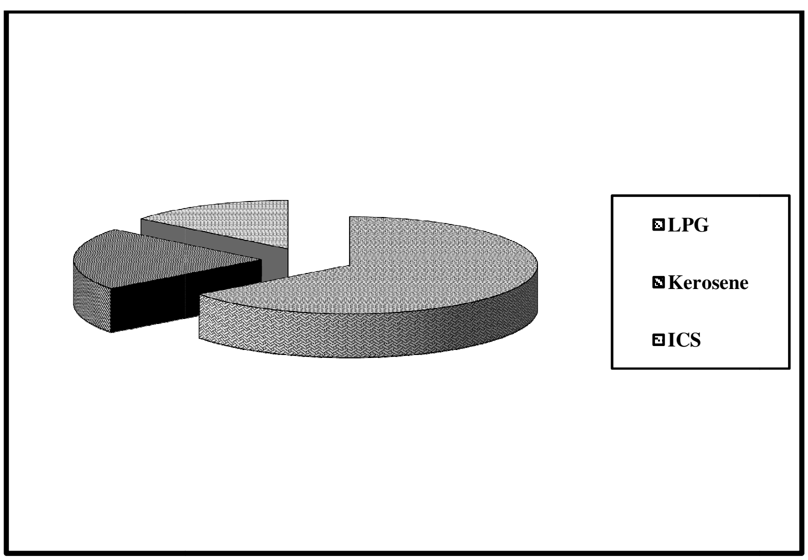

Figure 10: Willingness of people to use the alternative sources of energy

5.20 Correlation analysis

The results of correlation obtained from Pearson correlation test for different parameters like Family size, Livestock holding, Income, Total fuel wood consumption per day, Total CO_2 emission, Time spent in kitchen, Fuel wood consumption in winter, Fuel wood consumption in summer are given in Table 8. The result shows that total carbon emission increases with increase in fuel wood consumption which is also found to be statistically significant. (r=.932, p=0.01). Similarly, the fuel wood consumption in winter is also highly correlated with the family size (r=.773, p=0.01).

Table 8: Pearson correlation between the following variables

	Family size	Total fuel wood consumption per day	Total CO_2 emission	Time spent in kitchen	Fuel wood consumption in winter	Fuel wood consumption in summer	Livestock holding	Total amount of income per year
Family size	1	-.050	-.046	-.024	.773**	.219	.088	.109
Total fuel wood consumption per day	-.050	1	.932**	.168	-.051	.075	.065	.007
Total CO_2 emission	-.046	.932**	1	.098	-.087	.000	.014	.074
Time spent in kitchen	-.024	.168	.098	1	-.091	.081	-.004	-.149
Fuel wood consumption in winter	.773**	-.051	-.087	-.091	1	.352*	.177	.256
Fuel wood consumption in summer	.219	.075	.000	.081	.352*	1	.067	-.083
Livestock holding	.088	.065	.014	-.004	.177	.067	1	.065
Total amount of income per year	.109	.007	.074	-.149	.256	-.083	.065	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

CHAPTER VI
DISCUSSION

6.1 Energy consumption scenario

Nepal's energy scenario is dominated by forestry sector as it supplies more than 80 percent of total energy demand in Nepal. Firewood will remain as the major source for the foreseeable future and its current use is not sustainable. In MCA, the major energy source is firewood. The total energy consumption in sampled HHs is 7668.6 kg where the annual energy consumption by traditional and improved cooking stove is 4401.9 kg and 3266.7 kg respectively. And the average annual per capita energy consumption by TCS and ICS is 62.79 kg and 43.63 kg respectively whereas in SNPBZ the major energy sources is firewood 30%, kerosene 33%, dung 19% and liquefied petroleum gas 7.5% (Salerno et al., 2010). The energy consumption of the study area is higher than the National annual per capita energy consumption of 15GJ (MoF, 2007). It is similar to the energy consumption scenario in Chekampar site of MCA (Poudel, 2010). In this zone, winter is very cold and even in summer the temperature is not high with a mean annual temperature of 6 to 10^{o}C (DNPWC, 2006).Precipitation is in the form of snow and the temperatures drop far below freezing. The monsoon occurs between June and September providing about three -fourths of the total rainfall .The post -monsoon period (October to November) and the winter months (December to February) are usually dry. Due to this, maximum firewood consumption by the people in the Samagaun and also unavailable facilities of renewable energy source, lack of awareness among the people might also be the reasons for the maximum use of firewood than the other areas.

