ASSESSMENT OF PARABOLIC SOLAR COOKER AS ALTERNATIVE COOKING FUEL AND USERS' PERCEPTION TOWARDS IT IN BELDANGI REFUGEE CAMP, DAMAK

Submitted By

Khyam Raj Nepal

T.U. Registration Number: 5-2-202-206-2006

T.U. Examination Roll No.:12724

Dissertation submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Environmental Science

(Specialization Paper Mountain Environment)

Submitted To

Department of Environmental Science,

Khwopa College (Affiliated to Tribhuvan University),

Dekocha-5, Bhaktapur,

Nepal

January, 2016

LETTER OF RECOMMENDATION

This is to recommend that the thesis entitled "**Assessment of Parabolic Solar Cooker as Alternative of Cooking Fuel and users' perception towards it in Beldangi Refugee Camp,Damak**" has been carried out by "Khyam Raj Nepal" for the partial fulfillment of Master's Degree in Environmental Science with special paper "Mountain Environment". This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any degree in any institutions.

…….

Krishna Bhakta Duwal

Faculty, Khwopa College

Department of Environmental Science

Date

LETTER OF APPROVAL

On the recommendation of the supervisor Krishna Bhakta Duwal this thesis entitled"**Assessment of Parabolic Solar Cooker as Alternative of Cooking Fuel and users' perception towards it in Beldangi Refugee Camp,Damak**" submitted by Khyam Raj Nepal is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for Master's Degree of Science in Environmental Science with special paper" Mountain Environment".

…….

RabindraJaykhwo

Incharge, BSc and MSc

Khwopa College

Date

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by "Khyam Raj Nepal" entitled "**Assessment of Parabolic Solar Cooker as Alternative of Cooking Fuel and users' perception towards it inBeldangi Refugee Camp,Damak**" has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Environmental Science with special paper"Mountain environment".

EVALUATION COMMITTEE

Supervisor	Head of Department
Full Name with Designation	Full Name with Designation
External Examiner	Internal Examiner

Date of Examination: dd/mm/yr

DECLARATION

I hereby declare that the work presented in the thesis has been done by myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

Khyam Raj Nepal

Date

ACKNOWLEDGEMENT

This is my great pleasure to express my sincere gratitude to my supervisor Mr. Krishna BhaktaDuwal for his valuable time for guidance. His continuous support and constructive criticisms has been both challenging and encouraging make to come with this shape of report.

I would like to acknowledge the help of CRT-N, Kumaripati, Solar Technical Works, Sanepa, VFN Damak,VFN Chapa Gaunand UNHCRDamak for providing relevant information, literatures and suggestions.

I owe a special debt to my dear friends Mr. Ashok Dulal, Mr. Krishna P. Timsina, Mr. ManojGajurel, Mr. NabinBhurtel, Ms. PunamShrestha, and Mr. SarojShrestha for their continuous support and suggestion throughout the period. It would be unfair not to mention my dear friend Mr. DebendraTimsina who helped me for raising this concepts and continuous support in varied assistance along with computer work.

Lastly, I whole-heartedly would like to thank all the respondents, staff of different institutions for their co-operation during the field visit and interaction. I thank my family member and everyone who has helped me and contributed valuable suggestions, comments or criticisms.

Khyam Raj Nepal

Janauary, 2016

Abstract

This study was carried out to assess the effectiveness of Solar Cooker (SK-14) in Beldangi Refugee camp, Damak, Nepal and its contribution towards the sustainability. A questionnaire survey in user's household was conducted to assess the user's attitudes and field sample survey was conducted for the assessment of the saved amount of biomass and fuel related CO_2emission compare to baseline cooking technology.

Solar cooker has been used for cooking purpose along with solid biomass as briquette coal and fuel wood. According to the survey data the average numbers of hours using solar cooker is about 4 hour (3.95) per day,663 hrs in a year as average number of days using solar cooker is 46 days in per 100 days. Among these facts 74 % of respondent's family uses daily, 22% respondent's family uses occasionally and rest 4% are not using due to partial damage or lack of space. The user's expressed their satisfactions regarding the operation of SK-14, found to have 11% excellent, 55% goods, 17% satisfactory, 11% poor and 6% very poor performance.

The amount of heat energy contributed by the SK- 14 throughout the year is 1068.1 MJ for the cooking (average 663 hrs as effective operating hours in a year) with average power of 430watt. Again the amount of CO_2 emission reduction by one solar cooker in one year is found to be 3.906 tons if baseline cooking technology is traditional cook, which is equivalent to 1065.95 kg of fuelwood. Similarly, the amount of CO_2 emission reduction when improved cook stove is found to be 1.953 tons per year per solar cooker and this is equivalent to 532.75kg of fuel wood.

Keywords: *Beldangi refugee camp, clean energy, emission reduction, fuel wood, greenhouse gases, parabolic solar cooker*

Tables of contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXES

LIST OF ABBREVIATION

AEPC	Alternative Energy Promotion Centre
ADB	Asian Development Bank
CDM	Clean Development Mechanism
CES	Center for Energy Studies
CEF	Carbon Emission Factor
CER	Certified Emission Reduction
CRE	Center for Renewable Energy
CRT-N	Center for Rural Technology-Nepal
DMC	Damak Multiple College
DNA	Designated National Authority
EXCOM	Executive Committee (of UNHCR)
GHGs	Green House Gases
GoN	Government of Nepal
ICS	Improved Cooks Stove
IPCC	Intergovernmental Panel on Climate Change
IREF	Interim Rural Energy Fund
KP	Kyoto Protocol
LPG	Liquefied Petroleum Gas
LWF	Lutheran World Federation
MoSTE	Ministry of Science Technology and Environment

MJ	Mega Joule
PPP	Polluter Pays Principles
PoAs	Program of Activities
REF	Rural Energy Fund
RET	Renewable Energy Technology
UNFCC	United Nation Framework convention on Climate Change
UNHCR	United Nations High Commissioner for Refugee
VFN	Vajra Foundation Nepal
WECS	Water and Energy Commission Secretariat

CHAPTER 1: INTRODUCTION

1. Background

The majority of the refugees arrived in Nepal in the early 1990s, feeling increasing harassment of ethnic Nepalese in Bhutan. Most refugees have been living in the camps for over two decades in eastern Nepal.

According to report of Women's Commission for Refugee Women and Children (March, 2006), the refugee mainly depends on local forests for firewood collection. Initially United Nations High Commissioner for Refugees (UNHCR) began providing weekly ration of kerosene considering cheap, available and easy to obtain. But when the distributions began, the price has more than doubled in the last years, and strikes and blockades imposed as a result caused frequent scarcities of the fuel and delays in transporting it. The rapid rise in the price of kerosene has led UNHCR and its main implementing partner, the Lutheran World Federation (LWF), to embark on a major alternative fuel development program and plan to cease kerosene distribution in early 2006.

As mention in the report of Women's Commission for Refugee Women and Children (March, 2006) UNHCR and LWF are hoping to supply at least 50 percent of the refugee population with biomass briquettes (known as honeycomb or beehive briquettes) beginning in early 2006. However, there is much less willingness and reluctant to accept the introduction of alternative fuels due to preferences for high speed of cooking, ability to cook indoors and flexibility of cooking time and temperature. Later UNHCR planned to supply the remaining 50 percent of the refugee population with compressed coal dust briquettes, also beginning in early 2006, because of the large amount of biomass needed for the honeycomb briquettes. Refugees appear to be much more accepting of the charcoal than of the honeycomb briquettes. According to LWF a typical Bhutanese meal requires 1-2 briquettes to cook.

1.1 Clean Energy and Energy Consumption

There has been disseminated parabolic solar cooker program in Beldangi I camp (Jhapa) since the mid-1990s, supported by the joint Dutch-Nepali Vajra Foundation. The refugees use the cookers and are generally pleased with them. Because the cookers have so far been merely a supplement to kerosene, it remains to be seen how successful the program would be in the absence of non-solar alternatives. Solar is also problematic in Nepal as there is only enough sun about 50% of days (VFN 2006) during the year to effectively use the cookers – necessitating an additional fuel source and increasing overall cost. The VajraFoundation has estimated that each cooker costs NPR 9,500, including transportation and assembly as well as the stand, cooking pot and hay box (insulating box prevents loss of heat from food) at that time.

UNHCR has decided to cease most kerosene distribution as of January 2006. Charcoal briquette swill replace kerosene as the main fuel source in four of the camps, as local communities and/or refugees are trained to make honeycomb briquettes charcoal provides flexibility of cooking time and temperature, and can be re-used if not fully burnt. They cook relatively quickly but produce more smoke than either kerosene or the honeycomb briquettes.Alternative Energy, naturally generated energy source; any form of energy obtained from the sun, wind, waves, or another natural renewable source, in contrast to energy generated from fossil fuels are either renewable or sustainable without depleting a finite resource. These sources include wind, biomass, photovoltaic, solar thermal, geothermal, ocean and hydroelectric power. Alternative energy is renewable energy technologies vary widely in their technical and economic maturity, but there are a range of sources which offer increasingly attractive options. Their common feature is that they produce little or no greenhouse gases, and rely on virtually inexhaustible natural sources for their fuel. (CRT, 2007).

1.2 Energy Consumption Scenario of Nepal

The overall energy consumption of Nepal is largely dominated by the use of traditional noncommercial forms of energy such as fuel wood, agricultural residues and animal waste. The share of traditional biomass resources, commercial energy resources and renewable energy resources are 87%, 12% and 1% respectively. The share of traditional fuel is decreased from 91% in 1995/96, 88% in 2004/05 and 87% in 2008/09. The remaining 13% of energy consumed is through commercial source (Petroleum fuels, Coal and Electricity) and renewable. There is a slow pace of energy shift from traditional to modern one. The share of commercial has increased from about 9% in 1995 to about 12% in 2008/09.Similarly there is a growing trend in the alternative. Within the commercial source, electricity is in the higher side in substituting other fuels. Fuel wood consumption is increasing with the decreasing rate since last decade. Average annual growth is around 2.5% which is nearly equal to the population growth of the country at national level. More than 99% of the total fuel wood is consumed only in the residential sector (WECS, 2010).

