

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background of the Study

A most important and significant look in our modern civilization is energy of different forms. Many necessary functions can be at a standstill without energy. We need energy for home appliances, lighting, transportation, cooking, heating/cooling, communication, and industrial processes to produce and supply commodities of our daily needs. Thus we consider energy as one of the most important indicators of socio-economic development and we take per capita energy consumption as a key index of the development. Higher the per capita energy consumption, higher is the Human development index (H.D.I) considered. Developed countries have significantly higher per capita energy consumption. For example, the United States has a per capita energy consumption of 314.1 GJ/year; Japan has 162.5 GJ/year but for Nepal per capita energy consumption is just 15 GJ/year, which is far less than world's average per capita TPES of 76.6 GJ/year.

Nepal though being rich in water resources possessing around 50,000 Megawatt (MW) of economically feasible hydropower potential is facing a severe power scarcity up to 12 to 14 hours per day since last 6/7 years. Actual electricity generation from hydropower in Nepal is currently 800 MW from 20 major hydropower plants and a number of small and micro hydropower plants. But still electricity is a distant dream for many families in rural area of Nepal, 63% people doesn't have access on electricity and depend on oil-based or renewable energy alternatives. The discrimination is even higher when it comes to rural area, about 82% of nation's population lives in rural areas and only 30% of rural people have electricity access while around 90% of urban people are connected with electricity" (Power and People, A World Bank Study 2010) with an average of 76.3%. There is continuously increasing demand for electricity for households as well as for industrial and for other many purpose. Nepal's own demand for electricity has been growing at 9 percent annually and supply has simply not kept up.

Nepal's energy resources are presently classified into three categories namely the traditional, commercial and alternative. Traditional energy resources include fuel wood from forests and tree resources, agricultural residues coming from agricultural crops and animal dung in the dry form. 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, and micro level hydropower are categorized into the alternative energy resources in Nepal. Such resources are considered as the supplement of conventional energy resources.

Nepal's energy sector heavily reliance on traditional sources. 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% were derived from traditional resources, 12% from commercial sources and less than 1% from the alternative sources. The figure of total energy consumption by fuel types is: Fuel wood 77.7%, Petroleum 8.2%, Coal 1.9%, Electricity 2.0%, Biogas 0.6%, Agriculture residue 3.7%, Animal Dung 5.7%, the contribution of solar and micro hydro is very low (Water and Energy Commission Secretariat, 2010).

The energy consumed by sector for 2008/09 is by Residential 43.4%, Industrial 38.2%, Commercial 6.9%, Agriculture 2.1%, transport 0.2%, Others 9.1% (Synopsis Report WECS, 2012). As we all know these massive uses of traditional energy threat the sustainable development of country and the dependence on the imported fossil fuel; the rising price of fossil fuel in the international market is a burden on its foreign exchange and result trade deficit.

Energy is one of the vital inputs to livelihood and consistent availability of affordable energy sources are the prerequisites of socio-economic development of Nepal. The remoteness of many hill settlements of Nepal makes these areas inaccessible from electricity grid and therefore lower access to electricity facilities. In a country with our kind of terrain, it's hard in providing basic necessities also because of inadequate infrastructure development, scattered rural households, and high cost of centralized national grid power supply and poor purchasing power of the people.

The Use of Renewable energy technology can reduce the dependency on traditional energy and help to protect the environment. It also plays crucial Role in increasing people access in information technology and helps in accelerating the economic activities in remote areas of the country. Renewable energy resources are the energy resources that are obtained from sources that are replenished by nature. Some examples of renewable energy resources include moving water (hydroelectric power, tidal power, and wave power), thermal gradients in ocean water, biomass and bio wastes (bio energy and bio-fuels), geothermal energy, solar energy, and wind energy. Renewable energy resources (hydroelectric power, solar energy, biomass and bio-waste) are sustainably available in Nepal and therefore, adequate utilization of these resources could certainly complement the country's renewable energy portfolio. Being environment friendly, renewable energy also contributes to significant reductions in greenhouse gas (GHG) emissions, local/indoor air pollution, and minimizes the impact on the landscape, and physical,geographical and natural environments. A decentralizedrenewable energy system is likely to improve the life quality of therural population in Nepal.

Solar energy was first conceived as a viable alternative form of power as early as in the 1860s when coal was expected to be running out of supply. The oil crisis of 1973 brought renewed attention to the potential of solar power as alternative source of energy. In response, industrial countries made a concerted effort to develop solar power (Status of Solar Photovoltaic Sectorin Nepal, AEPC 2010). The first recorded use of Solar PV in Nepal can be traced back to 1963 when Civil Aviation Authority of Nepal installed a Solar PV system in Bhadrapur Airport to run navigation equipment. Its use for domestic electrification started in 1992/93 and gained momentum from 1996 when Alternative Energy Promotion Centre (AEPC) was established. To promote rural electrification through solar energy, Government of Nepal, in partnership with Danish, Norwegian and German governments, has introduced subsidy program to encourage the adoption of solar home system. The scheme is known as Solar Energy Support Program (SSP) and is one of the components of Energy Sector Assistance Program (ESAP) which is nested within Alternative Energy Promotion Center.

Solar PV Home System is the system in which the energy from sunlight is converted into electricity and Solar Home System (SHS) is defined as the household electricity supply system with solar photovoltaic panel capacity of 10 Wp or more and connected with battery, charge controller and appropriate number of DC lights” (AEPC, 2006). AEPC/ESAP started providing subsidy for SHS through interim rural energy fund (IREF) from April 2001. Total installed capacity of Solar PV in Nepal is more than 9 Megawatt (9,123,668 Wp, AEPC, Status of Solar Photovoltaic). It is estimated that over 390,000 population have access to electricity from these systems. AEPC has targeted to install 80,000 SHS by providing subsidy by of Rs 640000000 for fiscal year 2010/11 (Subsidy Disbursement status of SHS, 2012, AEPC). A total of 336000 units of SHS have been installed in 73 districts till December, 2012 and the trend is in increasing numbers. The Budget for the fiscal year 2014/15 also had put a major priority in solar energy. An agreement between the Government of Nepal (GoN) and the International Development Association (IDA) of the World Bank Group to generate 25MW of solar photovoltaic generated electricity was already signed February this year 2015. The agreement gives US\$130 million (12 Arba 92 Crores 59 Lakhs Nepalese Rupees) to the GoN to establish a grid solar and energy efficient project. A scheme had been also been proposed to promote rooftop solar plants in urban areas under the slogan of “UjyaloGhar, Ujyalo Nepal”.

## **1.2 Statement of the Problem**

It is a known fact that Energy is indispensable in modern societies and is one of the most important indicators of socio-economic development. It plays vital role in increasing and improving the living standard. Though Nepal possess about 2.27% of the world hydropower potential, less than 2% of its total energy demand is being met by electricity. The access to electricity is even low and inequitable particularly in the poor rural areas. Even in electrified areas, there has been an acute power shortage in recent years, with residents forced to live upto 14 hours of daily load shedding. In most of the rural areas, people are still using kerosene lamps, which is expensive as well as they are not easily available.

Very difficult terrain and scattered settlements makes centralized grid supply to all the population in Nepal very difficult. Photovoltaic technology is deemed to be one of the most appropriate means to provide electrical energy for various applications in remote areas of Nepal. (Shrestha, ET al.2003)

On average Nepal has 6.8 sunshine hours per day with the intensity of solar insolation ranging from 3.9 to 5.1kWh/m<sup>2</sup>-day (the national average is about 4.7kWh/m<sup>2</sup>/day) Using photovoltaic (PV) modules of 12% efficiency and assuming peak sunshine of 4.5 hper day, the total energy generated would be 80,000 GWh/day or2064 million tons of oil equivalent (Mtoe) per year. This energy would be nearly 17% of the world's total primary energy supply (TPES), which is estimated to be 12,267 Mtoe for the year 2008. If we use just 0.01% of the total area of Nepal, we can generate solar electricity at 8GWh/day; that is 2920 GWH/year,which is more than the energy generated from the Nepal Electricity Authority (NEA) owned power stations in the year 2008/09 (i.e.1839.5GWh). However, recently the Alternative Energy Promotion Centre's (AEPC) report on Solar and Wind Energy Resource Assessment in Nepal (SWERA) stated that the commercial potential of solar power for grid connection is only 2100MW (Current status of renewable energy in Nepal SurendraK.C. Samir Kumar Khanal, Prachand Shrestha, BuddhiLamsal,2011)

The solar photovoltaic system is emerging as an alternative energy source not only for rural household lighting but also for commercial purposes. With development of proper institutional setup,effective dissemination and involvement of government and donor agencies solar PV technology could make significant contribution in meeting rural energy needs for decentralized rural electrification (CADEC, 2003)

Nowadays there is high priority for development, use and promotion of clean energy, which can be easily available, economically affordable and environmentally sustainable, and the solar energy is one of them. The development of this solar energy will cut imported commercial fuel and help to reduce the trade deficit, help to tackle environmental problems like global warming, climate change etc.,so social research studies are to be carried out in this arena which will eventually help rural propel to increase their access to light, access to energy and leads to achieve higher standard of living.

### 1.3 Research Objectives

The primary objective of the study is to examine the impact of Solar Home System in Gaguda VDC of Doti district and to figure out prospects of using Solar Home System (SHS) in terms of energy access and their per capita consumption and it's the socio-economic benefits to the rural community. The specific objectives of the study are,

- ) To study the energy scenario and assess per capita energy consumption of the selected area.
- ) To measure the socio-economic impact on SHS installed households.
- ) To investigate the awareness and prevailing attitudes towards SHS.

### 1.4 Rationale of the Study

SHS is the reliable source of energy especially for lighting. It not only protects the ecological environment but also adds new scenario to the spots that ease the lives of rural peoples. The potential for Solar PV technology is obvious in those rural areas where extension of grid electricity may be techno-economically not feasible. This obviously invites for SHS installation.

About 83% of the total population still lives in rural areas of Nepal. Only 30% of rural people have electricity access, so kerosene is the most common source of lighting in rural areas. Dry cells are used to power radios and torch lights. An effort has been made to replace the kerosene lamps with efficient, cost effective, reliable and environmentally friendly SHS based torch lights. It also helps to improve child education due to increased study hours.

On economic point of view, SHS installation has not just helped to save Kerosene, battery etc., but also opens up new income generating opportunities in rural areas like weaving, photography, running mobile phone, Thangka painting etc.

Solar PV home system is only option for the rural electrification where due to various reasons such as diverse geology/structure of land form, the scattered settlement,

electricity from national grid is not feasible and costly. Running big hydroelectricity requires huge investment and long duration of time, in this context Solar PV Home System is highly suitable which also contribute, in a small way, to control the migration of people from rural to urban areas in search of better way of life and for other facilities. Solar energy is less costly than micro hydropower and other electricity and can be easily carried out from one place to other.

The study is very important for understanding and identifying the changes in the status, way of living and activities of SHS user household in the study area. Assessment of the impacts of SHS users, their activities, their capacities and understanding on utilization of SHS will certainly be helpful in forming Clean Development Mechanism (CDM). The outcomes of the study will be of great importance to policy makers to formulate appropriate plan for further development of the appropriate technology that better suits the rural people needs from each and every aspects.

### **1.5 Limitations of the study**

The study has taken respondents only from Gaguda VDC of Doti district as its sample, with a total of only 50 respondents. This was due to the time and resource constraints. Since the sample size is small and the study area was chosen in a typical environment (social, economic and cultural) VDC of a Doti District, generalization of the conclusion derived from the study in national/worldwide level may not be significant to others.

The sample size had more respondents adopting agriculture as a major occupation and using fuel wood as a major source of energy consumption. This could have influenced the outcome with a bias towards such group. The study has only considered few variables selected from the numerous factor affecting the solar energy consumption in the study area thus the study is limited in terms of deeper analysis. Had more items been taken, a clearer picture could have been obtained.

## **1.6 Organization of the Study**

The study has been organized in six chapters. The first chapter includes introductory part and study objectives of the study i.e. background, statement of the problem, objective of the study, rationale and the research limitation.

The second chapter focuses in review of literature. In third chapter methodology adopted for the study i.e. research design, rationale of the study area, sampling procedure, data collection techniques and tools is included.

Data presentation and analysis of the study has been organized in chapter four while discussion on energy scenario, socio economic and other various impacts of SHS has been made in chapter five. Major findings, conclusions and recommendation are included in chapter six. The references and annexes are incorporated in last.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Solar Energy Resources in Nepal

Solar energy was first conceived as a viable alternative form of power as early as in the 1860s when coal was expected to be running out of supply. The global oil crisis of 1973 brought renewed attention to the potential of solar power as alternative source of energy.