6.2 Firewood demand

Traditional cooking stoves is the dominant energy technology but these days the tourism is in the phase of development in MCA so that the improved cooking stove was found in the hotel and lodges in a dominant way. Traditional cooking stoves users demand the highest amount of fuel wood with 4401.9 kg per capita per year followed by Improved Cook stoves users with 3266.7 kg per capita per year. This value is slightly greater than the Chekampar Site i.e. 3438.3kg and 2817.8kg respectively (Poudel 2010). Due to the less efficiency of energy, this traditional stove demand high amount of firewood for cooking purposes. Consequently, they may either keep their stoves running for longer hours to keep their houses warm or they may cook more frequently, both of these actions require more firewood. Other reason may be due to the frequent use of firewood for cooking, heating, boiling water and space heating.

6.3 Carbon emission

The study shows that the carbon emission per capita per year by traditional cooking stove is 8055.47kg and ICS is 5978.15kg which is greater than that in Syafrubesi area (2190 kg/yr) carried out by Silwal, 2011. This might be due to the cold climatic region and it does not have any other alternative sources of energy rather than fuel woods carried out from near their forest.

6.4 Indoor air pollution

The kitchens of most private houses in Samagaun VDC are equipped mainly with open fireplaces for cooking (and heating in winter), known as traditional cooking stoves (TCS) fueled by wood. Due to the lack of a chimney or other fume outlet, these facilities emit fumes directly into the kitchen area. By contrast, modern buildings, especially tourist lodges, commonly have improved cooking stoves (ICS) with a pipe or chimney. From our research study it was found that the TSP in traditional cooking stoves is 2866 $\mu g/Nm^3$ and improves stoves is 1333$\mu g/Nm^3$ respectively. Some result suggest that above 8000$\mu g/m^3$TSP had been found in a kitchen where traditional stoves was used which far exceed the national limit of 230$\mu g/m^3$ TSP (Lohani 2011). According to a comparative study conducted by Reid et al. (1986), the mean personal exposure to TSP in traditional (*agena*) cooking stoves and improved stoves is 3.92 and 1.13 mg/m^3 respectively. In Samagaun we have found that 67.5% of respondent reported that they are suffering by eye irritation by using the firewood for cooking purposes. Whereas 16.5% of respondent reported that they have suffered by cough, 10.54% of respondent reported that they are suffered by asthma and 5.46% of respondent reported that they are suffered by ARI. The highest rate of chronic bronchitis was found in Jumla (Pandey, M.R., 1997). After many years of study, the Nepal Health Research Council (NHRC 2004) found that the prevalence of ARI among children aged below 5 was 38% (11 of 29 examined).In our study area, especially women and children are exposed to indoor air pollution since most of the time they live inside the house or work in the kitchen for cooking foods.

6.5 Renewable energy sources

The research shows that micro hydropower and solar are found as the renewable energy sources. Though the research was only focus on cooking purposes, by questionnaire base we found that people are willing to install other alternative energy like LPG, kerosene, ICS and other new technologies which are feasible to their locality. As we know that Samagaun lies in high altitude and according to its feasibility micro hydropower plan, solar cooking stove could be the best renewable energy resources. The installation of alternative sources such as LPG and other gas stove may decrease the firewood consumption and hence help to reduce the indoor air pollution.

CHAPTER VII
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The energy consumption scenario in this area is more or less similar to the national level. Most of the people are using biomass especially fuel wood burning in traditional cooking stoves. The firewood is being the most prevalent source of energy for cooking purposes. Traditional cooking stoves are found to be dominant as compare to improved cooking stove. The improved cooking stoves are found in hotels and lodges. The use of efficient cooking stove is decreasing due to lack of proper knowledge. Electricity and solar are used in very less quantity and almost all the households are using it only for lighting purpose.