1.3 Alternative Cooking Tool: Parabolic Solar Cooker

Nepal has abundant solar resources and evenly distributed throughout the country being located in favorable latitude. The average solar radiation varies from 3.6-6.2 KWh/m²/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. It has come out as a viable option to meet energy demand, conserve the forest resource, and reduce the pollution by utilizing suitable energy technology (DoS, 2011).

The solar energy can be collected by solar collector. People have devised two main types of artificial collectors to directly capture and utilize solar energy: flat plate collectors and concentrating collectors. Both require large surface areas exposed to the Sun. In Nepal mostly concentrating parabolic solar cooker of the type of SK-14 and which Nepalese revised version SK-14 Koe is being used. Both of them resemble each other except SK-14Koe have external metal wall on the edge of parabolic dish which helps to reduce the cold wind effect. The reflector focuses the sunlight on the bottom of the absorber plate, heating the pot in a fashion similar to a traditional electric or gas powered stove (VFN 2012).

Cloudy conditions and wind combine to make concentrating cookers highly difficult to use. In field studies, the concentrating cooker is not generally chosen due to its need to closely follow the sun (characterized by a low acceptance angle), its relatively high cost, and safety issues as focused sunlight can cause burns or eye damage. Nevertheless, in some applications, solar concentrators can make ideal cookers. So long as direct isolation is readily available and the user is experienced and careful, the concentrator represents a highly useful and powerful cooking tool. This does not require any primary energy. During cooking the SK-14 uses solar power at an efficiency of about 67% at an isolation of 700W/m^2 and uses neither primary energy, nor emits CO_2 (Lindeboom R. and Goverde R 2005).

The parabolic Solar Cooker has a reflecting surface in the form of a parabolic dish, which concentrates the solar rays at a focal point at which the black coated cooking pot is placed. It consists of 36 reflector sheets made from highly reflective aluminium with weight of 3 kg, with area of 1.5 m^2. The frame manufactured in rigid steel with powder coating for attractive looks and reflectors are fixed to a parabolic shaped metal frame. The adjustment and alignment towards the sunlight should be made after every 20-30 minutes to focus the sunlight. The deciding factor for well-functioning of Solar Cooker, is having the closest thing to a cloudless sky as possible, the temperature outside is less important. On clear, sunny winter days (down to –10° C) it can still use the unbelievable power of the sun (EG Solar, 2012).

1.4. Statement of Problems

Solar cooking technology is nowadays very observable and triable because of the pilot project. This technology fit in the refugees for current practices, is a crucial criterion for any solar cooking project which require more attention.

Today we are facing different type of energy crisis like lack of fuel firewood, scarcity of petroleum oil, gas, electricity etc. The very high price of the petroleum fuel makes the poor family very difficult for their livelihood. To overcome from these difficulties, we have to adopt renewable energy resource and put great concern to such type of environmentally friendly technology which has low operational cost and less pollution.

1.5 Objectives

General Objectives

i. To know the users' perception regarding effectiveness of parabolic solar cooker.

Specific Objectives

The specific objectives of the study are:

i. To know the amount of solar energy concentrated on the focal point of parabolic cooker.
ii. To calculate the quantity of biomass saved.
iii. To calculate the amount of carbon dioxide (CO_2) emission reduction.

1.6 Rationale of Study

This study on refugee camp will access to expose out the effectiveness of solar cooker in terms of reduction of CO_2 emission and dependency on fuel wood. The camps present a unique opportunity to carefully study a wide variety of different fuel options, and to weigh their respective advantages and disadvantages can be seen as a cooking fuel laboratory. Solar cooking technology has no pollution & no operational (running) cost a clean energy, certainly it may have good health impact on housewife, to reduce the risk of lung and eye diseases that affect millions of people worldwide, no pollution to the environment, and may fall within the purchasing capacity of the poor family who mainly depends on firewood and which is mainly responsible for the degradation of forests.

Meanwhile, in Nepal the potential Clean Development Mechanism (CDM) projects could be implemented through renewable energy technology (RET) and efficiency improvement projects like improved cook stove, gasifier, briquettes solar cooking etc (WECS 2010). Realizing this, Nepal should conduct intensive study on the present status of GHG emission, potential CDM projects based on the RETs and other alternative options (WECS, 2010).

One of the main intentions of the study is to calculate the save amount of biomass and carbon emission reduction by solar cooker. Using CDM, the government and private sectors in Annex I countries can develop or invest in this type of greenhouse gas (GHG) mitigation projects. Proved emission reductions will be credited to the country that invests to provide

solar cookers for the people. This Certified Emission Reduction (CER) will be counted towards the national CO_2 emission reduction target of the investing country, while the participating developing country gains the solar cooking technology for sustainable development. Those who use solar cookers instead of firewood are saving on GHG-emission. The crediting period are of two types i.e. Renewable crediting period at most seven years per crediting period and Fixed crediting period at most ten years the crediting period can start after the date of registration of the proposed activity as a CDM project activity (IPCC,2010).

CHAPTER 2: REVIEW OF LITERATURE

2.1 Theoretical Framework

Lindeboom R. and Goverde R, (2005) conduct a study on Solar Cooker (Towards sustainable relief-assistance Applicability of the sunny solution) in Refugee Camp and found to reduce about half the environmental impact (in primary energy use and CO_2 emission compared to the kerosene stove). In fact, most of the energy use of the solar cooker can be attributed to the back-up need: the usage of kerosene when the solar cooker cannot be used due to bad weather conditions. Cooking on a solar cooker turns out to be financially attractive as well.

KC and Nagata (2006) conducted research on refugee impact on collective management of Humse-Dumse community forest resources analyzing the relationship between forest resources, refugees and the host population and examined the past forest condition and management practices and the emerging managing practices due to the threat posed by the presence of the refugees. They concluded that the use of fuel wood by the refugees has been the most critical determinant of the growing resource scarcity and environmental damage and they acted as a trigger for the local population to act more assertively for themselves and be active participants in local protection and management of the forest resources.

As an extension of conventional CDM, it allows bundling and registration of similar kind of Green House Gas (GHG) emission reduction (or removal) projects having different implementation schedules over a period of time. As defined by the CDM Executive Board, A CDM program of activities (PoA) is a voluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or stated goal (i.e. incentive schemes and voluntary program), which leads to anthropogenic GHG emission reductions. Carbon financing is an opportunity to establish sustainable financing mechanisms and provide innovative solutions to address climate change through renewable clean energy. However, we do not have much time, the transition must begin immediately and action is required on all fronts. Internationally, it is critical that parties to the Kyoto Protocol reach an agreement that ensures global emissions fall substantially by the year 2020. By 2030 about half of global electricity could come from renewable energies and should have contribution from every stakeholder (IPCC, 2007).

Refugee Camp lies within ward number three and five, Beldangi of Damak Municipality within the latitude 26°20”-26°55” N and longitude 89°39”-88°04” E at an altitude of 135m from the mean sea level. The study area belongs to tropical and subtropical climate regime. The period from March to June is predominantly hot, dry and windy, July to August is hot and humid, September to October is pleasant, and November to February is cool and dry and the average annual minimum and maximum temperature is 10° C and 35 °C respectively while the average annual precipitation is 1900mm (Damak Municipality Brocheure, 2009).

The solar energy can be collected by solar collector. People have devised two main types of artificial collectors to directly capture and utilize solar energy: flat plate collectors and concentrating collectors. Both require large surface areas exposed to the Sun. In Nepal mostly concentrating parabolic solar cooker of the type of SK-14 and which Nepalese revised version SK-14 Koe is being used. Both of them resembles each other except SK-14Koe have external metal wall on the edge of parabolic dish which helps to reduce the cold wind effect. The reflector focuses the sunlight on the bottom of the absorber plate, heating the pot in a fashion similar to a traditional electric or gas powered stove (VFN 2012).

The parabolic Solar Cooker has a reflecting surface in the form of a parabolic dish, which concentrates the solar rays at a focal point at which the black coated cooking pot is placed. It consists of 36 reflector sheets made from highly reflective aluminium with weight of 3 kg, with area of 1.5 m^2. The frame manufactured in rigid steel with powder coating for attractive looks and reflectors are fixed to a parabolic shaped metal frame. The adjustment and alignment towards the sunlight should be made after every 20-30 minutes to focus the sunlight. The deciding factor for well-functioning of Solar Cooker, is having the closest thing to a cloudless sky as possible, the temperature outside is less important. On clear, sunny winter days (down to –10° C) it can still use the unbelievable power of the sun (EG Solar, 2012).

Solar cooker technology can be used as CDM under Kyoto Protocol (KP), for the Small Scale thermal power generation as mention in the small-scale CDM baseline methodology AMS-I.C (Version 18, EB56), Thermal energy production with or without electricity, for renewable energy technologies that displace technologies using fossil fuels. Reduction in

GHG emissions must be additional to any that would occur in absence of the project activity, i.e. a CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (AMS-I, Version 18).