Nepal, being located in favorable latitude, receives ample solar radiation. The average solar radiation varies from 3.6–6.2 kWh/m<sup>2</sup>/day, and the sun shines for about 300 days a year. The development of solar energy technology is thus reasonably favorable in many parts of the country. As per the recently published report of AEPC, 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA), the commercial potential of solar power for grid connection is 2,100 MW. With National average sunshine hours of 6.8/day and solar insolation intensity of about 4.7kWh/m<sup>2</sup>/day, there is a huge potential for development and promotion of Solar Home System in Nepal.

For a large part of the rural population consuming low electrical energy, there is no viable alternative to solar electricity for rural electrification. The operation and maintenance cost of diesel generators is too high, biogas technology does not work satisfactorily around the fairly cold high altitudes or in the mountains and would be difficult to achieve with roving herds of cattle. Small Hydro turbines need specific topographical conditions that are only found near a small percentage of users' dwellings. Solar electricity generating systems, which do not need fuel or extensive infrastructure, are easy and quick to install and thus could be very attractive option in Rural parts of the country. However, it cannot be claimed that solar electricity can solve rural electrification issues completely. Solar electricity too has limitations and problems but these can overcome with proper planning.

The solar electricity potential:

The country has 300 sunny days per annum and thus is very rich in solar power potential. Using PV module of 12% efficiency, total energy generated will be  $0.12 * 4.5 * 147,181 * 10^6 = 80,000 \text{ GWh/day} = 17.7 \text{ TW}$  (assuming peak sun to be 4.5 hours). This energy generated is more than energy required for fulfilling the whole energy demand of the world. The total estimated world energy demand at present is about 13 TW. If we use just 0.01% of the total area of Nepal, we can generate solar electricity of 8 GWh/day that is 2920 GWh/year (which is more than the energy generated by NEA in the year 2003 amounting 2261 GWh/year) (WECS, Energy Sector Synopsis Report 2010).

In Nepal, subsidy is provided to solar home systems in areas without electricity. In such areas, people derive their livelihood mainly from agriculture. Besides agriculture, people's source of income may be small business or sale of handicraft, all of which are labor intensive activities. In such context, SHS may increase the time available to work by allowing people to engage in economic activities even at night (AEPC/DANIDA: 1999).

Electricity provides light that is hundreds of times bright and at the same time cheaper than kerosene based lighting. Lighting with electricity allows business to extend well, which has potential of income and employment growth. It also enables women to engage in productive activities. (Power and People: The World Bank 2010).

“Electricity lighting may also increase study hours for school going children, increase their educational achievements” (Barnes, Perkin and Fitzgerald; 2003; Kulkarni and Barnes 2004).

Result shows that those households who opt to install SHSs have higher landholding, income (increase probability of initiating business by 3 times) and awareness. Education is another sector where SHS has had significant impact. Students with Solar Home System are 45 minutes more likely to study every day than without SHS. Surprisingly, findings show that there is no impact of SHS on health outcomes (Samuhik Abhiyan, 2010).

## 2.2 Meaning and Definition of SHS

Solar PV Home System is the system in which the energy from sunlight is converted into electricity. Solar Home System (SHS) is defined as the household electricity supply system with solar photovoltaic panel of capacity 10Wp or more and connected with battery, charge controller and appropriate number of DC lights” (AEPC,2006)

“Photovoltaics is civilized alternative that respects human values and does not promote predatory attitudes which leads to conflicts over energy resources” (Sao Paulo Declaration 1991).

The module, the basic building block of the systems consists of a numbers of solar cells electrically interconnected and encapsulated within a supporting structure. Solar cells usually in the form of thin films or wafers are semiconductor device(usually made up of Crystalline silicon) that converts 3-14% of the incident solar energy to DC electricity with efficiencies depending on illumination, spectrum intensity, solar cell design, material and temperatures. The modules are available in sizes from 20-50watts. Large power outputs from a single source can be obtained by combining modules. At present two types of systems are commercially available in the mountain areas they are,

- i. Centralized SPV power station
- ii. Standalone system or commonly known as Solar Home System (SHS) (10-120watts).

Centralized SPV power station can provide grid electricity by converting DC power generated from solar cells to AC. This system can provide lighting and other small scale power applications for the remote and isolated mountain areas. A SHS (40W) provides DC electricity to power 3 or 4 lights and a radio or TV for 3 or 4 hours per day. In most of the mountain areas SHSs are popular than centralized SPV power plant, as most of the centralized system installed during late 80's didn't function properly due to the operation, repair and maintenance problems primarily relating to DC-AC inverter.

Several wattages such as 10W,20W,36W,40W,50W,60W,75W and 100W of SHS are mostly available.

A 36Wp SHS comprises of a 36W panel(solar PV module)with a current rating of 2.2ampere, and which is used to charge the battery through the charge controller during the day time.So the charged stored in the battery during the daytime can be used to light the energy efficient lights during the night time (Lotus Energy EkeChinari, 2006).

How a solar-home-system works?

When the sunlight falls on the surface of the panel (modules)the electrons get excited and start moving in the metal stripes of the panels.When flow is high(i.e. peak son or more than average sun) the potential is built up and then since the two terminals of the panel is connected to the terminal of battery (negative and positive) via charge controller, the electrons or the charge get stored in the battery, which in turn can be used in the night time when there no sun light(Sharma,2003).

Photovoltaic (PV) modules use semiconductor materials to generate D.C. electricity from sunlight. A large area is needed to collect as much sunlight as possible, so the semiconductor is either made into thin, flat, crystalline cells, or deposited as a very thin continuous layer onto a support material. The semiconductor must be sealed into a weatherproof casing, with suitable electrical connectors.

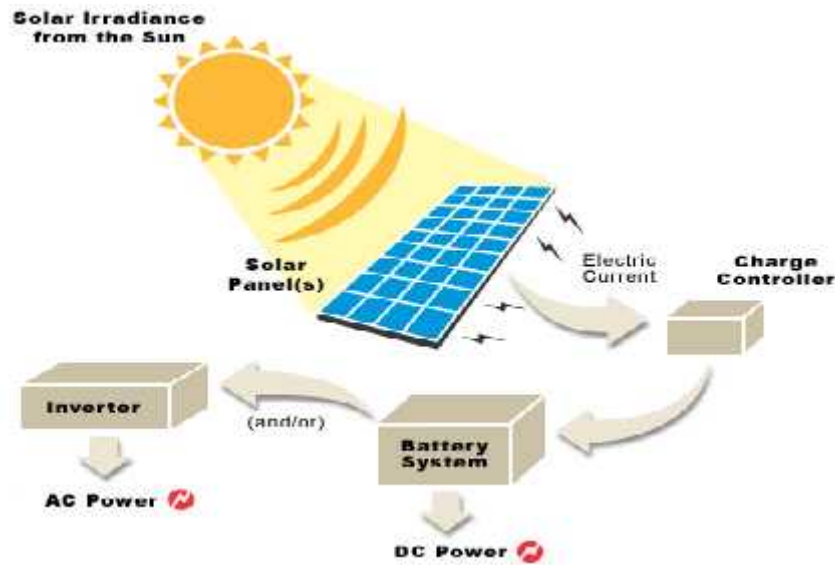


Fig 1: Layout of a Solar-Home-System

PV modules are specified by their ‘watt-peak’ (Wp) rating, which is the power generated under standard conditions, equivalent to bright sun in the tropics (they still work at lower light levels though). Most solar-home-systems use modules between about 10 Wp and 100 Wp rating.

The rechargeable batteries store spare electricity on sunny days, so that it is available at night and on cloudy days. They also provide a stable voltage (usually 12 V) for the devices which use the electricity. Standard lead-acid car batteries can be used, but they don’t last long if they are heavily discharged, so specially-made solar versions are strongly recommended. Other types of rechargeable battery like nickel-cadmium and nickel-metal-hydride are increasingly used, particularly in small systems like solar lanterns. They are more expensive, but easier to make small and portable, and more tolerant of being heavily discharged.

All equipment run directly from the PV supply must be designed for 12 V/D.C. operations. Efficient lights and appliances make best use of the limited supply of electricity. Efficient D.C. fluorescent lights are available down to about 3 or 4 W power rating, in both tube and compact forms. LED lights are even more efficient, and are now sufficiently cheap and reliable to be used as well. In most systems, an electronic charge-controller is used to protect the battery from being overcharged (when it is very sunny) or over-discharged (when people try to get too much

electricity from the system). The charge controller usually has lights or a meter to indicate the state-of-charge of the battery(Wikipedia).

### 2.3 History of PV Technology

- ) 1839AD Edmund Becquerel, the French experimental physicist discovered the photovoltaic effect.
- ) 1875- William Adams and R. Day discovered that the junctions of Selenium and platinum also exhibit photovoltaic effect.
- ) 1877- The first Selenium solar cell was constructed.
- ) 1904 - Albert Einstein provided the theoretical explanation to photovoltaic effect.
- ) 1918 - Polish scientist Czohralski discovered the method for mono crystalline silicon solar cell.
- ) 1941 - The first silicon mono crystalline solar cell was constructed.
- ) 1955 – Hoffman electronics semiconductor division produced the first commercial PV with 2% efficiency.
- ) 1958 – The efficiency of the solar cell was increased to 9%.
- ) 1958 – The first PV powered artificial satellite of Earth, Vanguard I, with 0.1W solar cell occupying an area of approximately 100cm sq. and powering a 5MW back up transmitter was launched. Three more PV satellite was launched in the same year.
- ) 1963- Sharp company became the first company to develop the first usable PV module.
- ) 1974 – The cost of PV power dropped down to US\$30/watt from US\$1,785/watt
- ) 1980 – ACRO Solar became the first manufacturer to produce PV modules with peak power of 1 MW
- ) 1983 – Worldwide production of PV modules exceeds 21.3MW with a business volume of 250Million US\$.
- ) 1999 – Total installed capacity of PV, modules exceeded 1,000 MW worldwide.

- ) 2002 – Total installed capacity of PV power exceeds 2000 MW of business volume of about 2 billion US\$([www.energyhimalya.com](http://www.energyhimalya.com)).

## 2.4 History of SPV in Nepal

There is no exact evidence on when solar PV was first time used in Nepal but it is said.

- ) First PV module was used in 1963 in Bhadrapur Airport for navigation purpose (Shrestha,1998).
- ) 1974AD Nepal Telecom(NTC) used solar PV power to operate a high frequency transceiver located in Damauli.
- ) 1980 NTC started massive use of solar PV power. It has remained as the largest corporate users of PV total installed capacity exceeding 700 kWp.
- ) 1987 ADB/N was using solar PV power to electrify its 100 branch offices.
- ) 1988 Centralized electricity supply from PV started. Nepal Electricity Authority (NEA) with the assistance of French government installed centralized solar PV power system in Simikot(50kWp).
- ) 1986/87 Use of solar PV technology to lift water for drinking and irrigation purposes.
- ) 1989 NEA installed another centralized solar PV power system in Kodari/Tatopani (30 kWp) and Gamgadhi (50kWp) of Mugu district.
- ) 1991/92 Recorded use of solar PV power for domestic electrification,with the effort of government of Nepal with financial support of France in Kodari,Tatopani,simikot aand Gamgadhi. The outcome proved failure as it was not a household based solar electricity system. Solar electricity was distributed from central station,a numbers of unforeseen technical and community mobilization problems cropped up (REDP,1997).
- ) 1993 Successful launching of Pulimarang village (Tanahu district)electrification project by Center for Renewable Energy(CRE)with the support from Solar Energy Light Funds(SELF), USA and Pulimarang

community support. During the first phase 46 SHS were installed after this use of PV for the rural electrification gained the momentum in valleys.

- J) 1993/94 Solar PV system has also been used by numbers of health post,schools in rural areas for lighting, operating vaccine refrigerator.
- J) 1995 The first highly subsidized (95%)68 SHS were installed at Chhaimale village in southern part of the Kathmandu by Wisdom Light Groups Pvt. Ltd.
- J) 1996 ADB/N provided 50% subsidy to install 40SHS at six VDCs in Kavreplanchowk district for the first time in Nepal.(Kayastha, 2000)
- J) 1996 The Government of Nepal established the Alternative Energy Promotion Centre (AEPC) to look after all RETs. It is National Executing Agency for REprograms and projects. It is under Ministry of Environment and has semi-autonomous status. It has mandate for policy & plan formulation, resource mobilization, coordination, quality assurance and Monitoring of RETs
- J) 2000 In October government announced renewable energy subsidy policy. Accordingly,subsidy will be provided to SHS of 10-120Watt peak (AEPC,2000).