The total amount of firewood used per day by TCS user is 2135kg/day whereas ICS users use 349kg/day. The average amount of firewood consumed by traditional and improve cooking stove were 62.79kg/day and 43.63kg/day respectively. The per capita/year firewood consumption of TCS and ICS user was 4401.9 and 3266.7 kg respectively. It was concluded that the total firewood consumption in the area was 7668.6 kg per year with 106.42 kg per capita per year. whereas the per capita firewood consumption for TCS user was 1.3 times more in comparison to ICS user. The per capita/year carbon emission of TCS and ICS user is 8055.47 kg CO_2e per capita/year and 5978.15 kg CO_2e per capita/year correspondingly. This calculation shows that ICS emits 1.3 times less CO_2 in the atmospheric environment than the TCS. And the average mean particulate concentration at normal atm. condition for traditional cooking stove was found to be 2866 $\mu g/m^3$ and for improved cooking stove it was found to be 1333 $\mu g/m^3$ both of which far exceed the national standard of 230$\mu g/m^3$ TSP.

The study shows that TCS user is more vulnerable; mostly women and children are facing the indoor air pollution because they spend most of their time in kitchen only.
Peoples are facing environmental problems like loss of biodiversity, destruction of wildlife habit, lack of grazing lands, health hazards and Glacial Lake Outburst Flood (GLOF). The study found that there was massive use of traditional form of energy.

But the people seem much willing of keeping renewable energy technology like LPG, Kerosene and ICS.

6.2 Recommendations

1. It is clear that fuel wood is the major source of energy so energy efficient technologies such as ICS should be widely promoted and regular monitoring is needed for reducing firewood consumption and saving forest thereby reducing greenhouse gas emission.

2. People are very much keen to install ICS and Solar panal but they are deprived of sufficient money and resources so financing system like subsidy program should be promoted by the government.

3. The fuel wood consumption data should also be collected in other season too, so that we could have a complete and comparative result.

4. Further research should be carried out to know the indoor air pollution cause by the traditional cooking stove.

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ANNEX-1

List of respondents

S/N	Name of respondent	Stove Type	TCS	ICS
1	*Dilma Lama*	Traditional	1	
2	*Aange Lama*	Traditional	1	
3	*TsheringChering Lama*	Traditional	1	
4	*NorbhuGalzin Lama*	Improve		1
5	*Chyoshang Lama*	Traditional	1	
6	*Tashimandal lama*	Traditional	1	
7	*Karma Samdu Lama*	Improve		1
8	*Tsering Lama*	Improve		1
9	*Rapke Lama*	Traditional	1	
10	*Aangma Lama*	Traditional	1	
11	*Nima Lama*	Traditional	1	
12	*Chenamo Lama*	Traditional	1	
13	*Yougang Lama*	Traditional	1	
14	*Gyushyang Lama*	Traditional	1	
15	*Tyezing Lama*	Traditional	1	
16	*ChowangHissi Lama*	Traditional	1	
17	*PasangChoden Lama*	Improve		1
18	*Ghurmi Lama*	Improve		1
19	*NingmarChering Lama*	Traditional	1	
20	*Tashi Lama*	Traditional	1	
21	*Anita Gurung*	Traditional	1	
22	*Raju Lama*	Traditional	1	
23	*ShrunagGyamtso Lama*	Traditional	1	
24	*ChewangDorje Lama*	Traditional	1	
25	*DawaButi Lama*	Improve		1
26	*Sonam Lama*	Traditional	1	
27	*LapkaChering Lama*	Traditional	1	
28	*Yangchen Lama*	Traditional	1	
29	*Norge Lama*	Traditional	1	
30	*Galzen Lama*	Traditional	1	
31	*Dhamjo Lama*	Traditional	1	
32	*PurnaKumariGurung*	Improve		1
33	*Tshering Lama*	Traditional	1	
34	*Yanji lama*	Traditional	1	
35	*ChimmiGalzen Lama*	Traditional	1	
36	*BirBahabur Lama*	Improve		1
37	*Urgent Lama*	Traditional	1	
38	*TashiChering Lama*	Traditional	1	
39	*ChowangDhurmi Lama*	Traditional	1	
40	*Norbu Lama*	Traditional	1	
41	*Tender Hiragan Lama*	Traditional	1	
42	*Pasang Lama*	Traditional	1	
		Total	34	8

Field Survey 2012

ANNEX-2

Household Schedule Interview

Name of Data Collector:

Name of Village:……………………….. **Date:**

Ward No:……

Time:................