Bhutanese exiles were given refuge by the government of Nepal on humanitarian grounds and were temporarily settled in Jhapa and Morang Districts of Nepal. Solar cooker (SK-14) has distributed among the refugees since 1998 in refugee camps by Vajra Foundation Nepal (VFN). According to VFN Annual Report 2004, about 75% of the population of this camp has been providing the possibility to use sunlight as a complementary source of energy for cooking by distributing 300 Solar Cooker and twice as many hay boxes. And later in 2006, for the different refugee camp additional 6,300 SK -14 was distributed. According to theVajra bulletin 2012, the project distributed 7000 solar cookers, 14000 hay boxes, 28000black paint cooking pot in seven different camps and 85000 refugees were benifited.741 cookers were damage due to big fire in camp along with other materials. Till now 1100 cooker distributed in host communities and 10000 local people and 51000 people were cooking meal by using parabolic solar cooker. After third country settlement program the disseminated Solar Cooker was redistribute in refugee camp associated area i.e. wards 1, 2,3,4,5 and 6 of Damak Municipality.Slowly, other international organizations, including United Nation High Commission for refugee(UNHCR) and the International Red Cross Society, started helping them, providing food clothing and other basic requirement. As of 2011, Beldangi I to the east had 12,793 residents; Beldangi II to the west had 14,680; and Beldangi II Extension had 8,470. (Vajar bulletin 2012)

2.2 Review of Related Studies

Energy and Environments

All of the refugees are obligate to respect the value, norms, rules and regulation of host country. Moreover United Nation High Commission for Refugee (UNHCR) have set a guideline for incorporating environmental factor in named UNHCR's Environmental Guidelineswere published in June 1996, and updated in August 2005.The main purposes of these guidelines are: to describe the basis for incorporating environmental factors into specific UNHCR guidance/guidelines and programmes, to provide more detailed

information and the rationale behind the Executive communities of UNHCR (EXCOM) policy statement and to serve as an awareness raising tool for UNHCR and other agencies involved with refugee and returnee operations.

The guidelines state that an environmental coordinator/focal point and environmental task force (ETF) should be appointed, and an environmental action plan (EAP) written; though only for refugee situations near environmentally sensitive areas where negative impacts are deemed potentially severe. ETFs are often established after the majority of urgent decisions are made; decisions, which affect levels of environmental impacts, like site location.

2.3Energy Consumption Scenario of Refugee

Nepal has abundant solar resources and evenly distributed throughout the country. Nepal has more than 300 sunny days in a year and the average isolation in Nepal is around 4.5kWh/m^2/day at optimum tilt. A snapshot assessment taken in Mustang, Nepal, the average saving per user per year on energy consumption was found to be around NRs4000(CRT/N, 2006).

In Nepal, half dozen solar kitchens have been installed during the last couple of years, most of which were successful for a while, but much of them not in operation. The Vajra Foundation has also installed Nepal's first solar steam kitchen on its school in Kathmandu, first Solar Community Kitchen in Nepal. Two Solar Reflector Community Cookers were built at the Modern Preparatory Secondary Boarding School in Itahari, Nepal, in 1998. The Solar Reflector Community Cookers have a frame area of 9 m^2 each and in the focus a temperature of 670^oC was measured. On a 5 mm chapatti plate with 410 mm diameter more than 400^oC was measured. The power of the two solar reflectors is enough for about 200 people to get 2 meals and 2 times tea easily on a sunny day.A typical amount of fuel wood consumption of a family is about 100 kg/week, i.e. 5200 kg/year. This may correspond to more than 4000 kg dry wood per year, corresponding to about 7300 kg CO_2 per year in Indonesia (Klimaschutzet.al, 2009).

For the 255 useful sunny days, average saving of fuel wood per day is 7 Kg Panamá VDC of Sankhuwasabha. Average saving of fuel wood per day depends upon different factors like family size, frequency of stove application, types of food being cooked, quality of wood etc. Average reduction of CO2 emission per year per Cooker is found to be 3267 Kg, in addition

average saving of kerosene per day 2.5 litres. Average saving of kerosene depends upon different factors like family size, frequency of stove application, types of food being cooked etc. Average reduction of CO2 emission per year per Cooker is found to be 1530 Kg in a house in Balaju, Kathmandu. If parabolic Cookers are used for commercial purpose like in Hotels or Lodges in remote areas also, saving of CO_2 per year per Cooker can go high (Source: CRT/ N Brocher, Base on data taken from the field). According to one producer, one large-scale commercially used Solar Cooker could save about 150 tons of wood annually (Sun Ovens International, 2011).

Subedi S (2012) conducted research on Impact on Humse-Dumse Community Forest analyzing the presence of Bhutanese Refugee Settlement in community forest as three refugee camps (Beldangi I, Beldangi II and Beldangi III) have been established inside the forest. The research had concluded that, settlement inside the Community Forests (CF) has reduced the forest area by one fifth. As the refugees had no strong income source, they had no other better alternative (for the fuel resource) than extracting fuelwood from the nearby village, Community Forest and from market. From the Community Forest User's Group (CFUG), landless people were more depended on the CF for both fodder and fuelwood. Annual extraction of both fodder (2896.07 t/yr) and fuelwood (1503.74 t/yr) by the Bhutanese refugees are quite higher than that of CFUG (fodder; 1792.53 t/yr and fuelwood; 289.16 t/yr), outstripping the forests annual sustainable supply (fodder; 152.83 TDN in t/yr and fuelwood; 1087.79 t/yr). Absence of refugee settlement would greatly reduce these extractions so that the CF resources do not get overharvested. Moreover, the refugee's involvement in illegal activities such as slice cutting of trees stems, uprooting of regenerating species and small herb saplings, collecting twigs and broken branches for fuelwood, collecting fodder for their livestock were increasing pressure load for the forest resources. All these activities of the refugees in longer will definitely decline the forest's sustainability to a very high extent. Therefore, there is an emerging need of strong policy amendment regarding these settlements inside the community forest.

The net thermal power of the cooker is approximately 600 watts in good sunshine. Very high temperature (above 300°C) is achieved in this cooker and the quantity of heat delivered to the cooking pot is proportionate to the reflector area. Two litres of water in a sunny day

(atmospheric temperature 24°C) takes about 15 minutes to boil. Almost every types of cooking such as boiling, frying, baking can be done in this cooker. Due to its deeply curved parabolic reflectors, the focal point lies inside the dish. This does not allow accidents such as catching fire or injuring eyes (EG Solar). However, care should be taken in handling it. Which are placed or mounted on the side of facing the sun and a typical type of metallic rod are arranged to make comfortable to move or aligned in proper direction. A very high temperature is achieved in the focus point because of the earth rotation the focus point of the parabola dish should be adjusted for attaining the maximum energy towards the sun in every 15-20 minutes. (VFN Brochure, 2011/12).

The global of Vajara project being convincing UNHCR and refugee to adopt solar cooking technology, adoption theory should be included which provides lot of benefits while using the solar cooking technology.

In our country Nepal, many solar kitchens have been installed during the last couple of years, most of which were successful installed and in operation but much of them not in operation. The Vajra Foundation has also installed Nepal's solar steam kitchen on its school in Kathmandu, Solar Reflector Community Cookers were built at the Modern Preparatory Secondary Boarding School in Itahari, Nepal, in 1998. The Solar Reflector Community Cookers have a frame area of 9 m^2 each and in the focus a temperature of 670^oC was measured. On a 5 mm chapatti plate with 410 mm diameter more than 400^oC was measured. (Klimaschutzet.al, 2009).

2.4 Certified Emission Reduction (CER) through Solar Cooker Project

There is high potential to conserve the forest resource. Under the international rules, there is a procedure called Joint Implementation/Clean Development Mechanism (JI/CDM), which allows a country to earn credit for reducing emissions and fund for solar cooking dissemination countries with deforestation/fuelwood crises. (Dieter S.1999)

Greenhouse gas emissions contribute to change in the global climate as well. The Clean Development Mechanism (CDM) Solar Cooker Project in Sabang Islands and Badar city in South East Aceh, Indonesia will prevent 3.5 tones carbon dioxide emissions per year, has

applied for renewable certified emission reduction (CER) verification and carbon credit for 7 years (UNFCC, 2006).

The project "Heqing Solar Cooker Project I" located on the rural area of Zhangye, Gansu province in northwestern China implemented by Beijing Harmonious Energy Development Co., Ltd., the proposed project will install 49,000 solar cookers for the rural residents with rated power of each solar cooker is 910 W and the total capacity of the 44.59 MW thermal make enable the rural residents to efficiently substitute solar energy for the fossil fuel (coal) used in daily cooking and water boiling, avoiding CO2 emission that would be generated by fossil fuel consumption. It is estimated that 143,762 tCO2e emission reductions will be produced annually (UNFCC, 2011).

The project "Ningxia Federal Solar Cooker Project" located on the dry land of southern Ningxia in northwestern China implemented by Ningxia Federal Intertrade Co., the project have install 19,000 solar cookers for the poor rural residents in Xiji county with a rural population of around 429,6001 or 100,000 households, with rating power of each solar cooker is 773.5W and the total capacity of the proposed project is 14.7 MW, will enable efficiently substitute solar energy for the fossil fuel (coal) used in daily cooking and water boiling, avoiding CO2 emission that would be generated by fossil fuel consumption. It is estimated that 40,702 tCO2e emission reductions will be produced annually (UNFCC, 2013).

2.5 Government Initiation on Alternative Energy

Institutionalize empowerments and legislative provisions have been initiated through the government of Nepal. Nepal is one of party country of Kyoto Protocol belongs to non-Annex I country can assisted in achieving sustainable development, contributing to ultimate objective of convention by mean of Clean Development Mechanism (CDM). In order to expedite and get benefit from CDM projects government of Nepal assigned Ministry of Environment (MoE) as Designated National Authority (DNA), with main function to develop and implement strategies and guidelines on CDM, launch necessaries promotional activities. Alternative Energy Promotion Center (AEPC) has established to promote alternative and clean energy. (MoE, 2006).