## **2.5 Periodic plans for Solar Energy**

### **2.5.1 Five Year Development Plans**

The Seventh Five Year Plan (1985-90) was the first of national policies to address Renewable Energy Technologies (RETs). The Plan recognized that RETs could replace traditional sources of fuel in rural areas and sought to encourage the development and adoption of alternative sources of energy like biogas, solar and wind. Later AEPC drafted the 20 Yrs. RE Perspective Plan in 2000. The plan envisioned for the government to provide subsidy for the use of solar energy, to make solar technologies meet rigorous standards, to give NGOs and the private sector a prominent role in the development and promotion of solar energy, and to support research and development activities.

During the Eighth Plan (1992-97), Alternative Energy Promotion Center was established in 1996 under then Ministry of Science, and Technology with the

objective of promoting and coordinating activities and programs at the national level. This was an important development that created a central authority that could formulate and enact policies related to renewable energy. The Ninth Plan (1997-2002) sought to tie the economic development of rural areas with rural electrification. Solar energy was identified as one of the most appropriate source of electricity in rural areas. Interim Rural Energy Fund (IREF) was set up to administer subsidies for solar PV systems and other RETs. Most importantly, Energy Sector Assistance Program (ESAP) was started during this period.

The Tenth Plan (2002-2007) focused on the use of alternative energy for economic development, sought to accelerate the commercialization of alternative energy technologies and to replace traditional sources of energy by modern and renewable sources. As planned, IREF was transformed into Rural Energy Fund (REF) during this period and Rural Energy Policy was promulgated in 2006. Rural Energy Policy (REP) seeks to link renewable energy to economic development and increase the role of local agencies, NGOs, and private sector in its promotion. With respect to solar PV, REP subscribes to increasing the provision of subsidy and linking solar energy to improvements in health education, irrigation, drinking water, and communication.

The Three years Interim Development Plan (2008-2010) has targeted to expand the services of electricity in such a way so as to ensure coverage of an additional 5 percent of the population through alternative energy sources. The interim plan has also identified a lack of coordinated effort for the development of alternative energy sources in order to provide electricity in the rural areas as one of the major challenges in the sector of electricity and power (Status of Solar Photovoltaic in Nepal, AEPC 2010).

### **2.5.2 Perspective Energy Plan**

The national planning commission prepared the Perspective Energy Plan (1991-2017). The plan has made a number of recommendations for the development of solar energy. The recommendations made are as follows.

- i. Provide government subsidy for a definite period of time, say 10 years.

- ii. Standardize solar technologies and ensure strict quality control.
- iii. Give the lead role to NGOs and private sector and the facilitating role to the government.
- iv. Support R&D activities in respect to water heating, cooking and cost reduction of solar PV system.

### **2.5.3 Solar PV in National Energy Policies**

Solar PV has found its place in following two policies of the Government of Nepal.

- i. Rural Energy Policy, 2006
- ii. Subsidy Policy for Renewable (Rural Energy), 2009
- iii. Besides, there is a special Delivery Mechanism developed and under practice for SHS promotion.

### **2.5.4 Rural Energy Policy, 2006**

With an overall goal to contribute to rural poverty reduction and environmental conservation by ensuring access to clean, reliable and appropriate energy in the rural areas, the Government of Nepal has promulgated “Rural Energy Policy 2006” with the following objectives.

- i. To reduce dependency on traditional energy and conserve the environment by increasing access to clean and cost effective energy in the rural areas.
- ii. To increase employment and productivity through the development of rural energy resources.
- iii. To increase the living standards of the rural population by integrating rural energy with social and economic activities.

### **2.5.5 Subsidy Policy for Renewable (Rural) Energy 2009**

#### **i.) Solar Home System**

Subsidy will be provided to households for installing SHS of 10-18 Wp, and more than 18 Wp from now onward as mentioned in following areas.

**Table no: 2.1****SUBSIDY POLICY FOR RENEWABLE (RURAL) ENERGY**

Geographical Location	10-18 Wp (NPR)	More than 18 Wp (NPR)
Karnali and adjoining districts* and very remote VDCs# categorized A in other districts	7,000	10,000
Remote VDC# categorized B in other districts	6,000	8,000
Accessible VDCs categorized C	5,000	6,000

\*Humla, Jumla, Kalikot, Dolpa, Mugu, Rolpa, Rukum, Jajarkot, Bajhang, Bajura, Achham, Dailekh, Darchula

# The very remote and remote VDCs of the remote districts are as per Ministry of Local Development (MoLD)/GoN notification in the Nepal Gazette. The category "A" comprises of very remote VDCs, while category "B" represents remote VDCs.

In order to provide quick relief from kerosene tuki and jharro etc. in the rural areas, a small solar PV system based on White LED will be promoted. A subsidy of NPR 2,000 per system will be provided to a SSHS consisting of at least 5Wp solar panel along with two sets of solar lamp.

**ii.) Institutional Solar PV System**

- i. The subsidy for Solar PV systems used by public institutions such as for operating computers in remote schools, vaccine refrigerators in remote health posts, FM radio equipment's in remote areas and remote Tele-centers etc. will be up to 75% of the cost of installation.
- ii. The subsidy amount of 75% not exceeding NPR15,000 will be provided for PV systems used in lighting for monasteries, temples, churches, mosques and other religious places in the remote area without electrification by any other means.

## 2.6 Current Status of Nepal's Solar Projects

### 2.6.1 National Rural and Renewable Energy Programme (NRREP) and Future plan

AEPC implemented the National Rural and Renewable Energy Programme (NRREP) from 16 July 2012. A consortium of five governments (Nepal, Denmark, Norway, Germany, UK), two multilateral banks (ADB, WB) and three intergovernmental organizations (UNDP, UNCDF, SNV) have committed USD 184 Million budget to execute this five-year programme. The development objective of NRREP is to improve the living standards of rural women and men, increase employment of women and men as well as productivity, reduce dependency on traditional energy and attain sustainable development through integration of alternative energy with the socioeconomic activities of women and men in rural communities.

#### Key Targets of NRREP (July, 2012-July, 2017)

S.N	Technology	Unit	5 Year Target	Year 1 Actual	Year 2 Actual	Plan		
						Year 3	Year 4	Year 5
1.	Solar PV Home Systems and Small Solar PV Home Systems	Nos.	600,000	99,324	87,038	125,000	125,000	125,000
2.	Institutional Solar PV Systems and drinking water pumping systems	Nos.	1,500	66	131	700	300	302
3.	Solar Dryer and cooker	Nos.	7500	-	212	1000	2,000	3,500

### 2.6.2 Scaling up Renewable Energy Program in Low Income Countries (SREP)

The Scaling up Renewable Energy Program in Low Income Countries (SREP) is a targeted program of the Strategic Climate Fund (SCF), which is one of two funds

within the framework of the Climate Investment Funds (CIF). SREP financing supports technologies such as solar, wind, bio-energy, geothermal, and small hydro technologies. The main targets of SREP in Nepal is to provide electricity access to 250,000 households through 30 MW of mini/micro hydropower, another 500,000 households through solar home systems along with provision of access to clean cooking fuel for 160,000 households through biogas plants, SREP also intends to support the transition of AEPC into Alternative Energy Promotion Board, which will serve as a one-stop shop for RE development in the country for projects up to 10 MW in capacity

### **2.6.3 Energy Sector Assistance Program**

EASP was set up by DANIDA In 1999 with a view to achieving ongoing sustainability in the rural / renewable energy sector in Nepal within a 20 year timeframe. ESAP phase I planned to install approximately 25,000 SHS and in first phase ESAP I far exceeds its target. The first phase of the program built a strong foundation for future action and provided benefits to around 1.5 million people in rural Nepal.

ESAP 2 aims to provide energy solutions to more than 1 million households in Nepal. Access to clean, cheap and reliable energy in remote rural areas can make an important contribution to improved health, better education and the reduction of poverty. By promoting rural development, the programme will help to support and sustain the ongoing peace process.

### **2.7 Major Users of Solar Electricity in Nepal**

First officially recorded use of solar electricity in Nepal is not known. But it is said that the Nepal Telecommunications Corporation (NTC) was the first organization to use solar electricity to power a high frequency communication transceiver located in Damauli in 1974. Since then NTC has become one of the significant users of solar electricity amounting to more than 1000 kWp generating about 47000 kWh/day of electrical energy at more than 3000 locations, without national grid supplied

electricity. Seventy five percent of all the Public Call Offices (PCO) in NTC are being powered by PV.

Similarly Ncell is another major user of solar energy in the country. Ncell brings mobile connectivity to rural, mountainous Nepal by building solar-powered sites. Over 10 percent of Ncell's network works on solar energy, including the Mount Everest site at 5,300 meters. As of August 2015, Ncell had 344 solar-powered sites in Nepal, constituting about 13 percent of its 2G/3G network. The solar sites are now covering about 1-2 percent of the population of Nepal. By 2018, Ncell plans to add 400 more solar sites, to cover additional 3-4 percent of the population in remote areas. <http://www.teliasonera.com/en/sustainability/all-in/solar-power-is-connecting-the-remote-in-the-himalayas/>

### Application of PV Power by Sector (until 2005)

**Table No: 2.2**

S. N.	Service	PV Power, kWp	% Power	No. of Installation
1	Telecommunications	1001	21.6	3000+
2	Utility supply (centralized)	100	2.1	2
3	Stand-alone system	3328	71.8	75000+
4	Water supply	93	2.0	25
5	Aviation	37	0.8	45
6	Miscellaneous	78	1.7	100+
	Total	4636	100	

Stand-alone Solar Home System (SHS) constitute above 5000 kWp with 185017 numbers as of until 2008/09. The trend of SHS installation shows a steep rise after 2000 due to the subsidy policy implemented by AEPC/ESAP. Till December 2004, 51 solar PV pumping systems have been installed, of which 28 were installed after 2000 with subsidy provided from AEPC. (WCES, 2010)

## 2.8 Yearly Installation of Solar Home System in Nepal

**Table no: 2.3**

S.N.	Fiscal Year	District Total No	Capacity	(Wp)	MW
1	Up to 056/57		11758	442652	0.44
2	057/58	35	6211	242064	0.24
3	058/59	63	13745	543486	0.54
4	059/60	65	18482	650669	0.65
5	060/61	71	15106	411095	0.41
6	061/62	67	17887	462679	0.46
7	062/63	67	6788	175052	0.18
8	063/64	61	6690	167113	0.17
9	064/65	68	34755	822964	0.82
10	065/66	73	53595	1249430	1.25
<b>Total</b>			185017	5167204	5.17

Source: AEPC (2010)

## 2.9 Total Energy Consumption by FuelTypes (2008/09)

**Table no: 2.4**

Types	Ag residue	Animal dung	Fuel wood	Petroleum	Coal	Electricity	Biogas	Microhydro	Solar
%	3.7	5.7	77.7	8.2	1.9	2.0	0.6	0.01	0.0001

Total Consumption 401 Million GJ (WCES 2010)

## 2.10 Number of Households by Usual Type of Fuel Used for Cooking

**Table No: 2.5**

Area/ sources	Firewood	Kerosene	LPG	Cow dung	Bio-gas	Electricity	Others	Not stated	Total
Nepal	3,470,224	55,610	1,140,662	563,126	131,596	4,523	22,583	34,973	5,423,297
Urban	268,643	20,990	707,674	15,776	19,121	1,255	4,107	8,009	1,045,575
Rural	3,201,581	34,620	432,988	547,350	112,475	3,268	18,476	26,964	4,377,722

(Source: Nepal Population and housing Survey, 2011)

## 2.11 Number of Households by usual source of lighting

**Table No: 2.6**

Area/sources	Electricity	kerosene	Bio-gas	Solar	Others	Not stated	Total
Nepal	3,647,746	991,510	15,264	403,504	330,170	35,103	5,423,297
Urban	983,995	42,297	3,671	2,082	5,438	8,092	1,045,575
Rural	2,663,751	949,213	11,593	401,422	324,732	27,011	4,377,722

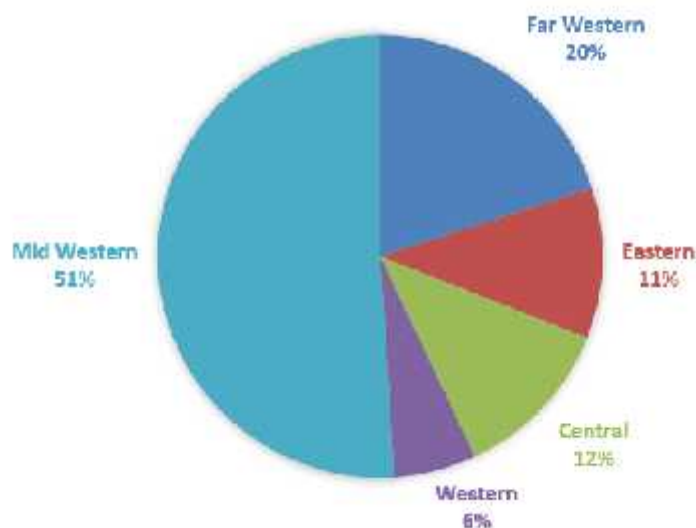
(Source: Nepal census,2011)

## 2.12 Region wise SHS Installation (2012-2013)

During this period, 91,879 solar home systems, with a total capacity of 2,026 kWp, were supported. More than 51 percent of the installations were done in the mid-western region of Nepal.