Altitude:…… m

Temperature………^{0}C Indoor pollution meter reading:………..

1. General Information:

a) Name of Respondents…………………....................... Age of Respondent…………

Family Size………… Ethnic Group…………….. Gender………

b) Are you a local resident or migrated? If migrated, then from where?

....

2. Details on Household:

Age Group	No.	Sex		Education			Employment status	Remarks
		M	F	Under SLC	Under Graduate	Above Graduate		
0 - 5								
6 - 14								
15 - 45								
46 - 60								
above 60								

3. Land holding Ownership:

Owned	Rented in			
	Irrigated (khet)	Non-irrigated (Bari)	Shrub land	Forest land

3. Livestock Holding:

Type of animals	
Yak	
Chauri	
Horse	
Sheep	
Goat	
Others (specify)	
	Total

4. Agriculture
a)Indicate crops which you cultivate
i) Maize ii) Millet iii) Wheat iv) Barley v) Other

b)If you are engaged in farming, what are the pressing issues?
i) Lack of fertilizers ii) Poor soil iii) Lack of land iv) Lack of markets
v) Low rainfall (drought) vi) Pests vii) No funds viii) Lack of equipment ix) Flooding

5. Sources of income
a) How do you classify yourself?
i) Employed ii) never employed iii) Businessman
iv) Retired/retrenched

b) What are your main sources of income?
i) Agriculture ii) Hunting iii) Fishing iv) Charcoal production v) Livestock vi) Trading

6. Income: Annual income of the households:

Sources of Income	Amount
Agriculture	
Cattle/Livestock	
Others	
Total	

7. Other Details;

a) How long have you lived in this area
(i) Less than 20 years (ii) Over 20 years (iii) Less than 10 years

b) How do you characterize your homestead?
i) Permanent ii) Temporary

c) Type of House?
i. Thatched roof ii. Tile/slated roof iii. Mixed iv. RBC/RCC roof
v. Straw roof vi. Other

d) If the main fuel is wood/ firewood from where do you collect it?

S.N	From where do you collect fuel wood?	When/ month	Rank
1.	Community Forest		
2.	National Forest(Protected Area)		
3.	Private Forest		
4.	Leasehold forest		
5.	From local market		
6.	Others		

e) When did you go for fuel wood collection?

S.N	Months	Necessary/ Not	Time consumption	Total Bhari (Kg)	Remarks
1.	Baisakh				
2.	Jestha				
3.	Ashad				
4.	Shrawan				
5.	Bhadra				
6.	Ashoj				
7.	kartik				
8.	Mansir				
9.	Poush				
10.	Magh				
11.	Falgun				
12.	Chaitra				

f) During last five years, do you feel any changes in time consumption to collect the fuel wood from forest?

S.N	Time description	Reason
1.	Much more time than earlier	
2.	More time	
3.	As usual	
4.	Less time than earlier	
5.	Much less than earlier	

g) Which species are used for,

S.N	Timber/ Wood	Fuel wood	Fodder

h) Do you get sufficient amount of fuel wood from forest?

Yes /No

If No, what type of problem are you facing? Like as

S.N	Reasons	Rank
1.	Far from forest	
2.	Restriction from community board	
3.	Lack of information on time	
4.	Least availability in the forest	
5.	Difficult to get permission	
6.	Others	

j) What is your average electric consumption?

i) Below 20kWh/month ii) 20-25 kwh/month iii) 50-100 kwh/month iv) Above 100kwh/month

k) What is the source of lightening?

i) National grid ii) Local mini hydropower iii) Solar iv) Lamp v) Others (specify)

9. Hours of day spent in households work:

Work	**Time taken for each unit**	**No. of manpower**	**Who is involved**
Fuel wood Collection			
Cooking			
Fetching water			
Cleaning utensils			
Livestock Caring			
Dung collection			
Others (specify)			