Initiation has been made in Nepal to conserve the environment, reduce greenhouse gas emission and to encourage the clean energy by means of different policy and legislative provision. As mention in the Climate change policy, 2011 effort will be given to formulation and implementation of allow carbon economic development strategy that supports climate-resilient socio-economic development by 2014.Adopting a low carbon emissions and climate-resilient development path for sustainable socio-economic growth by reducing GHG emissions through additional development and utilization of clean, renewable and alternative energy technologies and formulating and implementing plans to address adverse impacts of climate change; Auditing the energy intensity of industries every two years to promote energy efficiency and submitting the audit to the designated authority for climate change; Encouraging low carbon emission by providing financial and technical support and incentives and generate financial resources by promoting carbon trade and Clean Development Mechanism.

The identified renewable energy sectors for CDM programmatic approach and the key drivers that can help them achieve optimum carbon intensity so as to follow the de-carbonized pathway for development are: Family Type Biogas Plants Program, Medium & Large Size Biogas Plants program, Solar Water Heating, Solar Cooking Program, Improved Cook Stove Program, Biomass Applications in Industry and Village Electrification Program. As for 15 April 2013 DNA has approved 17 CDM projects of which 6 projects have received CER. Four of them are Bio-gas projects, one Improved Cook Stove project and one Micro-hydro project (MoSTE, 2013).

Government of Nepal (GoN) have made different initiation on policy level and organization level to promote the renewable energy as clean energy, understanding the need and interest shown by the public, made a policy to provide subsidy on the parabolic and box solar cookers since fiscal year 1998. This policy is carried out through Alternative Energy Promotion Centre (AEPC), Nepal. This government policy has given high priority to the promotion and deployment of solar cooker. The policy has contributed to stimulate the demand of the solar cookers and increase its application in rural and urban areas. An Interim Rural Energy Fund (IREF) later transformed into Rural Energy Fund (REF) has been set up to administer the subsidy and Rural Energy Policy was promulgated in 2006. The amendmentofsubsidy policy, Subsidy Policy for Renewable (Rural) Energy2009 (2066 BS)

addresses, among other Renewable energy technologies (RETs), the policy related to solar energy system to link renewable energy to economic developments. Policy state that subsidy will be provided to solar cooker, considering usefulness of the solar cooker the present subsidy rate will be continued. The subsidy will be 50% of its market value, but will not exceed NRs.5, 000. (MoE 2009)

CHAPTER 3: RESEARCH METHODOLOGY

3.1Study Area

For the study of solar cooker,Beldangi refugee camp and sixes wards of Damak Municipalities i.e. wards 1, 2,3,4,5 and 6 is selected as associated area. The Beldangi refugee camps consist of three settlements in Damak, JhapaNepal.

Study Area Map

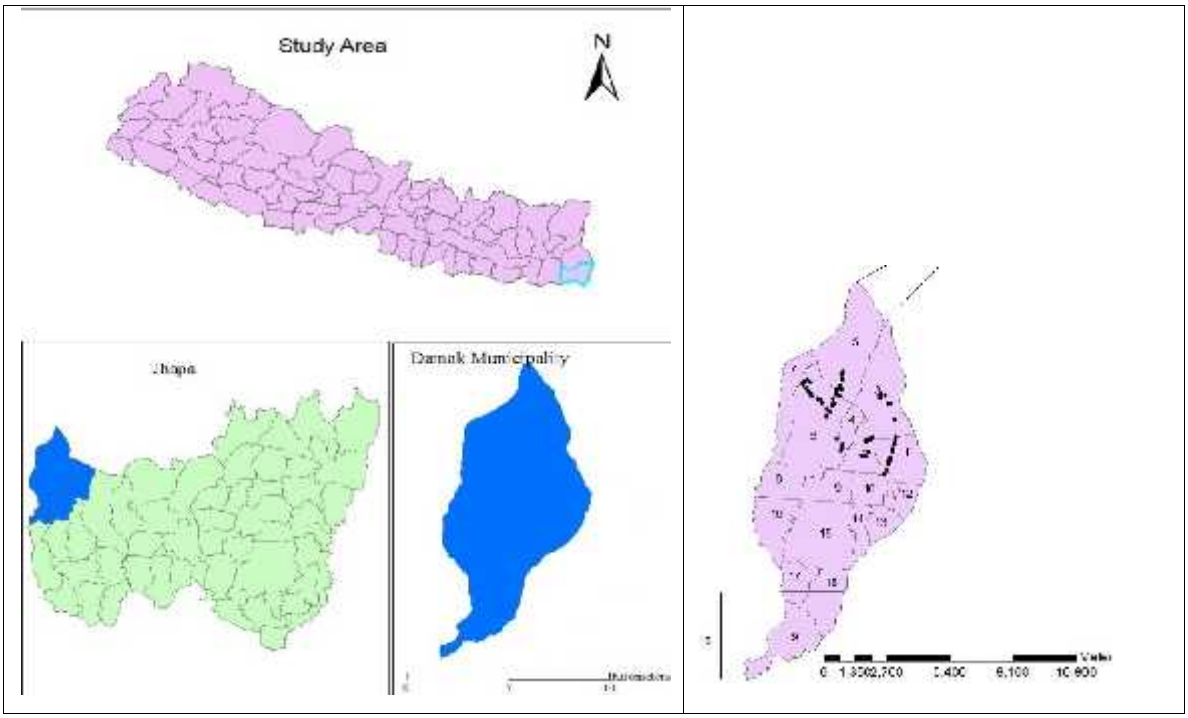

Figure 1: Map of Study Area

3.2. Research Processes

For the general information of SK-14 inductive reasoning method is used and involves specific observation measurement to arrive at a certain conclusion regarding the application effectiveness and efficiency. On the next part for the calculation of saved amount of biomass and amount of CO_2 emission reduction through deductive reasoning method is used and involves logic to arrive at a specific conclusion based on generalization of household survey.

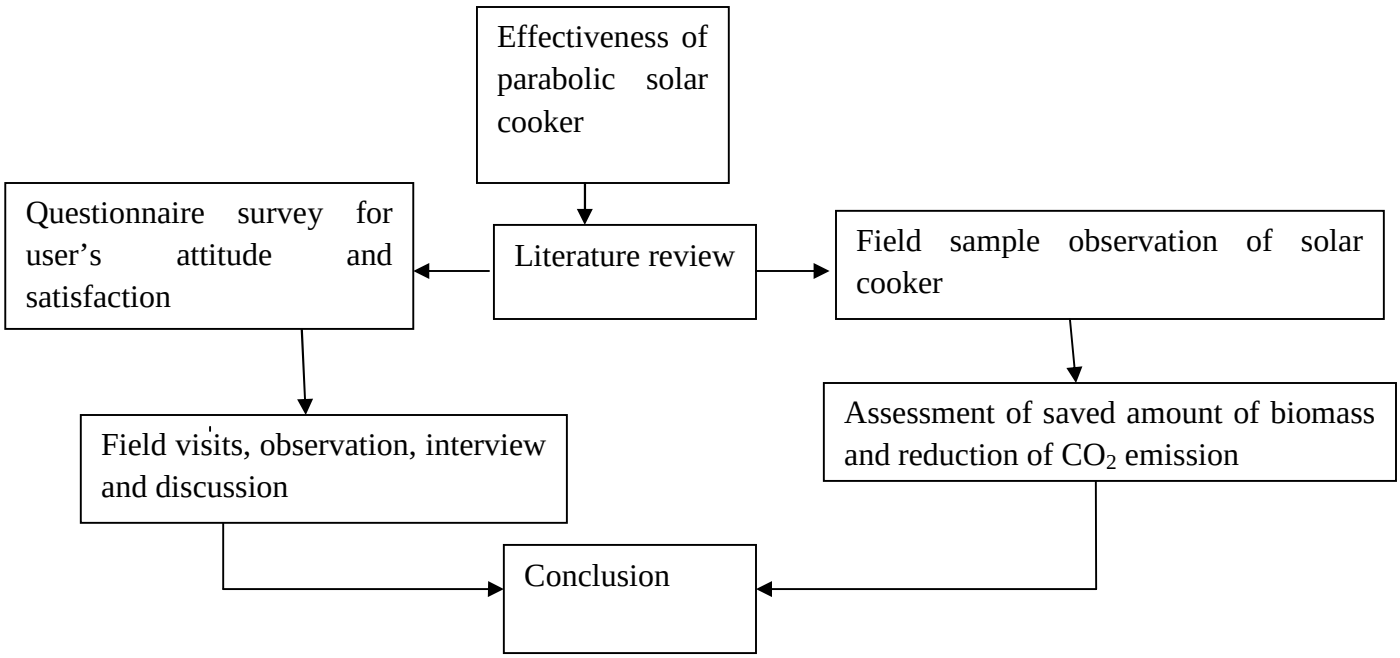

Figure 2: Research processes

3.3 Methods

To assess the impact and user's satisfaction a ordinal numeral scale is used from 5 to 1 for corresponding attitude excellent goods, satisfactory, poor, very poor and will therefore an average of the summation weighted value is presented in different statistical tools By comparing the average scores of the different aspects considered, a ranking could be derived of their relative importance. This ranking assigned along with the weighting factors, which have been derived by applying the ordinal value method. No two aspects have the same ordinal value, as there is always a difference in average score, even though this difference is sometimes very small in real system. For the answer of interval value type the middle value or average value is considered for calculation.

On the other hand, for the calculation of saved biomass and saved amount of carbon dioxide emission, the amount of concentrated energy in focus is done by calculating the amount of heat absorbed by 5 kg water in blackened pot of Solar cooker. For the calculation of power of solar cooker, the boiling test was performed for different 20 sunny days in month of April and September along with measurement of solar insolation is noted by using insolation data received from metrological station of DMC.