**Pie Chart No: 2.1**

**Region wise SHS Installation(2012-2013)**



## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

This section describes the methodology that was used by us to carry out our research. It presents the research design, rationale of the selection of study area, nature and sources of data collection, universe and sampling, techniques and tools of data collection and data processing and analysis and the research methods.

#### **3.1 Research Design**

The study was focused on the solar energy scenario in rural areas. The purpose of the study is to describe the socio-economic impact made by the use of SHS in the household level of Gaguda VDC of Dotidistrict. For this study, a descriptive and exploratory research design was utilized. The descriptive method was used for the qualitative data obtained during the study. The data's which were not quantifiable was explained literally. The simple statistical tools are used to describe and analyze the result. On the other where interdependence between various characteristics/activities which are influenced by SHS exists exploratory research design was used.

#### **3.2 Rationale of the Selection of Study Area**

Since the few years back SHS has emerged as an important source of alternative energy in Gaguda VDC of Dotidistrict, so the present study has been carried out in Gaguda VDC. And further no one ever had researched in the same topic before in this area.

Another reason to select Gaguda is that the development was heard very much in the local newspapers about the benefit the people of Gaguda receiving from the SHS. Also, I was familiar with local culture and practices as I was working in a same district on a project for my job, hence I selected the Gaguda VDC considering my feasibility of conducting survey. This VDC lies in the Far western part of the Nepal of Doti district which is also an administrative headquarter of Far western region.

### **3.3 Nature and Sources of Data Collection**

In order to meet the above objectives, primary and secondary information were generated through field studies, and literature review. Both primary and secondary data were used in this study. Data gathered are both qualitative and quantitative in their nature.

#### **3.3.1 Primary Data**

Questionnaire was the main tool for collecting information in the field survey. The primary data were collected employing the following techniques: interactions with users' groups, field observation and interview through structured and semi structured questionnaire as per the convenience to aid to the study. Used sets of questionnaire are attached in the Annex I.

#### **3.3.2 Secondary Data**

Since, this research is mounted on the base of description and analysis, secondary data plays the vital role. The various internal and external sources were used for acquiring the secondary data. The various sources consist of,

- i. Village Development Committee
- ii. Central Bureau of statistics
- iii. Alternative Energy Promotion Centre
- iv. Various Solar Home System providing companies
- v. Google
- vi. Bulletins/reports, etc.

### **3.4 Quantitative and Qualitative Research**

Since, this research was more concentrated towards the prospects of SHS in rural area of Nepal i.e. Gaguda VDC of Doti district, the degree and depth of impact of SHS is different in different aspects of rural livelihood was studied. On this regard quantitative research was carried out. It is because it helps to analyze the calculated

information with the standard normative values and helps in comparisons. The attitude, awareness and perception of various stakeholders- SHS users were studied through qualitative research method. However, every information cannot be quantified nor all the data can be interpreted quantitatively so various elements was interpreted in qualitative nature.

### **3.5 Population and Sampling**

The population of this study was all the households form Gaguda VDC of Doti District. The samples were categorized into groups on the basis of demographic variables namely gender, literate/illiterate and occupation. Total population of Gaguda VDC is 3,058 having 1,401 male and 1,657 female populations with total 584 households. The total installed SHS in Gaguda VDC of Doti district is 242 HHs (National Population and Housing Census, 2011). The sample consisted of 50 households which were selected randomly and out them 40 samples were SHS users and remaining 10 samples were non SHS users.

Out of total 50 sample HHs, 21 sample households belongs to ward no. 2 and remaining 29 sample HHs belongs to ward no. 3. The questionnaires included both type i.e. open ended and close ended in order to acquire reliable information by making the respondent comfortable and ease to provide the information.

### **3.6 Techniques and Tools of Data collection**

This research has been conducted by employing various methods for data collection. Both primary and secondary data has been collected. The researcher had herself collected the primary data from the respondents by conducting the questionnaire survey with the SHS users. For the collection of primary data following data collection techniques were adopted.

#### **3.6.1 Households Survey**

The name list of the household head was obtained from the AEPC office and house to house survey was conducted. The questionnaire forms were filled up by the researcher

interviewing with household heads. In the absence of household head, another senior person present at the home was taken as the respondent.

### **3.6.2 Observation**

To explore energy related problems and prospects in the study area, visual observation by the researcher was also conducted. General problems, kitchen and study room environment, the probable remedies were observed. The data's were collected observing the households environment, solar home system wiring, condition of panel, elevation of panel setup, battery conditions, types of bulbs etc. were closely monitored by the researcher.

### **3.6.3 Key Informant Interview**

A Key Informant Interview is loosely structured conversations with the people who have specialized knowledge about the topic. To dig out its major key informant's interview were conducted within the study area. The key informants were Teacher, local political leader, VDC staffs, Businessman and Local SHS technician. By interviewing them on the basis of prepared set of questionnaire allowing the respondents enough flexibility to provide the information, the information was recorded.

## **3.7 Data Processing and Analysis**

The collected raw data was molded as per the requirement and objectives of the research. The various steps that are followed are,

### **3.7.1. Data Processing**

- i. Editing: The collected raw data were edited to detect error and omissions. So to overcome the possible error in our research editing was done carefully.
- ii. Coding: In order to make the research more systematic and scientific, assigning of numerals or symbols to answer has been carried out, so that it helped to allocate the answer whenever necessary.

- iii. Classification: The result of research study is at large volume in the form of raw data. So in order to simplify it has been classified into homogeneous groups, so a meaningful relationship can be profoundly studied.
- iv. Tabulation: After the necessary classification of data the next step taken was arranging the data in respective tables/ charts. The tabulation is essential in order to systematize and logical arrangement of data for further manipulation.

### **3.7.2 Data Analysis**

All the data's has been analyzed systematically and scientifically by using different statistical tools. Primary data has been analyzed according to its nature, so as to address the objectives of the study. Quantitative data has been analyzed using simple statistical tools like frequency and percentage distribution. Qualitative data has been analyzed descriptively and to the extent possible with use of tables and frequency distribution.

## **CHAPTER FOUR**

### **DATA PRESENTATION AND ANALYSIS**

This chapter attempts to analyze the collected data and information from the field survey and various sources in response to meet the objectives of the study and to derive the major findings of the study. Firstly it includes the brief introduction of Doti district and Gaguda VDC regarding its demographic, socio-cultural, economic, geological, political and other aspects.

#### **4.1 Study Area**

##### **4.1.1 Doti District**

Doti district lies in the Seti zone of Far Western Developmental Region with its headquarter at Silgadhi. It is located at 28°54' to 29°28' Northern longitude and from 80°30' to 81°14' Eastern latitude. This hilly district is situated at western part of capital Kathmandu. Its total area is 2025 sq.km. And its altitude varies from 400 m to 6000 m. It shares its boundaries with Acham and Surkhet district in East, Dadeldhura and Baitadi in West, Bajhang in North and Kailali in South. There are all together 540 wards, 50 VDC, 11 Elikas, 1 Municipality and 2 electoral constituencies.

According to National Population and Housing Census 2011, the total population of the district is 211,746 with male 97,252 and female 114,494. The average household size is 5.11 and population density 131 persons/km<sup>2</sup>. There is total 41,440 households. With an average household size of 5.11, among which 39,720 HHs use firewood for cooking, 206 HHs use kerosene, 1,131 HHs use LPG, cow dung by 55 HHs, biogas by 33 and 6 HHs depend on electricity for cooking.

Similarly 12,498 HHs use electricity as a source of lighting, 4,185 HHs use kerosene, biogas by 148 HHs and 4,984 HHs use solar as source of lighting.

This district is famous for historical places like Raika Palace and Shaileshwori Temple. The major occupation of people is Agriculture (81%) beside this it is a regional headquarters of Far western Development Region.

#### **4.1.2 Gaguda VDC**

The study was undertaken at Gaguda VDC of Doti district. This VDC lies in constituency no.1 of Doti district. Total area of this VDC is 28.77 sq. km. It lies between the altitude of 486m to 1962 m. Total population of Gaguda VDC is 3,058 having 1,401 male and 1,657 female populations. There are all together 584 households with an average household size of 5.24.

Among which 578 HHs use firewood for cooking, 2 HHs use kerosene for cooking. Similarly 242 HHs use solar as a source of lighting and 42 HHs use kerosene as source of lighting (National Population and Housing Census 2011).

Within the VDC, our study is mainly focused in ward no 2 and 3 which is composed of different ethnic groups; largest population in the Gaguda is Chettri and Kami respectively. Besides, the other castes and ethnicities like Dalit, Thakuri and Brahmin have their considerable presence.

Most of the houses have tile/slate roof houses followed by thatch/straw roof house. The wall of the house was made by mud and stone. The villagers are getting drinking water supply from different sources like 285 were benefitting from tap/piped water, 70 HHs from covered well/kuwa, 85 HHs from uncovered well/kuwa, 122 HHs from spout water and 18 HHs from river. They get health services from a health post and private clinic.

As far as social organizations are concerned, mainly four types of organizations are found namely community forest users group, Mahila Samuha and Political Parties and Schools. There are one higher secondary, two secondary and three primary schools in the VDC. The governmental representation was limited with public schools, health posts and police bits.

Most economic activity revolves around agriculture, livestock and trade of agro products. The climatic condition is suitable for the horticulture. Most household used to sell fruits,vegetables,milk of cows and buffalos which is collected and transported to Kathmandu.No. of households are also found involved in poultry farming. Some people are found involved in business and government job, as well as gone abroad for labor.

There was no grid electricity connection till Magh 2071. All together installed SHS in 242 HHs has been taking significant advantage from Solar Home System. People generally use Firewood as sources of cooking fuel. The kerosene was used for lighting but after Solar was installed it is used as the alternative source of lighting.

## 4.2 Socio-Economic Characteristics of the SHS Users Groups

### 4.2.1 Ethnicity/Caste

Ethnicity/caste composition is the components related with socio-cultural aspects. Different ethnic/caste hasownculture,practices and needs which significantly affect their energy consumption pattern. The ethnicity/caste composition of the respondent is presented below in table no.4.1.

**Table No: 4.1**

#### **Ethnicity/Caste Composition of the Sample HHs**

S.NO	Ethnicity/Caste	No. of HHs	Percentage (%)
1	Chettri	23	46%
2	Dalit	14	28%
3	Brahmin	5	10%
4	Thakuri	5	10%
5	Magar	3	6%
	Total	50	100%

Source: Field Survey, 2014

Above table shows that Chettri are the predominant in installing the solar home system(46%) because their population is higher in that area and they have good economic conditions. Second largest population of Gaguda VDC is Dalit that's why this ethnicity has second largest (28%) sharing in installation of SHS.

#### 4.2.2 Sex and literacy composition of SHS users

The analysis of sex and literacy status of the respondent is one of the important parts of our research. These factors directly and indirectly affect the people's perception, their understanding and behaviors towards the energy consumption. Beside this other social and economic parameters like occupation, income generation etc. are also influenced by sex and literacy composition. The sex and literacy composition of the samples is presented below in table no.4.2.

**Table No:4.2**

#### **Sex and literacy composition of the respondent HHs**

Sex/Literacy	Literate		Illiterate		Total Population	
	No	Percentage	No.	Percentage	No	Percentage
Male	115	68.86%	52	31.14%	167	47.71.%
Female	97	53.00%	86	47.00%	183	52.29%
Literacy rate	212	60.57%	138	39.43%	350	100%

Source: Field Survey, 2014

The above table shows that in the study area, the female population is higher 52.29% than male population, 47.71%. The total population of 50 samples HHs is 350, with average family size 7 per household.