10. Fuel wood consumption

S.N	Purposes	Necessary/Not	Winter Bhari (kg)	Rainy Bhari (kg)	Total (Kg)
1.	For cooking				
2.	For livestock				
3.	For space heating				
4.	Alcohol preparation				
5.	Drying food				
6.	For selling				
7.	Celebration				
8.	Others				

11. Do you think that, does this stove take long time for cooking food?
Yes/ No

12. Are you willing to use other alternatives rather than fuel wood?

If Yes	If No
ICS	Expensive
Kerosene	Lack of information on importance
LPG	Due to unfeasibility in local market
	Poor economic condition
	No idea
	Others

13 Water resources:
a) Indicate sources of drinking water,
i) Well ii) Stream iii) Bore hole iv) Other (specify)

b) Do you think there is enough water in your area for drinking and other purpose?
i) Yes ii) No iii) Fair enough

14. Improved Cooking System (ICS):
a) Do you have improved cooking stoves? Yes………..No…….
b) If yes: when did you install it? …B.S.
c)How did your family know about ICS?
i) Relatives/ Neighbor ii) Media (Radio/ Television /Campaign) iii) Training/ Workshops
iv) Others
d) Did any organization give you subsidy?
If Yes: How much? …Rs
Which organization? …
e) What benefits had you anticipated before installing the ICS?
a) Reduced Firewood Consumption b) Save time for cooking
c) Clean indoor Environment d) Prevent from ceiling getting black
e) Others (Specify
f) What benefits did your family get after the installation of ICS?
b) Reduced Firewood Consumption b) Save time for cooking
d) Clean indoor Environment d) Prevent from ceiling getting black
f) Others (Specify
g) How much money did you spend to install? …Rs.
h) How many minutes does it take to cook food? …….
i) If No: Are you planning to install it? ....

15. Solar:
a) Do you have installed solar plant? a) Yes b) No
b) If Yes: When did you install it? ....B.S
c) How much money did you spend to install it?..............Rs
d) Did any organization give you subsidy?
e) If Yes: How much...Rs
f) Which organization?
g) How much lights are running? ....Nos
h) How long time do you use it? ....

i) If No: Do you know about Solar Plant?

j) Are you planning to install it? ....

16. Do you have any health problems related on respiratory or optical by using these cooking stoves?

a) Yes b) No

If yes, what are the major health problems?

S. No.	Health problems	Main Sufferer
1.	Eye irritation	
2.	Cough	
3.	Asthma	
4.	ARI	

17. Does the use of firewood have environment problems in your opinion?

If you know, what are the most important environment problems?

S.N	Environmental Problems	Rank
1	Destruction of wildlife habitat	
2	Health hazard	
3	Losses of biodiversity	
4	GLOF	
5	Lack of grazing land	

ANNEX-3

Step-by-step calculation of ambient particulate concentration

1. Calculate total particulate weight (in grams) as follows:

Final weight of dry filter(gm) - initial weight of dry filter (gm) = total particulate weight (gm)

2. Calculate total time sampler was running (in minutes):

$$\_\_\_\_\_\_\_\_ \text{ Hours run} \times \frac{60 \text{ minutes}}{\text{Hour}} = \_\_\_\_\_\_\_\_ \text{ minutes}$$

3. Calculate average flow rate for the sampling period:

$$\frac{\text{Initial flow meter rate + final flow meter rate}}{2} = \_\_\_\_\_\_\_\_ \text{liters/min}$$

4. Calculate volume of air sampled (in liters):

Average flow rate x time = volume sampled

$$\_\_\_\_\_\_ \frac{\text{Liters}}{\text{Minute}} \times \_\_\_\_\_\_\_\_ \text{ minutes} = \_\_\_\_\_\_\_\_ \text{ liters}$$

5. Calculate average particulate concentration (in grams per liter):

$$\frac{\text{Total particulate weight}}{\text{Volume of air sampled}} = \_\_\_\_\_\_\_\_ \frac{\text{grams}}{\text{liters}}$$