For concentrated energy

The amount of concentrated radiation or amount of heat energy absorbed by blackened kettle is calculated by boiling 5 kg of water and the amount of energy exchange on water is equal to

Heat gained by water (Q) = ms (t_2-t_1)

Where, m = mass of water

s =specific heat of water

t_1 =initial temperature of water

t_2=final temperature of water after boiling. (For the calculation of power of SK-14 time taken for boiling is also noted)

For the calculation of amount of biomass saved by solar cooker

Saved fuel wood consumption is calculated from the energy provided by the solar cooker and by converting this energy into amount of biomass with the same effective energy. The biomass and CO_2emission reduction was calculated by the help of methodologies recommended by CDM guidelines. The effective energy provided by the solar cooker is calculated by multiplication of its power P and the effective time t of use. To calculate the energy of biomass equivalent to this effective energy E_{eff}, the efficiency η of baseline cooking technologies is used. Thus the corresponding energy of saved biomass per solar cooker isi.e.HGy= t P / η and saved amount of carbon is (C) = HGy*CEF

=P*t*CEF/ η

P = effective power of solar cooker in Watt

CEF=Carbon Emission Factor; default value IPCC default emission factor for solid biomass = 29.9 kg C/Gjor 0.0299kgC/MJ is used.

For the saved amount of CO_2-emission by using solar cookers

The emission reduction ERy during a given year y is calculated as follow:

$ER_y = BEy - PE_y - L_y$ …… (1)

Where:

ER_y= the emission reductions produced by the proposed project during the year y in tCO2e.

BE_y=the baseline emissions from heat displaced by the project activity during the year y in tCO2e.

PE_y= the emissions produced by the proposed project during the year y in tCO2e, which is equal to zero because solar cooker do not emit any GHG.

L_y= the leakage emissions produced by the proposed project during the year y in tCO2e. (This was not considered in calculation, because the study is not for project implementation).

The baseline emission of the proposed project (BE_y) could be calculated by the following formula:

$BE_y = HGy * EF_{CO2} / \eta$ …… (2)

Where:

BE_y= the baseline emissions from heat (generated by burning coal or fuelwood or/and other traditional cooking technology) displaced by the project activity during year y in tCO2e.

HG_y = the net quantity of heat supplied by the project activity during the year y in TJ.

EF_{CO2}= the CO_2 emission factor of coal (tCO2e/ TJ).

η = thermal efficiency of the coal-fired/traditional cooking stove that would have been used in the absence of project activity.

Then,

$BEyCO_2 (t, n) = (n * P * t * CEF * 44/12 \text{ kg } CO_2/\text{kg C}) / \eta$ ……. (3)

n = number of installed solar cookers

t = mean operating time (hours per period) of solar cookers

The mean operating time the Solar Cooker during the period is considered calculated by summation of the recorded duration of equipment used and dividing the sum by the number n of equipment's which are applied for the summation i.e. $t = \Sigma t/n$.

3.4 Assumption for the Calculation

The concentrated energy is uniform for different Solar Cooker in Beldagi refugee camp regardless their orientation and operation in climatic condition.

The energy concentration capacity of solar cooker is as same as the time of performing water boiling test for the rate of concentrating of amount of heat is same as the user's effective operation period to the period of water boiling test performance.

The efficiency of traditional stove and improved cook stove is uniform in all the season and all the environmental condition.

The carbon emission factor (CEF) value for solid biomass and other fuel default value are adopted from IPCC disclosed value.

3.5 Data Collection

Primary data: Primary collection has been collected by the following processes: Daily insolation data were collected from metrological station of Damak Multiple Campus

Direct observation: The certain findings have been made on the basis of direct observations using device i.e. Pyranometer.

Interviews and questionnaire: Certain queries related to operation of Solar Cooker and their previous cooking technology has been solved through the semi structured interview with users. The required sampling size for user survey is calculated by the following steps: $n= zP(1-P)/e$, where z corresponds to 90% confidence level, p is the allowed error margin ("precision") and the e value taken is 10% (According to "General Guidelines for Sampling and Surveys for Small-Scale CDM Project Activities" in Annex 30 of EB50, 90% confidence level and 10% precision shall be used if there is no specific guidance in the applied methodology). P(1-P) represents the square of standard deviation (S2) and the P.

(Further detail of installation of solar cooker is collected by contacting with installer agency.)

Secondary data: For the secondary data, relevant information had been taken from different sources like related articles, journals, books, dissertation papers and consultation with experts on the subject.

3.6 Limitations

The study was carried out on the basis of the observed primary data and the given information.

1. The period of the data collection is only in the month of April and September.
2. The standard amount of production of heat from any given amount of fire wood exactly same for the given area for given particular atmospheric condition.
3. The uncertainty in information may occur when comparing country-specific emission factors with the default ones. The default emission factors wholly represent for this specific study area.
4. The amount of kerosene and firewood used for preparing one meal indeed varies on numerous uncontrollable variables like good housekeeping of the refugees.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

4.1 Features of Parabolic Solar Cooker

The characteristic feature of mostly used domestic type parabolic solar cooker i.e. SK-14 and SK-14 Koe in Nepal is summarized as follows with their respective features.

Table 1: Feature Summary of Parabolic Solar Cooker

SN	Feature	SK-14	SK-14 Koe
1	Disc diameter	1.4 m	1.4 m
2	Aperture area	1.5 m^2	1.5 m^2
3	Cost	Rs. 16000	Rs 30000
4	Subsidy	Rs 5000	Rs 4000
5	Manufacturer	CRT-N, Kumaripati, Lalitpur	Solar Technical Works, Sanepa, Kathmandu.
6	Mobility	Fixed and portable	Fixed only
7	Weight	About 20 kg	About 25 kg

Source: Respective Organization, 2013. CRT-N Kumaripati and Sanepa

The SK-14 using pattern is different in refugee camp, which being sharing among one to four families as they live in cluster of houses. Survey reveals that average more than 9 people are using one Solar Cooker SK-14. The cost of installation is free initially, later some charge (NRs.150 and NRs. 600) was collected for each solar cooker at the time of redistribution, as they redistributing in single family by repairing and republishing the cooker after the abandon of owner family who involved in third country settlement program. The entire user expresses their satisfaction regarding the service provided from company.

Almost all respondents agree to cook outsides as they are ready to adopt the technology that sustain environment and asset to save the other petroleum fuel, while some respondents whose house lies near to road have been affecting to cook outside by dust particles. Mostly SK-14 is used for heating of water for bathing, washing clothes. Thus; Solar Cooker is helping to improve the life quality and maintaining the standard by promoting the environmentally friendly technology and safe drinking water.

4.2 Comparison of solar cooking purpose

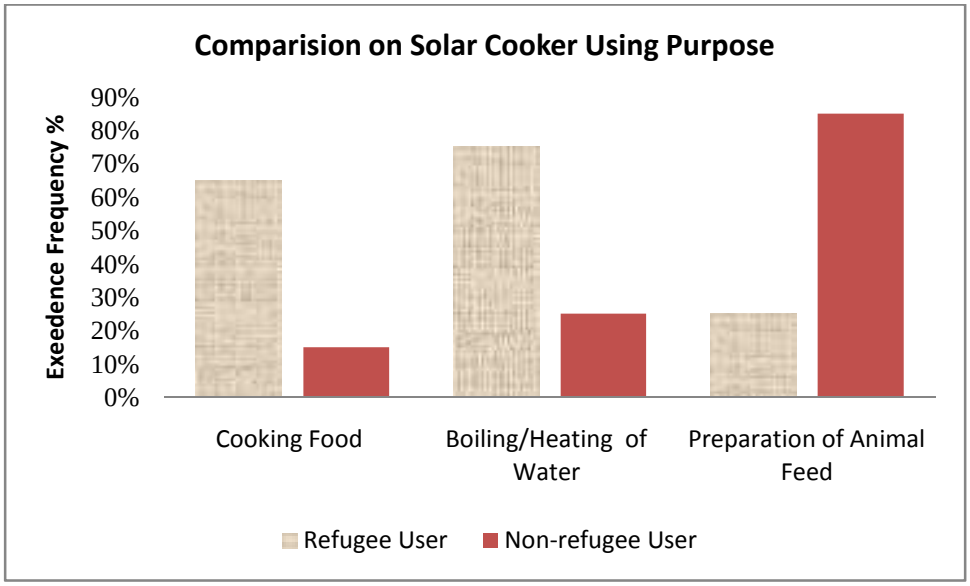

Figure 3: Frequency % Bar Diagram by Purpose of SK-14 Using

Moreover, the survey reveal that about 30% of respondent refugee express satisfaction regarding effective and conveniently distribution or availability of fuelwood, kerosene and briquette; 20% do not express their satisfaction and 50% respondent feel hardly availability. The general information and solar cooker using pattern is summarized in the following table.

Table 2: Solar Cooker Using Pattern

SN	Title	Remarks
1	Type of solar cooker used	All SK-14
2	Average solar cooking hour per day	4 hours
3	Average solar cooking day in 100 days	46 days
4	Average user per solar cooker	9 persons
5	Other cooking fuel type	Mostly: Fuelwood, Briquette coal Rarely: LP gas and kerosene
6	Cooking stove type	Altogether ICS and Traditional stove and corresponding Gas stove and kerosene stove

4.3 Users' Attitudes and Satisfaction

In this scenario of cooking fuel scarcity, installation of SK-14 becomes strong support for their life. According to the survey data, the average numbers of hours using solar cooker is near 4 hours (3.95) per day and average number of days using solar cooker is 46 days in per 100 days. Among these facts 74 % of family uses daily, 22% respondent family uses occasionally and rest 4% respondent are not using due to partial damage or lack of space. The user's satisfactions about the operation of SK-14 is found to have 11% excellent, 55% goods, 17% satisfactory, 11%poor and 6% very poor as shown in figure 3.