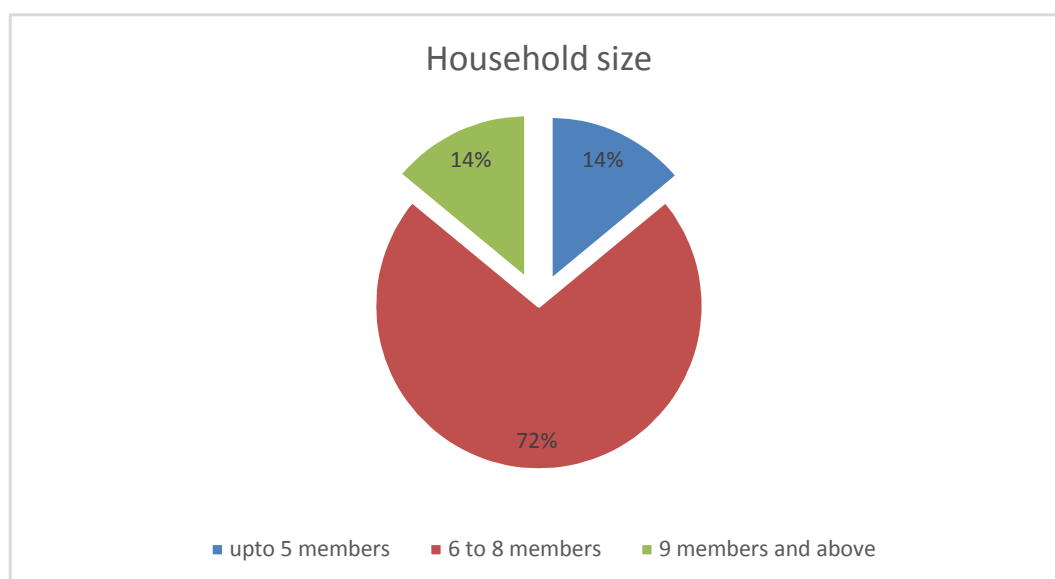
In the above table the literacy rate is calculated by taking literacy status of household's members as well as by adding school going male/female as literate in their respective composition. The literacy rate is higher in male (68.86%) than in female (53.00%). The overall literacy rate of the study area is 60.57%.

### 4.2.3 Household Size of the Respondents

Different households have different energy needs. It is obvious that higher the household size, higher will be the energy needs and vice versa. Distribution of households according to family size is shown below.

#### Pie Chart No: 4.1

#### Distribution by the Households size of the Respondents



Source:Field Survey, 2014

The above figure shows that Highest no.of household(72%) has family size between 6 to 8. Similarly14% households have family size up to 5 members while 14% HHs has family size of 9 members and above. The average household size of sample respondents of Gaguda VDCis 7.

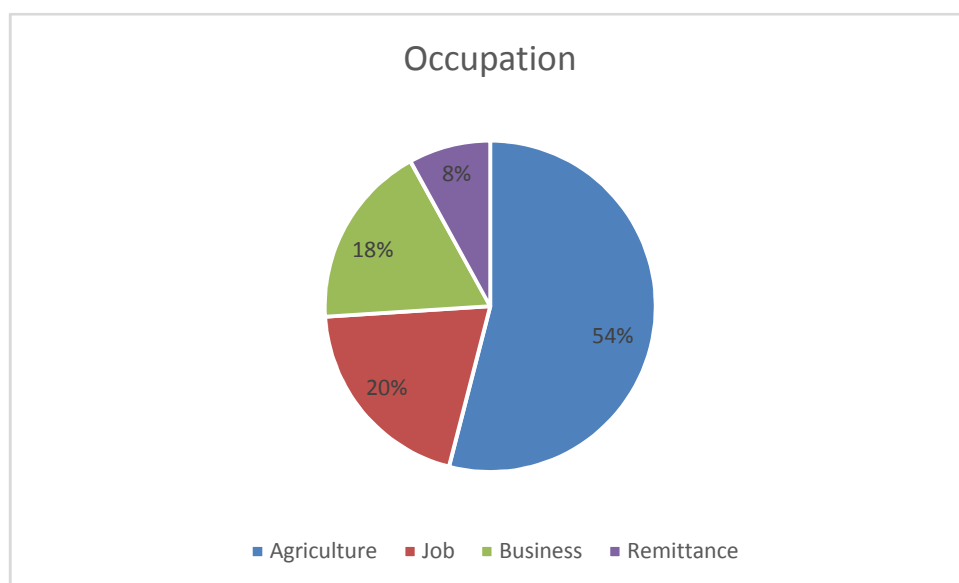
### 4.2.4 Occupational Status of the Sample HHs

Occupation is one of the important indicators of the socio- economic status of the people.It also determines the household's wealth, well-being, literacy status and social stigma in society which plays a vital role in the energy consumption pattern.If household has member involved in service, business or in any kind of job they are

well known to alternative energy sources like Solar, Bio-gas and they also have caliber to bear the cost of installation. As we know more than 80% people are engaged in Agriculture in Nepal. People who can fulfill their basic needs by farming are also found during the study forced to adopt SHS to fulfill their energy needs, for their social status, or as imitating. On the basis of major occupation in the study area, the households engaged in Agriculture, Business, Job, service and service in foreign country has been shown below.

**Pie Chart No: 4.2**

**Distribution by Occupational status of the Sample HHs**



Source:Field Survey, 2014

The above pie-chart shows that majority of HHs (54%) are involved in agriculture as their major occupation. About 20% people are involved in service like army, police, teaching and health post. The third largest HHs 18% are involved in business like shop and hotels. The fourth largest majority of HHs i.e. 8% is working in abroad as labor, that's why our economy is dependent in remittance currently. The low productivity and disguised unemployment may be the reason for people that push them to go abroad for labor.

#### 4.2.5 Annual Income Supporting Annual Expenditure of Sample HHs

The income of the households is crucial factor that determines the people's way of living, their socio economic strata etc. which directly affect their access and affordability towards basic needs as well as other needs including energy needs. In the study area major sources of income are Agriculture, Job, Business, service in abroad countries. They make expenditure to fulfill their verities of needs. The annual income that can support annual expenditure of sample HHs is shown in below table 4.3

**Table No: 4.3**

##### **Distribution of the Responent that can support Annual Expenditure for**

S.N	No. of Months	No. of HHs	Percentage (%)
1	1-3 months	1	2
2	4-7 months	5	10
3	8-12 months	23	46
4	12+ months	21	42
Total		50	100%

Source:Field Survey, 2014

The above table shows that about 46% households can support annual expenditure for 8-12 months. This category includes HHs mostly whose major occupation is agriculture and service. 42% HHs said that they can support expenditure for more than 12 months; they are those HHs who are doing job, involved in business and mostly those whose family member are in abroad for labor.

10% HHs can support expenditures only for 4-7 months, they all are dependent in substantive farming and have no other sources of income. Some are found installed SHS by taking loan as well as imitating for their social prestige too. Only 2 % of sample HHs can support expenditure for 1-3 months.

#### 4.2.6 Increased Study Hour after Installation of SHS

In rural areas of Nepal where there is no electricity (grid and non-grid), mostly people use Kerosene as sources of lighting. Students are forced to study under dim light of tuki fueled by kerosene or torch lights that uses dry cell. The efficiency of these lights is low and students finds difficulty in studying in those environments. Solar Home System provide efficient cleaner and brighter lights which helps student to study in brighter light as well as help the family by cutting expenses required in buying kerosene. Respondent of SHS users has found increased study hours of their children has been shown in below table no 4.4.

**Table No: 4.4**

#### **Distribution of Respondents by increased in Study Hour after SHS Installation**

S.n	Increased Study Hours Daily	No. of households	Percentage (%)
1	Increased by 1 hour	11	34%
2	Increased by 2 hours	18	56%
3	Increased by 3 hours	3	9%
Total		32	100%

Sources: Field survey, 2014

32 households out of 40 SHS installed households have their school going children. About 34% HHs admit that after installing SHS their children studying hours have been increased by 1 hour at night daily. Around 56% HHs admit increment in night study by 2 hours and 9% HHs admit 3 hours increment in study hour at night daily after SHS was installed.

The fact is to increase or decrease in study hours not only the solar light but various variables like studying environment, household work to be done by children etc. are also crucial in determining the study hour of students.

#### 4.3 Energy Use Situation in the Study Area

### 4.3.1 Fire Wood Consumption by sample HHs in the Study Area

Among the traditional energy resources, fuel wood is the largest energy resources in Nepal providing about 77% of the total energy demand in the year 2008/09. In Gaguda VDC also Fuel wood is the primarily sources of energy used for cooking purposes.

In Gaguda VDC the average cost of one bhari firewood of about 45 KG is Rs 75. One Kg Fire Wood is equivalent to 16.75 MJ. The annual fuel wood consumption by the respondent HHs of Gaguda VDC is shown in Annex-II

The per capita fire wood energy consumed by SHS user's households  $X \frac{\text{total fuel wood energy consumption of SHS installed HHs}}{\text{total population of SHS installed HHs}}$

$$\begin{aligned} &= 2614005/278 \\ &= 9402.8956 \text{ MJ} \\ &= 9.40 \text{ GJ/year/person} \end{aligned}$$

The per capita fire wood consumed by SHS non users  $X \frac{\text{Total fire wood energy consumption by SHS non users}}{\text{total population of SHS none installed HHs}}$

$$\begin{aligned} &= 678375/72 \\ &= 9421.875 \text{ MJ} \\ &= 9.42 \text{ GJ/year/person} \end{aligned}$$

There is almost same amount of firewood wood energy is consumed by SHS users and non-users. Economically, 196560kg of fire wood is used by 50HHs equivalence to NRs.327600 annually.

### 4.3.2 Kerosene Consumption by Sample HHs in the Study Area

In rural areas of Nepal kerosene is the most commonly and dominant sources of energy used for lighting. The annual fuel kerosene consumption by the respondent HHs of Gaguda VDC is shown in Annex-III.

The cost of one liter kerosene is Rs 115 in Gaguda VDC. In the above table, HHs no 1-40 represent SHS users while HHs no 41- 50 of lower part of the table represents the non SHS users.

The people of Gaguda VDC was also found to use Kerosene for the purpose of cooking and igniting firewood and lightening.

Energy consumption per person by SHS users =  $9975/278 = \text{liter/year/person}$

$$\begin{aligned} \text{The per capita kerosene consumed by SHS users} &= \frac{\text{Total consumption of kerosene by SHS installed HHs}}{\text{Total population of SHS installed households}} \\ &= 9975/278 \\ &= 35.8812 \text{ MJ} \\ &= 0.03588 \text{ GJ/year/person} \end{aligned}$$

Energy consumption per person by non SHS users =  $14315/72 = 198.82$  liter/year/person

$$\begin{aligned} \text{The per capita consumption of kerosene by SHS non users} &\times \frac{\text{Total consumption of kerosene by SHS non user's}}{\text{Total population of SHS non users HHs}} \\ &= 4340/72 \\ &= 60.2778 \text{ GJ} \\ &= 0.06027 \text{ GJ/year/person} \end{aligned}$$

$$\begin{aligned} \text{Annual cost paid by SHS users households who also uses kerosene} &\times \frac{\text{Total cost paid for kerosene}}{\text{Total no. of their Households}} \\ &= 32775/40 \\ &= \text{Rs.}819.375/\text{households/year} \end{aligned}$$

$$\begin{aligned} \text{Annual cost paid by SHS non user for kerosene} &= \frac{\text{Total cost paid for kerosene}}{\text{Total no. of their HHs}} \\ &= 14260/10 \\ &= \text{Rs.1426/households/year} \end{aligned}$$

The figure shows that by installing SHS a household can save at least Rs. 606.625 annually compared to SHS non users of Gaguda VDC. It also shows that annually 285 liters of kerosene is used by sample population of Gaguda VDC with a cost equivalent to NRs. 32775.

#### 4.3.3 Solar Energy Consumption by Sample HHs in the Study Area

In Gaguda VDC 40 HHs are taking advantage from the solar energy. Beside its general uses, during load shedding the use of this solar energy is common. Then consumption of solar energy in Gaguda VDC is shown in table below

**Table No: 4.5**

**Annual Consumption of Solar Energy**

S.N	Solar Capacity (Wp), A	No. of HHs, B	Energy (kWh) (A*B*365*4.5/1000)	Energy(MJ) 1 kWh = 3.6MJ
1	20	11	361.350	1300.860
2	25	17	698.0625	2513.025
3	30	12	591.300	2128.680
	Total	40	1650.7125	5942.565

Source: Field Survey, 2014

For calculating solar energy consumption, annually 365 days is taken assuming peak sunshine of 4.5 h per day as most favorable days for producing solar energy. The per capita solar energy consumption is calculated as:

$$\begin{aligned} \text{The per capita solar energy consumption} &= \frac{\text{Total solar energy consumption}}{\text{Total population of SHS installed HHs}} \\ &= 5942.565/278 \end{aligned}$$



The total energy consumption of sample households of Gaguda VDC, obtained by adding consumption of Fire wood + Kerosene+ Solar energy. The share of different types of energy is shown below in table.