6. Then convert to micrograms per cubic meter (µg/m3):

$$\_\_\_\_\_\_ \frac{\text{Grams}}{\text{Liters}} \times \frac{1 \times 10^6 \ \mu g}{1 \text{ gram}} \times \frac{1 \times 10^3 \text{ liters}}{1 \ m^3} = \_\_\_\_\_\_\_\_ \frac{\mu g}{m^3}$$

ANNEX-4

Total amount of bundle used and average weight of per bundle:

S/N	Family Size	Amount of bhundle used per day	Wt of per bundle firewood (Bhari)
1	4	1	40
2	6	2	35
3	5	1	30
4	9	2	40
5	5	1	40
6	6	2	35
7	5	2	45
8	6	1	50
9	6	2	45
10	4	2	40
11	7	2	35
12	4	1	45
13	6	2	30
14	4	2	45
15	9	3	40
16	7	2	40
17	6	2	40
18	2	1	40
19	5	3	35
20	4	1	40
21	5	2	35
22	8	2	35
23	4	1	40
24	7	2	40
25	3	1	45
26	3	1	45
27	2	1	40
28	4	1	40
29	5	2	40
30	6	2	50
31	7	2	40
32	6	1	40
33	6	2	35
34	1	1	30
35	8	2	40
36	1	1	35
37	8	2	40
38	10	3	45
39	1	1	40
40	2	1	35
41	3	1	40
42	5	1	40
		Average=2bhari(bundle) consumed per day	Average= 40kg

Field Survey 2012

ANNEX-5

Firewood consumption per day in Kg

Amount of firewood consumption per day in kg	Stove Types		Total
	TCS	ICS	
30	4	1	5
35	1	1	2
40	6	3	9
45	2	0	2
50	0	1	1
55	0	0	0
60	1	0	1
70	7	1	8
80	8	1	9
90	4	0	4
100	1	0	1
Total	34	8	42
Average firewood consumption in kg	62.79	43.63	

Field Survey 2012

ANNEX-6

National Ambient Air Quality Standards for Nepal

Parameter	Units	Averaging Time	Concentration in Ambient Air, maximum	Test Methods
TSP (total suspended Annual particulates)	µg/m^3	Annual 24-hours$_a$	230	High volume sampling
PM10	µg/m^3	Annual 24-hours$_a$	120	Low volume sampling
Sulfur Dioxide	µg/m^3	Annual 24-hours$_b$	50	Diffusive sampling based on weekly averages
			70	To be determined before 2005.
Nitrogen Dioxide	µg/m^3	Annual 24-hours$_b$	40	Diffusive sampling based on weekly averages
			80	To be determined before 2005.
Carbon Monoxide	µg/m^3	8 hours$_b$ 15 minute	10,000	To be determined before 2005
			100,000	Indicative samplers $_c$
Lead	µg/m^3	Annual 24-hours	0.5	Annual Atomic Absorption Spectrometry, analysis of PM10 samples $_d$
Benzene	µg/m^3	Annual 24-hours	20$_e$	Annual Diffusive sampling based on weekly averages

µg/m^3 = micro gram per cubic meter , PM 10 = particulate matter of diameter 10 micron or less
a= 24 hourly values shall be met 95% of the time in a year. The standard may be exceeded on 18 days per calendar year, but not on two consecutive days.
b= 24 hourly standards for NO_2 and SO_2 and 8 hours standard for CO are not to be controlled before MoPE has recommended appropriate test methodologies. This will be done before 2005.
c=Control by spot sampling at roadside locations: minimum one sample per week taken over 15 minutes during peak traffic hours, i.e., in the period 8 am –10 am or 3pm–6 pm on a workday. This test method will be re -evaluated by 2005.
d= If representativeness can be proven, yearly averages can be calculated from PM10 samples from selected weekdays from each month of the year.
e= to be reevaluated by 2005.

Source: MOPE (2003)

ANNEX-7

Study Illustrating Photographs

Figure 1:Traditional cooking stove

Figure 2: Improved cooking stove

Figure 3: Questionnaries Survey

Figure 4: Stock of fuel wood

Figure 5: Air sampler fixing near to the stove

Figure 6: Air Sampler

Figure 7: Focus Group Discussion

Figure 8: Weighing the bundles of firewood