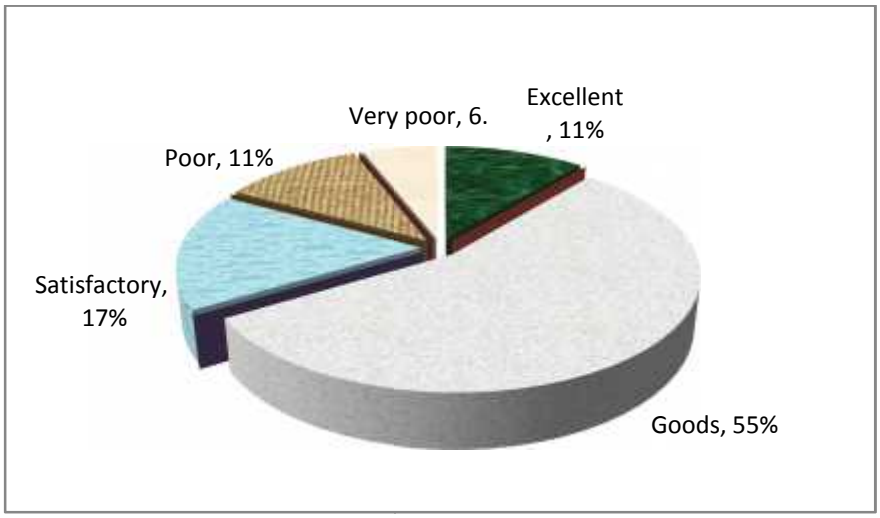

Figure 4:SK-14 Performance Satisfaction Level

Mostly, solar cooker is operating in between 9 am to 12 noon and 12 noon to 3 pm as it is the time of intensive solar irradiance and meal taking. The tea and breakfast can't prepare early in morning. The night meal is usually preparing in day time and is kept in hay box preventing from radiation of heat hence remain hot up to the meal time.

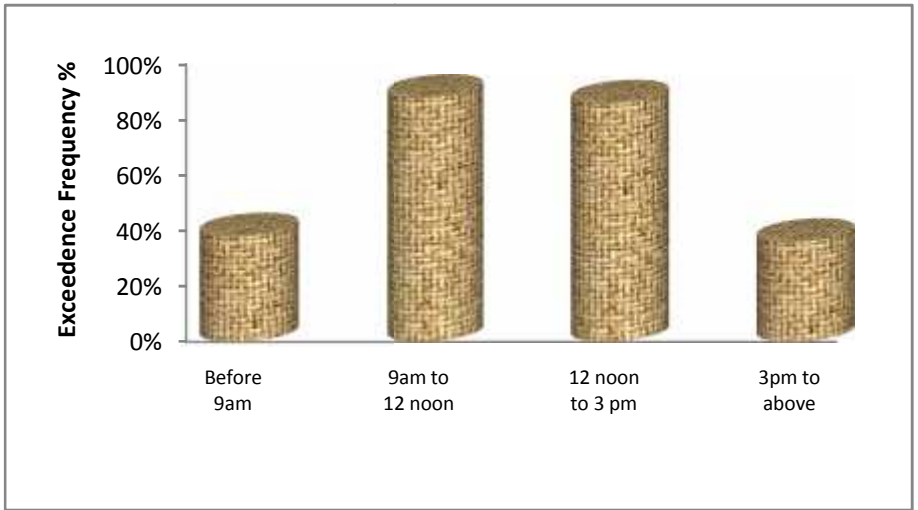

Figure 5: Cooking Time performance Order

Among the users, about 49% of the respondent said that they have to pay more attention for operation of solar cooker then other traditional coking fuel,38% said attention should pay just as much as other traditional cooking fuel and 13 % said less attention should give.

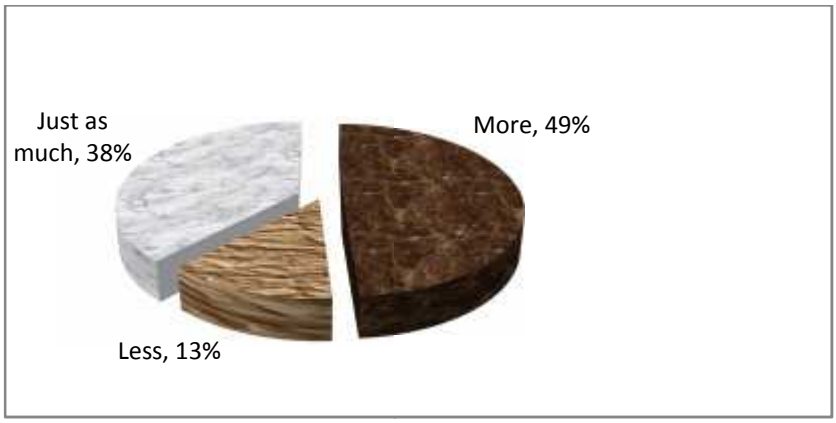

Figure 6: Comparisons of attention given for SK-14 and other cooking fuel

Only 7% of respondent said there is improvement in taste of solar cooking food item then cooked in other fuel, 52% said no improvement in taste and 41 % said there is nothing difference in taste.

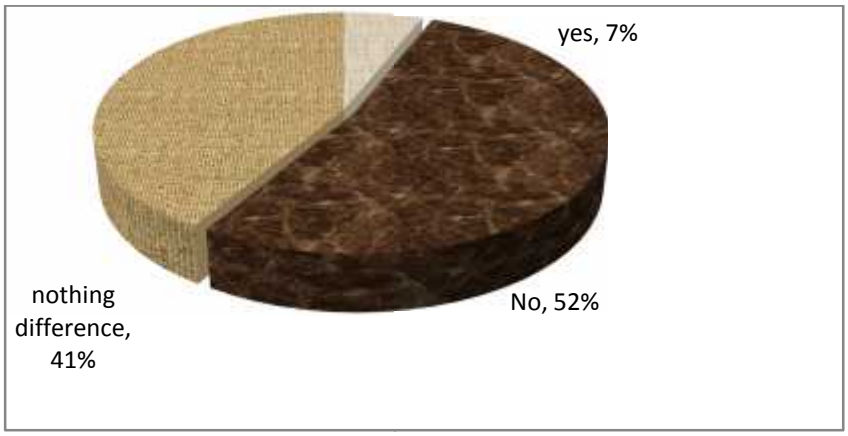

Figure 7: Attitude towards taste improvement

Most of the difficulties expressed by respondent about solar cooker were that attention should be given for regular alignment; difficulties for regular use; disturb in vision and need more space to get the better isolation for operation. If suitable types of rotating mechanism

devised i.e. with suitable electrical and mechanical hybridization for alignment toward sunlight would be a better alternative for optimum utilization of renewable and sustainability of the environment.

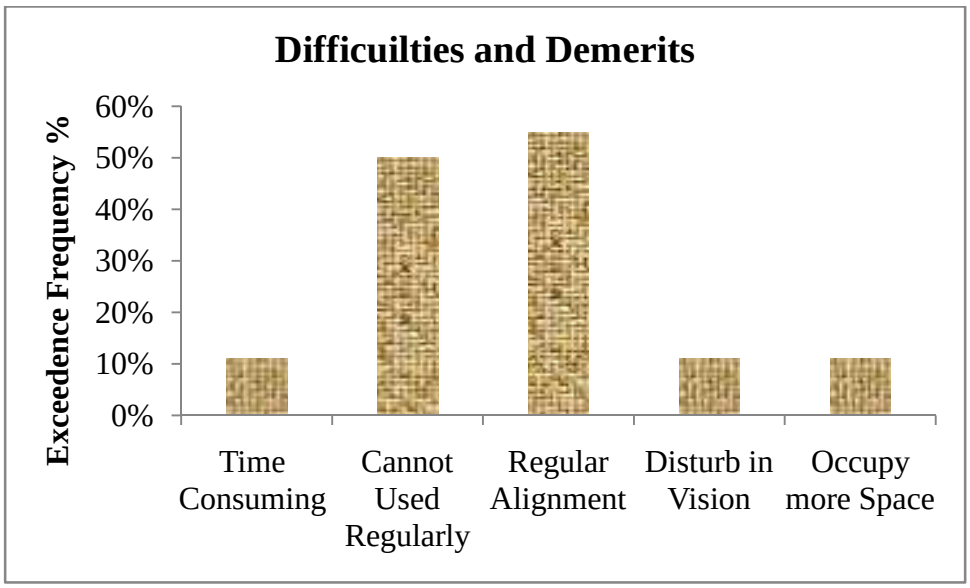

Figure 8: Difficulties and Demerit of Solar Cooker

It has been seemed that Solar Cooker cannot be used regularly due to weather conditions and need more attention and time for alignment. In fact, most of the energy use of the solar cooker can be attributed to the back-up need; the usage offuelwood, briquette coal or kerosene when the solar cooker cannot be used due to bad weather conditions. Therefore, for cooking a small meal or for just boiling water for tea.

With ordinal scale the betterment of operation of solar cooker and different baseline cooking technologywassummaintioned and average score is presented in following bar diagram. In this score system score 1 to 5 represents very poor to corresponding poor, satisfactory, good, and excellent respectively.