**Table No: 4.6**

**Distribution by Share of Energy in Gaguda VDC**

Types	Quantity	Energy (MJ)	Cost(NRs.)	Share on Energy (%)
Biomass (kg.)	196560	3292380	327600	99.38
Kerosene (lit.)	409	14315	47035	0.432
Solar PV(kWh)	1650.71	5942.565	871000	0.179
	Total	3312637.565	1245635	100 %

Sources: Field Survey, 2014

As we know Nepal's energy sector heavily reliance on traditional sources (87%). The share of fire wood energy is maximum among total energy consumption in Gaguda VDC, which is 99.38 %. Annually 196560 kg, 3292380 MJ energy is derived from biomass equivalence to Rs.327600 by the sample HHs.

The share of Solar PV Energy is 0.179 %. Annually 5942.565 MJ energy is derived from Solar PV by 40 SHS installed households at the cost of approximately Rs.757137.

#### **4.4 Solar Home System Use Information in Study Area**

##### **4.4.1 Distribution of SHS by Date of Installation**

Households of Gaguda VDC have installed SHS in different years, which are shown below in table.

**Table No: 4.7**  
**Date of Installation of SHS by Year**

S.N	Year of Installation	No. of Households	Percentage (%)
1	2066	2	5
2	2067	8	20
3	2068	14	35
4	2069	16	40
Total		40	100%

Sources: Field Survey, 2014

In Gaguda VDC 5% solar home system was installed in year 2066. In year 2067 BS there was increase in SHS installation by 20% and this continually increases in subsequent years in 2068 and 2069 with a share of 35% and 40% respectively.

#### 4.4.2 Distribution of SHS by system Size and cost

Different households use SHS of varying capacity from 20Wp up to 30Wp considering their energy needs, cost of the system etc. The various sizes and cost of the systems installed in Gaguda VDC are shown below in table no 4.10

**Table No: 4.8**  
**Distribution of SHS by system Size and Cost**

S.N	Size of the System (Wp)	No. of HHs	Percentage	Range of Average Cost Per System (Rs.during B.S. 2067-2069)
1	20	11	27.5	20,000-22,000
2	25	17	42.5	25,000-28,000
3	30	12	30	30,000-33,000
	Total	40	100%	10,67,000

Sources: Field Survey, 2014

The above table shows that highest no of households (42.5%) has installed 25Wp system .The reason for its maximum use might be because of its minimal cost and it also fulfills the basic energy requirements of the households. About 27.5% households have use 20Wp solar home system. Percentage of households using 30Wp is 30% and it might because of its high cost.

There is no uniformity regarding the cost of Solar Home System. The cost of same size system also varies as per the installing company. The range of average cost for 20Wp is between Rs.20,000 to 22,000.The cost of 25Wp SHS varies between Rs. 25,000 to 28,000 and cost of 30Wp lies between Rs. 30,000 to 33,000. In total the average cost of these 40 SHS is was ten lakh sixty eight thousand. There should be effective efforts to make uniformity in cost so that users can get optimum benefits from it.

#### 4.4.3 SHS Installer Company in the Study Area

In the study area, 5 different solar companies have launched their programs from 2066 to 2069 B.S. are shown in table no 4.11

**Table No: 4.9**

#### **Distribution by SHS Installer Company**

S.N	Name of the Company	No. of Households	Percentage (%)
1	Clean Home's Energy Nepal Pvt.Ltd.	5	12.5
2	Renewable Nepal Alternative Energy Pvt.Ltd.	21	52.5
3	Shikhar Renewable Energy Pvt.Ltd.	7	17.5
4	Swaviman Urja Bikash Co.Pvt.Ltd.	4	10
5	Ultra Solar Energy & ST. Eng. Pvt. Ltd.	3	7.5
	Total	40	100%

Sources: Field Survey, 2014

Among the companies, the most popular company is Renewable Nepal Alternative Energy Pvt. Ltd., which has alone installed more than half of the total SHS installed (52.5%) in Gaguda VDC. The second popular Company is Shikhar Renewable Energy Pvt.Ltd.which has installed about 17.5% SHS in Gaguda VDC and Ultra Solar Energy &ST.Eng. Pvt. Ltd.Company is the least popular with only 7.5% installation.

The goodwill of the company, its service and facilities, promotions, prices of the system, personal and other relations etc. play role in deciding the popularity of the company.

#### 4.4.4 Information Means/Sources in the Study Area

Energy plays vital role in making access to information and technology. Different electronic means like Television,radio, mobile phone etc. are used as source of information in the study area is shown below in table:

**Table No 4.10**  
**Information Sources in the Study Area**

S.N	Type of Sources	No. of Households	Percentage (%)
1	Radio	38	95
2	Mobile phone	33	82.5
3	Television	4	10

Sources: Field Survey, 2014

Out of 40 SHS installed households, 95% households have at least a radio in their homes. Similarly 82.5% household has at least a mobile phone with anyone of their family member. And only 4% of people has access to Television.

#### 4.4.5 No. of Bulbs Used by Households in the Study Area

No. of bulbs used for lighting by households in the study area varies as per system capacity, types of bulbs used, no. of family size etc. which is shown in the table below in table no 4.13

**Table No 4.11**  
**Distribution of Bulbs for Lighting**

S.N	No. of Bulbs	No. of Households	Percentage (%)
	1-3	6	15
	4-6	31	75.5
	7 and above	3	7.5
	Total	40	100%

Sources: Field Survey, 2014

The above table shows that more than half of the Solar Home System installed households (75.5%) in Gaguda VDC has 4 to 6 bulbs used for lighting. 15% households has bulbs between 1to 3 and 3 households has bulbs equal and more than seven.

The no of bulbs depends upon the system capacity, requirements of the house and on types of bulbs used for lighting. During the study it is found that all bulbs are not used at a time by households, they are used alternately. Appropriate no. of bulbs as per system capacity helps in longevity of battery and panel.

#### **4.4.6 Types of the Bulbs Used in the Study Area**

The efficiency of the solar energy greatly depends upon the types of bulbs used rather than in no. of bulbs. The light produced by bulbs like CFL, W/LED is cleaner, brighter and efficient than tube light. In the study area different types of bulbs are found using by households is shown below in table no.4.14

**Table No:4.12**  
**Distribution of Bulbs According to Types and Watts**

S.N	Types of Bulbs	Watts	No. of Households	Percentage
1	Only CFL	5	3	7.5
2	CFL + Tube	5,10 and 5,10	11	27.5

3	CFL + W/LED	5,10 and 1.5 and 2.5	23	57.5
4	CFL + Tube + W/LED	5 and 5,10 and 2.5	4	10
	Total		40	100%

Sources: Field Survey, 2014

Among the bulbs most households 57.5% are using CFL and W/LED while 27.5% households are found using CFL and Tube light. 10% households are found using all CFL, W/LED and tube while only 7.5% households are using only CFL.

In the field the SHS users are found quite aware about advantages of high efficient bulbs and the trend of using them are in fashion.

#### 4.4.7 SHS used for Lighting by Sample HHs in the Study Area

The main purpose of installing SHS in rural areas like in Gaguda VDC is primarily for lighting in nights. Solar energy is mostly used to do household work in night, for children to read and write as well as for other commercial purposes like lighting for hotel and shop. No. of hours used for lighting on the basis of households is shown below in table no 4.15

**Table No: 4.13**

#### **Solar Home System Used Daily for Lighting in Night**

S.N	No. of Hours Used for Lighting	No. of Households	Percentage (%)
1	For Two Hours	20	50
2	For Three Hours	17	42.5
3	For Four Hours	3	7.5
	Total	40	100%

Sources: Field Survey, 2014

The above table shows that half of total SHS installed households were using SHS for about 2 hours for lighting daily in a night. 42.5% household were using SHS for lighting 3 hours daily while 7.5% households were found SHS using 4 hour for daily

lighting. In Gaguda VDC most of the respondents are farmer, so the general use of solar light is for kitchen works at night and for student to study two/three hours at night.

#### 4.4.8 Environmental Impact of SHS Compared to Kerosene Lamp

Regarding the environmental impact of SHS compared to kerosene lamp there is common general answer that almost 100% respondents of GagudaVDC state that kerosene lamp produce smoke that makes room dirty as well as there was chances of accident of fire hazards but solar energy is smokeless and it helps their children to study more and helps to keep the room clean and bright.

#### 4.4.9 Major Problems Faced with SHS

Using solar energy technology requires proper knowledge and understanding from its installing phase to its use, operation and maintenance. The initial cost of SHS is quite high in compare to traditional sources of energy so many people find it unaffordable. Beside this, proper guidelines are required for its operation and maintenance. Some major problems faced by SHS users of Gaguda VDC is shown below in table no 4.16

**Table No: 4.14**

#### **Major Problems Faced by SHS Users**

S.N	Types of Problems	No. of Households	Percentage (%)
1	Cost	5	12.5
2	Operation/Maintenance	15	37.5
3	Both cost and Maintenance	10	25
4	Less efficient during bad weather	10	25
	Total	40	100%

Sources: Field Survey, 2014

The above table shows that 12.5% households take SHS cost is high for them while 37.5% households faced problem of operation and maintenance like battery fuse, changing water level in battery etc. 25% HHs complains that during rainy season and when weather is cloudy the energy produced by their SHS is not enough for them, so the cost of SHS should be reduced by giving more incentives to rural low income households as well as there should be awareness programs on SHS and skilled technician available in village for its maintenance.

## **CHAPTER FIVE**

### **ENERGY SCENARIO, SOCIO- ECONOMIC AND OTHER IMPACTS OF SHS**

Nepal's energy resources are presently classified into three categories namely the traditional, commercial and alternative. Traditional energy resources include fuel wood from forests and tree resources, agricultural residues coming from agricultural crops and animal dung in the dry form. 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, and micro level hydropower are categorized into the alternative energy resources in Nepal. In Gaguda VDC the all these three kinds of energy resources are in use.

#### **5.1 Energy Scenario**

##### **5.1.1 Scenario of Fire Wood Consumption**

Among the traditional resources fire wood consumption is very high i.e. 74.96% of total energy consumption in sample HHs of Gaguda VDC. About 196560 kg, 3292380 MJ equivalent to Rs 327600 is derived from firewood. Both SHS users and non-users use almost similar quantity of firewood mainly for cooking purpose which varies from 5 to 10 bhariper month.

The excessive use of fire wood energy is not a new phenomenon, almost in all rural parts of Nepal, fire wood is the most common and major sources of energy. The Gaguda VDC is surrounded by community forestry so people access to fire wood is easy, cheaper, and using it for cooking purpose is like the part of their way of living which all leads to the maximum use of fire wood than any other resources in the study area.

##### **5.1.2 Scenario of Consumption of Kerosene**

Among the commercial energy sources, the mostly used common source of energy in Gaguda VDC is kerosene. The consumption of kerosene is relatively low in SHS installed households about 4 to 9 liters per year which they mainly use for lighting, igniting firewood and cooking purpose.

The solar home system non users consume annually about 10 to 15 liters of kerosene for the purpose of lighting, igniting firewood and cooking purpose. A SHS installed households save at least NRS 1426  $((32775-14260)/10)$  annually by the application of SHS than SHS non users.

In total about 409 liters, 14315 MJ energy equivalent to RS 47035 is consumed by sample HHs of Gaguda VDC.

### **5.1.3 Scenario of Solar Energy Consumption**

Under the AEPC about 242 HHS of Gaguda VDC had installed the SHS in subsidy. The villagers were found using 20Wp system to up to 30Wp system using CFL of 5 and 10 watt, Tube light/ FL of 5 and 10 watt, W/Led bulbs of 2.5, 5 and 1.5 and 2.5 watts for lighting respectively. Annually 1085400 MJ energy is derived from 40 SHS installed HHs in Gaguda VDC.

The SHS was found mainly used for lighting the bulbs in the night for educational purpose for the children as well as for the commercial purposes like lighting the hotel and shop for doing business. The villagers found to be very happy with the arrival of new technology in their village but at the same time they were found complaining about the inefficiency of SHS during the bad weathers. The installation cost was also not so affordable for every households at Gaguda VDP and the maintenance of SHS was very tough for them. There should be provision on easily availability of SHS components, skilled technicians and awareness program on SHS which will help in further development and promotion of SHS.

### **5.2 Per Capita Energy Consumption**

The average per capita energy consumption of sample HHs of Gaguda VDC is 12.54 GJ/person/year. The per capita energy consumption is calculated by adding different forms of energy used by population of the sample households. Consumption of Firewood, Kerosene and of Solar PV all was converted into one measurable unit in MJ and their addition was divided by total population of the sample households.

The average per capita energy of sample HHS of Gaguda VDC almost tally with national per capita energy consumption i.e. 15 GJ. Still Per Capita Energy Consumption is less, the reason might be people access and right over energy is obviously low in rural parts of the country especially in rural mountainous part than in Terai, and similarly the consumption of energy is also very low in rural part of the country compared to urban areas.

### **5.3 Socio- Economic and Other Impacts**

As we have already mentioned that in remote areas where electric energy as well as other sources are less viable and costly, the SHS will be an effective substitute which increases people access to energy and helps to adopt a better way of living. Installing SHS has several benefits which are discussed below;

#### **5.3.1 Social Benefits**

Among the various social benefits noticed by SHS users of GagudaVDC, the major benefits we are going to discuss here is its positive impact on Education and Women Empowerment.

Students were compelled to study under dim light of tuki before the installation of SHS. The lights coming from that kerosene powered tuki was not bright enough, smoky and causes headaches for children to study. After SHS installation, under the clean and bright, non-smoky light children are found increased their study hour from at least 1 hour per night to up to 3 hours.

SHS powered communication sources like TV, Radio, Mobile phone has played great role in increasing awareness about gender equality in the villagers. People are made aware to send their girls also to schools. Other social benefits like women can save time and energy required in searching fuel wood etc. have been decreased. Beside this women perform different households and income generating activities in solar lights at night like battikathne, taparibunne, making woolen bags etc. which has helped in overall development of women of Gaguda VDC.

### **5.3.2 Economic Benefits**

Among the various economic benefit, one of the important economic benefit is it saves the money for kerosene, torch light batteries etc. which helps to boost the economic condition not only of the households but of the entire country. The money paid for import of these oil products will be reduced by SHS and helps to reduce the trade deficit.

Solar energy has provided gateway to different income generating activities at Gaguda VDC. Beside this it has helped in diversification and commercialization in rural areas. By using solar energy different income generating activities like making handicrafts, woolen products etc. was significantly increased. These solar lights are also used in local shops, hotels at night which also help to increase the business. In conclusion this solar energy is helping in developing and promoting entrepreneurship at local level.

### **5.3.3 Environmental Benefit**

One of the most important benefits of solar energy is it cuts the carbon footprint. Solar electricity is green, renewable energy and doesn't release any harmful carbon dioxide equivalent (CO<sub>2</sub>e), black carbon (BC) and other pollutants. A typical solar home PV system could save over a tone of CO<sub>2</sub>e per year - that's more than 30 tones over its lifetime.(Wikipedia)

The benefit is solar light do not produce indoor air pollution like kerosene lamps and it also reduces the chances of accidental fire hazards. Respondents also noticed that due to availability of solar energy and other various forms of energy community forest has been conserved well.

### **5.3.4 Health Benefits**

According to the respondents, Health benefits like respiratory diseases, headache, and fire hazard etc. due to smoke of fire wood won't be there in solar lights. The SHS is

also used to run the health posts in evening and nighttime in Gaguda VDC during emergency and normal time.

### **5.3.5 Poverty Reduction and Rural Development**

According to Nepal Living standards survey (NLSS-III, 2010-11)poverty rate is 25.16 percent.The poverty is much higher in rural areas (27.43%) than in urban areas (15.46%). Generally poor people highly depend upon traditional sources of energy. The energy price influences the energy use(consumer choices and behavior). Higher the per capita energy consumption signifies higher human development index(HDI). Similarly rural development is the strategy of fulfilling the basic necessities of people with high degree of self-respect and freedom. People access to solar energy and its various positive impacts plays crucial role in poverty reduction and rural development as follows.

Firstly solar energy helps in increasing people access to energy.In remote parts where SHS is highly feasible and less costly than development of any other form of energy,SHS will be a wise substitute.Higher the per capita energy consumption signifies higher human development index(HDI).

Secondly, solar energy in one hand help to reduce the consumption of imported fossil fuels and on the other hand helps in initiating income generating activities at local level. So it saves huge money from paying to kerosene as well as for other fuels. Different income generating activities like making handicrafts, weaving woolen product etc. can be run from solar energy which helps in overcoming economic vulnerability in rural remote areas.

Thirdly SHS plays role in development of social sector like education,health, women empowerment etc. Students can read and write well in cleaner and brighter solar light,solar energy can be used in running computer at school,to run health facilities in night and keep medicine cool in refrigerator in local area.Other social benefits like women can save time and energy required in searching fuel wood etc. will be decrease. Women perform different households and income generating activities in solar lights at night like battikathne,taparibunne, making woolen bags etc. which has helped in overall development and empowerment of women.

Fourthly,it also has increased the people access to information through TV, Mobile phone, Radio so that people have got opportunities to learn and understand different socio-economic, political aspects of the entire world. Their way of living has been transformed to modern, competitive and creative living.

In conclusion access to Solar energy has helped rural people to boost their income, to study more and towards overall development of their lives and make them self-reliant which certainly plays crucial role in reducing the poverty and in rural development.

### **5.3.6. Awareness and Attitudes towards SHS**

The sampled HHs of Gaguda VDC had a limited knowledge of SHS and neutral perceptions regarding its use and raising the awareness. However the sampled HHs showed the clear positive attitude toward the SHS development. The people were found aware of such benefits of the SHS and even willing to install the SHS without the government subsidy however due to financial condition they were not able to install it.

### **5.4 Problems Faced with SHS**

There is no doubt that SHS has helped local people not only by providing energy but also from its positive consequences on social, economic, environmental and on other various aspects of lives. In spite of its high degree of usefulness, some problems faced with SHS in Gaguda VDC are as follows.

- i. **Cost:** Though there is subsidy, the initial installing cost of SHS is high. It is really difficult for low income people to install SHS. About 45% of sample respondents of Gaguda find the Cost of SHS as a major problem during its installation and for further promotion and development.
- ii. **Maintenance:** Maintenance problem like fuse problems, changing distilled water in battery, low durability of battery and charge controller etc. are the problems frequently faced by SHS users of Gaguda VDC. More than 40 % HHs of the study area find maintenance as major problems. Lack of skilled manpower and repairing centers is also another problem for them.
- iii. **Low Efficiency during Bad Weathers:** About 15% HHs of the study area find low efficiency of SHS during cloudy, rainy and humid day. The lights were not brighter enough and even all loads don't work during such time.

## CHAPTER SIX

### MAJOR FINDINGS, CONCLUSION AND RECOMMENDATIONS

#### 6.1 Major Findings

Following are some of the highlights of the key findings.

- ) Gaguda VDC of Doti district is the study area.
- ) The VDC has 584 households with total population 3,058, male 1,401 and female 1,657.
- ) It is found that out of total households, 242 households have been taking advantage from solar energy.
- ) Out of 242 SHS households 40 HHs who were using SHS and 10 SHS non users SHS users were taken as sample population for the study of case. Therefore in total there were 50 households were taken as a sample population for the study.
- ) The total population of sample households is 350 persons, male 167 (47.71%) and female 183 (52.29%).
- ) In the study area average HHs size is found to be 5.24.
- ) The total area of Gaguda VDC is 60.18 sq. km.
- ) Highest no of households in the study area are Chettri (69.82%) followed by Kami (21.97%).
- ) The average literacy rate of sample HHs is 60.57%, Male literacy 68.86% and female literacy rate 53.00%.
- ) Major occupation status of the sample HHs was Agriculture 54%, job 20%, business 18% and remittance 8%.
- ) 46% sample households agreed that their income supports expenditure for 8-12 months while 42% sample HHs for 12+ months and 10% for 4-7 months and 2% sample HHs were only 2% were capable for 1-3 months.
- ) After the installation of SHS, 56% sample HHs noticed the increased of study hours of their children by 2 hours, 34% HHs by 1 hour and about 9% households by 3 hours per day.

- ) Fire wood is the most common and highly used sources of energy by both SHS users and non SHS users. It shares the highest value in per capita energy consumption calculation. About 3292380 MJ, energy is used by 50 samples HHs annually in the study area equivalence to NRs. 327600.
- ) Almost every household's user were found to use kerosene whether they were SHS user or non SHS users but the consumption of kerosene in non SHS installed household was found a bit higher.
- ) The per capita energy consumption from kerosene is 0.03588 GJ/year/person which is almost half than solar home system none users i.e. 0.06027 GJ/year/person
- ) By installing solar home system, the HHs can save at least NRs. 606.625 annually used for paying kerosene.
- ) Annually 409 liters of kerosene is used by sample HHs (including both SHS users and non-users) equivalence to NRs 47035.
- ) The per capita energy consumption of solar energy is 0.02138 GJ/person/year.
- ) The Per capita energy consumption of SHS users is 9.45726 GJ/person/year which is slightly higher than non SHS users i.e. 9.48027 GJ/person/year.
- ) The average Per capita energy consumption of total 50 samples HHs of Gaguda VDC is 9.46468 GJ which is around one third less than national per capita energy consumption of 15 GJ.
- ) In the study area, SHS installation has started from 2066 BS with lowest no. of installation 5% and last recorded installation was in the year 2069 BS by 40% HHs.
- ) 25Wp SHS is most popular in the study area used by 42.5% HHs, 30Wp was used by 30% HHs and lowest household about 27.5% has installed 20Wp system.
- ) The prices of same capacity SHS also varied according to installing company. The average cost of installation of 20Wp system lies between Rs. 20,000 to Rs. 22,000, for 25Wp system the cost lies between Rs. 25,000 to Rs. 28,00 and the average cost of 30Wp lies between Rs. 30,000 to Rs. 33,000 including subsidy during the year 2067 B.S to 2069 B.S.

- ) Among 5 solar energy companies, most popular company in Gaguda VDC is Renewable Nepal Alternative Energy Pvt.Ltd., which has alone installed more than half (52.5%) of the total SHS installed .
- ) In the study area 95% HHs takes radio as major source of information while 82.5% household has at least a member with mobile phone and only 10% of HHs uses TV.
- ) 75.5% sample households in the study area had installed 4 to 6 no. of bulbs, 15% HHs has 1 to 3 bulbs and only 7.5% HHs has no. of bulbs more than seven bulbs.
- ) In the study area 27.5% HHs uses CFL and Tube Light, 57.5% HHs uses CFL and W/LED, 7.5% HHs uses only CFL and 10% HHs use all three CFL, Tube light and W/LED.
- ) 50% HHs uses SHS for lighting for about 2 hours per day while 42.5% HHs used for 3 hours and 7.5% HHs for uses for 4 hour per day.
- ) 100% sample HHs agreed that SHS helped them to keep home environment clean and healthy compared to kerosene.
- ) 40% SHS users faced problems with its maintenance while 45% HHs find it costly and 15% HHs complain about its low efficiency during bad weathers.

## 6.2 Conclusion

Solar electricity has numerous end use applications such as lighting, on health, education and communication etc. By the promotion of the solar energy 242 HHs of Gaguda VDC had been benefited from the cleaner, brighter and smokeless light that has increased the study hour of the children at night. The users are also free from health problems like headaches, respiratory problem, eye infection etc. caused by smokes from fire wood.

People access to information has also increased and no of households with TV, radio, mobile phone has been increased which eventually has increased the public awareness on various social, economic, political etc. issues and on way of living. People has started sending girls to school, women entrepreneurship at local level has been started.

SHS in one hand has reduced the household expenditures used for purchasing the fossil fuel, on the other hand it has increased the probability of initiating own business and income generating activities in local level like communication services, hotel and shop business, battikathne business, taparibunne business, woolen bags business etc. supporting local people to earn and utilize their extra time.

As solar electricity is green, renewable energy it doesn't release any harmful carbon dioxide equivalent (CO<sub>2</sub>e), black carbon (BC) and other pollutants to the environment. So it is eco-friendly and most appropriate technology for the electrification of rural remote areas.

All the respondents of Gaguda VDC have very positive attitudes towards SHS and they agreed that it had helped them in development of socio economic and other various aspects of their lives. Still reduction in the cost of installation and provision of skilled technicians for operation and maintenance of SHS at local level is most for its further promotion and development.

### **6.3 Recommendations**

Form the present study about the energy impact of solar home system to the users, some recommendations are made as follows.

#### **A) Regarding the Cost**

- i. The initial cost of installing SHS is high such that all people can't support it. So subsidy should be increased for the rural areas while there should be also provision of subsidy to urban areas people who are willing to install it.
- ii. Beside subsidy government should provide incentives in imports and transportation of components of solar energy system rather than providing incentives to kerosene.
- iii. The cost of installation of same capacity in the same locality also differed as per the installing company. So cost of installation according to its capacity and geographical region should be fixed by concerned government authorities.
- iv. There should be provision of interest less loan and insurance policy for SHS.

- v. SHS installation should be made as much possible as free for those poorest people of remote areas where grid electricity infrastructure seems costly.