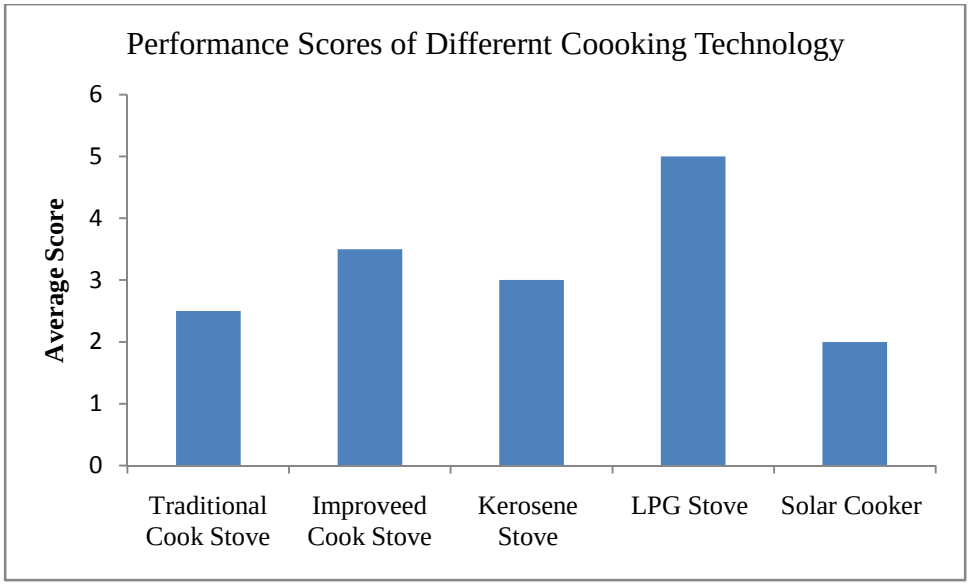

Figure 9: User's Performance on DifferentCooking Technology

4.4 Concentrated Amount of energy and Performance Assessment Test

To calculate the amount of radiation concentrate on focus of the solar cooker different 10 days' test have been performed and corresponding converted amount of heat energy is calculated and presented in the following table. This test was performed on different day of

April and September 2013. Mass of the water (m) = 5 kg (With full capacity of pot) Specific Heat of Water (s) =4200 joule /kg/°C.Here dt is difference in time. Final temperature is consideredas 100 C^0 for boiling of water in all observation.

Table 3: Test for Power of Solar Cooker (April)

SN	**Initial Temp. (°C)**	**Final Temp.(°C)**	**Time Taken (Sec)**	**Heat(Q)concentrated (Mega joules)=ms(dt)**	**Power of SK-14=Q/t**	**Remarks**
1	26	100	63*60	1.554	411.1	Fluctuation in irradiance due to cloud movement
2	24	100	66*60	1.596	403.0	Clear sky but occurrence of wind
3	23	100	58*60	1.617	464.6	Clear sky
4	25	100	56*60	1.575	468.4	Clear sky
5	26	100	59*60	1.554	438.9	Clear sky
6	23	100	61*60	1.617	441.8	Clear sky but occurrence of wind
7	26	100	72*60	1.554	359.7	Fluctuation in irradiance due to cloud movement
8	24	100	68*60	1.596	391.2	Regularity in irradiance but comparatively low visibility
9	24	100	69*60	1.596	385.5	Regularity in irradiance but comparatively low visibility
10	23	100	67*60	1.617	402.2	Clear sky but occurrence wind

Table 3: Test for Power of Solar Cooker (september)

SN	Initial Temp. (°C)	Final Temp (°C)	Time Taken (Sec)	Heat(Q)concentrated (Mega joules)=ms(dt)	Power of SK-14=Q/t	Remarks
1	26	100	63*60	1.554	441.1	Fluctuation in irradiance due to cloud movement
2	24	100	56*60	1.596	475	Clear sky
3	23	100	58*60	1.617	464.6	Clear sky
4	25	100	56*60	1.575	468.4	Clear sky
5	26	100	59*60	1.554	438.9	Clear sky
6	23	100	61*60	1.617	441.8	Clear sky but occurrence of wind
7	26	100	62*60	1.554	417.7	Fluctuation in irradiance due to cloud movement
8	24	100	62*60	1.596	429.03	Regularity in irradiance
9	24	100	59*60	1.596	450.8	Regularity in irradiance
10	23	100	67*60	1.617	402.2	Clear sky but occurrence Cloud movement

The amount of concentrated radiation at the focal of solar cooker or radiation absorbed by blackened kettle (at average time of 62 minute or1.035 hour) is equal to heat gained by water (Q) is found to be 1.6674 MJ. Again the amount of heat energy contributed by the SK- 14 throughout the year is 1068.1MJ for the cooking (average 663 hrs as effective operating hours in a year) with average power of 430 watts.

4.4Amount of Saved Biomass and Carbon dioxide Emission

The potential of saving biomass and Carbon dioxide emission reduction by using solar cooker with compare to baseline technologies, per effective time of using in year is calculated and summarized as below in the table 4. The efficiency of Traditional Cook Stove is considered 8% and 16% that for Improved Cook Stove (ICS) for Nepal. (CSE)≠The

Efficiency of Kerosene stove is considered 43% and 60% that for Gas stove. (Source: www.teriin.org/renew/tech)

Table 4: Amount of Saved Biomass and Reduced Amount of CO_2 by Solar Cooker (SK-14)

SN	**Fuel Source**	**Carbon Emission Factor (CEF) (kg C/MJ)**	**Stove Type**	**Saved Amount of Biomass (kg equivalent C/SK-14/year) by the use of solar cooker**	**Reduction in CO_2 Emission (tones equivalent CO2/SK-14/year)**
1	Solid biomass	0.0299	Traditional Cook Stove	1065.95	3.906
2	Solid biomass	0.0299	Improve Cook Stove	532.76	1.953

As the kerosene is not use for cooking and LP gas is not on assess, so mostly solid biomass, coal briquette and fuel wood used for cooking purpose. That socioeconomic background leads to refugee to intensely use the solar cooker and save the fuel wood as well emission. The amount of CO_2 emission reduction for single solar cooker is found to be 3.906 tons per year (considering 663 hrs as effective operating hour in a year) when baseline technology is traditional cook stove, which is equivalent to 1065.95 kg of fuel wood. (Emission factor of fuel wood. Similarly, the amount of CO_2 emission reduction when improved cook stove is found to be 1.953 tons per year per solar cooker and this is equivalent to 532.76 kg of fuel wood.

Figure 10: Fuel Related CO_2 Emission per Cooking Technology Types

Figure: 10 show the variation in CO_2 emission by different types of cook stoves to obtain the same amount of heat energy. This is comparison of solar Cooker with other baseline technology. Here amount of CO_2 emission is calculated for only on the phase of operating or cooking. This study concerns with comparing the amount of fuel related emission at the time of operation of stoves. Here CO_2 emission at different processes i.e. manufacturing processes, transportation processes is not included. As information obtained above and the amount of GHG emission is inversely proportional to the efficiency of cooks stove hence high GHG emission will be the consequence for low efficient cooks stove. In addition traditional stove when replaced by Improved Cooks Stove (ICS) more than half of GHG emission will have been reduced implies that more emphasis and priorities in improved technology.

Traditional cooking stoves produce more CO_2 than solar stoves from the above mention statistical data

The Bhutanese refugees havelegallyrestrictedtoany movement, engage in economic activities either inside or outside the camps, special permission is required if they want to leave the camps for more than one day. However, since the refugees intermingle so well with the local Nepalese population, they work outside the camp as teachers, carpenters, factory workers, construction sides worker, helper and labor in nearby market and field. The low wages types work and mainly male member involvement do not sufficient to run their

family. They receive some coal briquettes instead, but need firewood in addition, and this for the refugee families who cannot afford to buy firewood brings them into conflict with the local population, who collect firewood in the same local forests.

Moreover, the different legislative provision, subsidy policy for clean environment and renewable alternative energy does not support and cannot be inclusive for the refugee but their activity certainly influenced the local forest and environment i.e. depletion of forest resource due to firewood collection from local forest and emission of GHG by conventional low quality energy resources that they are maintaining this affirmation.

According to the survey data the average numbers of hours using solar cooker is near 4 hour (3.95) per day and average number of days using solar cooker is 46 days in per 100 days As the record archiving by VFN for three years 2002 to 2004, the number of days that solar cooker can be used have classified as Sunny days; a day in which solar cooking can be used for the full length of the day: cloudy and rainy days; on which no use of the solar cooker could be made at all; half sunny days; a day in which the solar cooker could only partly be used resemble to the data.

Their records show that on average 48% of the days could be fully used for solar cooking, while on average 31% of the days were useless for solar cooking. The half sunny days amounted on average 21 % of the days (VFN, 2004). These findings are supported by the solar insolation database of the Department of Hydrology and Metrology, Nepal in the year 2010 as on the similar location, Bara Simara located in eastern Terai. The percentage of days with total solar radiation more than 14 MJ/m^2 is 62.19% with excellent days with high radiation more than 18 MJ/m^2 (38.63%).

The study on general background of solar cooker (SK-14) shows readiness to adopt the new technology but certainly there is no alternative option for non-sunny days for the user. The life style of scarcity and severity of refugee make themselves identical and unique in their life processes. Lack of asses to local natural resources strictness in their mobility and economic activity no other better adoptable option for coking fuel made them to pay more attention for SK-14. On the other hand, most of refugee women do not go outside for economic activity or other activity, as they mainly involve in cooking (about 90% of women involve in cooking activities), hence can contribute more time for operation in day time

which is most favorable for operation. Thus the impact and effectiveness of Solar Cooker for the livelihood of refugee people in some extent may different than other general context.

The sharing pattern reveals that about 50 % of families are sharing SK-14 among the same caste or among their relative. Hence improved solar cooking technology solar community kitchen i.e. installation of solar reflector community cooker can't be success due to cultural factor. Even this most of the respondent don't feel uneasy to cook outside and they are ready to adopt the environmentally friendly technology.