### **B) Regarding Maintenance**

- i. Government should run campaign to make people aware about SHS, its use and impact on the users.
- ii. Repairing centers and shops for buying and repairing different components of SHS should be made available within the locality.
- iii. People's easy access to skilled technicians on SHS should be made available at local level.
- iv. Local people should be trained for the proper operation and maintenance.

### **C) Regarding Technology**

- i. Use efficient solar PV panels which are more than 10-15 % efficient.
- ii. Use of high efficient bulb like ultra-efficient led for more efficiency and durability.
- iii. Use reliable battery for efficiency and longer life.

### **D) Policy Level**

- i. Primarily research is foundation for making any kind of policy,so research centers on solar energy with involvement of experts should be run in different part of the nation.
- ii. There should be long term like five years plan on solar energy with clear objectives and fixed targets on installing SHS throughout the nation.
- iii. Government should make policy on commercial production of solar energy and provision of selling it to the grid connection.
- iv. Effective implementation of clean development mechanism (C.D.M) for solar energy should be ensured.
- v. Effective monitoring and evaluation of various institutions and programs on solar energy should be done on regular basis.

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**Annex-1****A STUDY ON THE ENERGY IMPACT OF SOLAR HOME SYSTEM TO ITS USERS.**

(A Case Study of Gaguda VDC of Doti District, Nepal)

**Questionnaire on:****A. Demographic/Social/Education**

- a. House owner Name, Mr. /Ms. /Mrs. \_\_\_\_\_
- b. Household size \_\_\_\_\_
- c. No. of Male \_\_\_\_\_ Female \_\_\_\_\_
- d. Literate:  
Male \_\_\_\_\_ Female \_\_\_\_\_
- e. Illiterate:  
Male \_\_\_\_\_ Female \_\_\_\_\_
- f. No. of School going members  
Male \_\_\_\_\_ Female \_\_\_\_\_
- g. Study hours per day:  
Before SHS \_\_\_\_\_ after SHS \_\_\_\_\_

**B. Economic**

- a. Major occupation of family members \_\_\_\_\_
- b. Family income can support households expenditures for  
1–3 months  4–8 months  8–12 months  12<sup>+</sup> months
- c. Any income generating activities by using SH energy

Activities	Energy Consumption (units)	Economic benefits/month
Business		
Services		
Others		

### C. Energy

#### a. Total households consumption

Types	Quantity (D/W/M/A). Cost	Annual consumption
Fuel wood		
Kerosene		
Cattle dung briquettes		
Others		

### D. Solar Home System

- a. Installed year \_\_\_\_\_
- b. Capacity (Wp) \_\_\_\_\_
- c. Company Name \_\_\_\_\_
- d. Total Cost (Rs.) \_\_\_\_\_
- e. Govt. Subsidy (Rs.) \_\_\_\_\_
- f. Electric Appliances used  
 TV  Radio  Mobile  Other

#### g. Types of Lamps

Types of Lamps	No.	Watts
CFL		
FL/TL		
WLED		
Others		

- h. No. of hours use daily  
 Lighting \_\_\_\_\_  
 Other use \_\_\_\_\_
- i. Environmental impact of SHS compared to Kerosene lamp  
 \_\_\_\_\_
- j. Major problem faced with SHS application  
 Cost \_\_\_\_\_

Operation/Maintenance \_\_\_\_\_

Others \_\_\_\_\_

k. Photovoltaic is advance technology and can be used to covert solar energy into electricity.

\_\_\_\_\_

l. I would like to install a SHS in my home

Yes  No

m. I am willing to install SHS in my home even I do not get government subsidy

Yes  No

n. I would like to work voluntarily raise public awareness of SHS

\_\_\_\_\_

## Annex-II

### Annual Fuel wood consumption by HHs

S.N.	Quantity in Kg( 1 Bhari=45kg)	In MJ(1 kg Fuel wood =16.75 MJ)	Total annual cost( 1 Bhari =RS 75)
1	3780	63315	6300
2	4320	72360	7200
3	2700	45225	4500
4	4320	72360	7200
5	3780	63315	6300
6	3780	63315	6300
7	3780	63315	6300
8	4320	72360	7200
9	4860	81405	8100
10	3780	63315	6300
11	4320	72360	7200
12	4320	72360	7200
13	3780	63315	6300
14	3780	63315	6300
15	4320	72360	7200
16	4860	81405	8100
17	3780	63315	6300
18	2700	45225	4500
19	3780	63315	6300
20	3780	63315	6300
21	3780	63315	6300
22	3780	63315	6300
23	3780	63315	6300
24	3780	63315	6300

25	3780	63315	6300
26	3780	63315	6300
27	4320	72360	7200
28	4320	72360	7200
29	4320	72360	7200
30	4320	72360	7200
31	4320	72360	7200
32	3780	63315	6300
33	2700	45225	4500
34	4320	72360	7200
35	2700	45225	4500
36	3780	63315	6300
37	2700	45225	4500
38	3780	63315	6300
39	4860	81405	8100
40	4320	72360	7200
Total	156060	72360	7200
41	4320	90450	9000
42	5400	63315	6300
43	3780	63315	6300
44	3780	72360	7200
45	4320	63315	6300
46	3780	72360	7200
47	4320	45225	4500
48	2700	63315	6300
49	3780	72360	7200
50	4320	678375	67500
Total	40500	3292380	327600
Grand Total	196560	72360	7200

Sources: Field Survey, 2014

**Annex-III**  
**Annual Consumption of Kerosene by HHs**

S.N.	Quantity in Lit. (yearly)	MJ (1 Lit = 35 MJ)	Total annual cost ( cost/lit = R.s. 115)
1	7	245	805
2	8	280	920
3	5	175	575
4	7	245	805
5	6	210	690
6	7	245	805
7	7	245	805
8	8	280	920
9	9	315	1035
10	8	280	920

## STUDY ON THE ENERGY IMPACT OF SOLAR HOME SYSTEM ITS USERS: ANNEXES

11	8	280	920
12	9	315	1035
13	6	210	690
14	9	315	1035
15	9	315	1035
16	9	315	1035
17	9	315	1035
18	6	210	690
19	9	315	1035
20	6	210	690
21	9	315	1035
22	8	280	920
23	5	175	575
24	5	175	575
25	5	175	575
26	5	175	575
27	8	280	920
28	8	280	920
29	8	280	920
30	8	280	920
31	8	280	920
32	6	210	690
33	6	210	690
34	9	315	1035
35	6	210	690
36	6	210	690
37	4	140	460
38	4	140	460
39	9	315	1035
40	6	210	690
Total	285	9975	32775
41	15	525	1725
42	12	420	1380
43	13	455	1495
44	12	420	1380
45	12	420	1380
46	11	385	1265
47	14	490	1610
48	10	350	1150
49	13	455	1495
50	12	420	1380
Total	124	4340	14260
Grand Total	409	14315	47035

Sources: Field Survey, 2014

**Annex-IV**  
**Respondent Households of the Survey**

S.No	Household Owner Name	VDC	Ward No.
1	Bir Bahadur Bista	Gaguda	2
2	Raju Devi Lohar	Gaguda	2
3	TikaRokaya	Gaguda	2
4	Asi Devi Khadka	Gaguda	2
5	Raju Ddevi Kami	Gaguda	2
6	KaluLohar	Gaguda	2
7	Ram Bdr Dhami	Gaguda	2
8	Nanda Singh Thakulla	Gaguda	2
9	Bisna Devi Kami	Gaguda	2
10	Sita Devi Batala	Gaguda	2
11	Radha Devi Khadka	Gaguda	2
12	Mana Devi Kami	Gaguda	2
13	ChaniBohara	Gaguda	2
14	Phungi Kami	Gaguda	2
15	Loge Kami	Gaguda	3
16	Devi Kami	Gaguda	3
17	Ganga Devi Khadka	Gaguda	3
18	Piyuli Devi Thapa	Gaguda	3
19	Khadka Raj Joshi	Gaguda	3
20	Bhagarathi Devi Bista	Gaguda	3
21	MunaBhul	Gaguda	2
22	Rudra Bahadur Malla	Gaguda	2
23	Jaban Si Bam	Gaguda	2
24	SitaKumariMalla	Gaguda	3
25	NardaBdr Bam	Gaguda	3
26	Nanna Devi Thapa	Gaguda	3
27	Ganga Devi Thapa	Gaguda	3
28	Naru Devi Bogati	Gaguda	3
29	Maheshowri Thapa	Gaguda	3
30	JayaramOjha	Gaguda	3
31	Paru Devi Saud	Gaguda	3
32	Jagtara Devi Ojha	Gaguda	3
33	Uma Devi Khatri	Gaguda	3
34	Panda Devi Magar	Gaguda	3
35	Gausari Magar	Gaguda	3
36	MunadeviKhadayat	Gaguda	3
37	Durga Devi Khadka	Gaguda	3
38	HeukeDamai	Gaguda	3
39	Amrita Devi Deuwa	Gaguda	3
40	Tilak Kumar B K	Gaguda	2
41	Sher Bahadur Saud	Gaguda	3
42	Amrita Devi Dhole	Gaguda	3
43	Mina Devi Dangj	Gaguda	3

44	Belmati Devi Pun Magar	Gaguda	2
45	Lalita Devi Malla	Gaguda	2
46	PremBahdurSharki	Gaguda	3
47	Suna Devi Balayar	Gaguda	3
48	BhimBahdur Bhat	Gaguda	3
49	Chandra Man Bohara	Gaguda	3
50	Bhawana Devi Saud	Gaguda	2

Sources: Field Survey, 2014

**Photo Annex**



Fig: SHS installation, Gaguda (ward no 2) Fig: SHS installation, Gaguda (ward no 3)

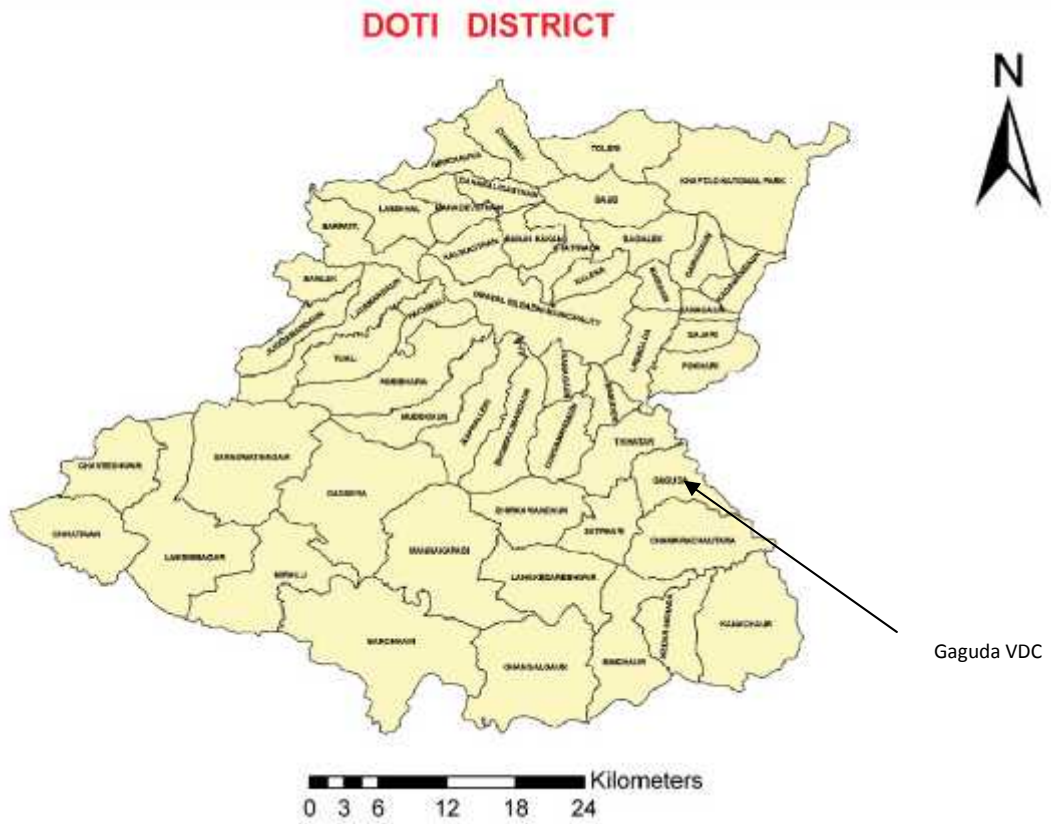


Fig: Family members at night under FL Fig: Children reading under WLED, Gaguda VDC

## Map of Nepal



### Map of Doti District Including Gaguda VDC



Source: Source: DDC Profile 2065 B.S