About 30% of respondents had expressed their satisfaction regarding the effective and convenient distribution of fuel wood, kerosene, and briquette while about 50 % of respondent's express satisfactions regarding the good performance of solar cooker. For this installation of solar cooker become helpful in refugee life and most of the cooker is used for cooking daily food, heating and boiling water etc. Lower the consumption of fuel wood, kerosene and other fossil fuel consequently improve environmental quality.

On the other hand, Nepal is one of non-developing countries which contribute only 0.025% of total Green House emission can perform Carbon finance assessing the data about solar cooker for the reduction of greenhouse emission under clean development mechanism (CDM) of Kyoto protocol which help for the sustainable development of non-Annex I countries. As solar cooker project being small in seen but it contributes a considerable amount of reduction in CO2 emission. The amount of CO_2 emission reduction is found to be 3.906 tons per year per cooker when baseline technology is traditional cook stove. And the amount of CO_2 emission reduction is found to be 1.967 tons per year per cooker when improved cook stove is in operation as baseline. This amount is quite equal to the Clean Development Mechanism (CDM) Solar Cooker Project in Sabang Islands and Badar city in South East Aceh, Indonesia that consider to prevent 3.5 tones carbon dioxide emissions per year, (Suharta H., 2009) has applied for renewable certified emission reduction (CER) verification and carbon credit for 7 years.

The growing awareness on the imperatives for a global energy future which marks a distinct departure from past trends and patterns of energy production and use. These imperatives emerge as much from the need to ensure energy security, as they do from the urgency of controlling local pollution from combustion of different fuels and, of course, the growing challenge of climate change, which requires reduction in emissions of greenhouse

gases(GHSs), particularly carbon dioxide. The clean development mechanism (CDM) created recently, can be a valuable instrument to promote alternative energy use in this sensitive mountain areas. The additional income generated by CDM programs can be a great benefit that helps the users in financing solar cookers and so improving diffusion. Carbon financing and the sale of carbon credits were introduced as innovative sustainable financing mechanisms for non-Annex-I countries like Nepal.

The subsidy provided by government seems contradiction itself because the market value of solar cooker SK-14 is NRs 16,000, and for SK-14 Koe is Rs 30,000 and the 50% of which is greater than NRs 5,000.

Table 5: Test of parabolic solar cooker for preparation of different items of food.

As per test of parabolic solar cooker in 2013, the time required for preparation of differentfood items was observes on sunny day in September are mention below;

Food items	Quantity (kg)	Starting am/pm	Cooked am/pm	Total time (min)
Rice	1	8:45	9:12	25
Curry	1	9:40	10:10	30
Pulse	0.5	11:15	11:50	34
Beans and potatoes	1	11:00	11:43	43
Rice	1	12:00	12:34	24
Curry	1	12:30	1:20	40
Pulse	0.5	1:00	1:46	46

So the food and other items which are cooked in solar cooker depend on whether condition of sun light. It is necessary to know that the sun is sunny in whole years.

CHAPTER 5: DISCUSSION

5.1Discussion

Solar cooker has been used for cooking purpose along with solid biomass as briquette coal and fuel wood. According to the survey data the average numbers of hours using solar cooker is about 4 hours (3.95) per day,663 hrs in a year as average number of days using solar cooker is 46 days in per 100 days. Among these facts 74 % of respondents' family use daily, 22% respondents' family uses occasionally and rest 4% are not using due to partial damage or lack of space. The users expressed their satisfactions regarding the operation of SK-14, found to have 11% excellent, 55% goods, 17% satisfactory, 11% poor and 6% very poor performance.

The amount of thermal energy generated by the SK- 14 throughout the year is 1068.1MJ for the cooking (As average 663 hrs as effective operating hours in a year) with average power of 430 watts. Again the amount of CO_2 emission reduction by one solar cooker in one year is found to be 3.906 tons if baseline cooking technology is traditional cook, which is equivalent to 1065.95 kg of fuel wood. Similarly the amount of CO_2 emission reduction when improved cook stove is found to be 1.953 tons per year per solar cooker and this is equivalent to 532.76 kg of fuel wood.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

- As observed from the study the use of SK-14 helps to maintain the energy mixing and energy use diversity, improve quality of life, lower the indoor air pollution, reduce the import of fuel. As most of the energy consumption in refugee camp is mainly met by fuel wood from the market are brought from nearby Community Forest along with imported coal.
- A little amount of kerosene is distributed and can use only for lighting purpose. They have low economic access to electricity and petroleum fuel. Thus, Solar Cooker certainly lowers the pressure on forests and fossil fuel and helps to improve the environmental quality and life standard.
- It has been observed that Solar Cooker can't be used regularly due to weather conditions and must pay more attention and time for alignment. In fact, most of the energy use of the solar cooker can be attributed to the back-up need: the usage of fuel wood, briquette coal or kerosene when the solar cooker cannot be used due to bad weather conditions. This background of energy consumption solar cooking technology become an alternative with low environmental hazards and no operating cost that is helping to the relief assistance in the refugee camp. If refugee provided with environmentally sound technology obviously can contribute towards the sustainability.
- The amount of CO_2 emission reduction for single solar cooker is found to be 3.906 tons per year (considering 663 hrs. as effective operating hour in a year) comparing with baseline technologies i.e. traditional cook stove is in operation which is equivalent to 1065.95 kg of fuel wood.
- The amount of CO_2 emission reduction when improved cook stove is found to be 1.953 tons per year per solar cooker and this is equivalent to 532.76 kg of fuel wood.

6.2 Recommendations

1. Suitable mechanism for automatic rotation of solar hybridization should be implimented to rotate along the direction of sun light.

2. Refugee must be made aware for conservation of forest, encourage them to use the alternative source of energy that enables to conserve the forest and reduce the emission of greenhouse gases.

3. Heat concentration of solar cooker should be increased by setting back up in cooking technology so fluctuation in irradiance due to cloud movement cannot disturb in cooking.

4. Solar isolation is high between 9am to 3pm so automatic displacement of cooking items should be managing by applying modern technology in solar cooker.

REFERENCES

ADB, 2006: Asian Development Bank, Fuel for Life - Household Energy and Health Report, 2006.

ASM-I, Version 18: CDM small project guideline

Broacher, 2009: Damak municipality.

CES, 2001: Efficiency Measurement of Biogas, Kerosene and LPG Stoves. Retrieved from Tata Energy Research Institute (TERI), India. Efficiencies Measurement of Cook Stoves.

.

CRT, 2007: Annual Report (2007), Center for Rural Technology, Lalitpur, Nepal (CRT/N).

Dieter S. (1999) Joint Implementation/ Clean Development Mechanism (JI/CDM) - Solar Cooker Project in Nepal.

EG Solar, 2012: A report of global energy scenario,Eoropean committee for solar cooking research.

DoS, (2011): Department of Statistic, Government of Nepal in Figure, 2011

IPCC 2006: Intergovernmental Panel on Climate Change Revised Workbook 1996, Guidelines for National Greenhouse Gas Inventories.

IPCC, 2007: Synthesis Report, Intergovernmental Panel on Climate Change.

IPCC, 2010: synthesis report, intergovernmental panel on climate change

KC and Nagata, (2006): Refugee Impact on collective management of forest resources: a case study of Bhutanese Refugees in Nepal's Eastern Region. The Japanese Forest Society and Springer, 11:305-311.

Klimaschuet.al, (2009): solar cooker project in idonesia.

Lindeboom R. and Goverde R, 2005: Towards sustainable relief-assistance Applicability of the sunny solution, as a part of their study on the topics of Energy & Materials Science &Policy, Utrecht University.

MoE, 2011: Climate Change Policy, 2011Ministry of Environment, Government of Nepal

MoE, 2006: Rural Energy Policy, 2006, Ministry of Environment, Government of Nepal

MoE, 2009: Subsidy Policy for Renewable (Rural) Energy2009 (2066 BS), Ministry of Environment, Government of Nepal

MoSTE, 2013: Ministry of Science Technology and Environment Designated National Authority for Clean Development Mechanism of the Kyoto Protocol April 2013.

Solar Cooker International,(1994): solar cooker experts and advocates: International Directory, First edition,SCI, California USA synopsis.

Subedi S, (2012): Thesis on Impact on HumseDumse Community Forest presence of Bhutanese refugee camp in Beldangi(I, II, III)

Suharta H., 2009: Report about implementation of solar cookers in Indonesia: Serambi Indonesia, 2004, Banda Aceh Press JI

Sun Oven International, 2011: (Retrieved on april 2013 from: http

UNDP, 2012: World Energy Assessment, UN Development Program, UN Department of Economic and Social Affairs, (Retrieved December 2012: http://www.undp.org/energy/activities/wea/drafts-frame.html,acessed)

UNHCR, 2005: Environmental Guidelines United Nations High Commissioner for Refugees, Geneva.

UNFCC, 2006: Clean Development Mechanism, solar cooker project in Sabang and Badar city in South East Aceh

UNAFCC, 2011, Heqing solar cooker project I.located in zhangye, Gansu .Bejing Harmonious Energy Development Co. Ltd.

UNFCC, (2013), Ningxia Federal Solar Cooker Project in Southern Ningxia in northwestern China

VFN, 2006: Annual Report (2006), Vajra Foundation Nepal, Kathmandu (VFN-Nepal).

VFN, 2012: Vajra Bulletin 14th edition (Chapa guan Kathmandu Nepal).

WECS, 2006: Energy Synopsis Report, Water and Energy Commission Secretariat. Kathmandu Nepal

WECS, 2010: Energy Synopsis Report, Water and Energy Commission Secretariat. Kathmandu Nepal

Women's Commission for Refugee Women and Children, 2006: report March, 2006www.womensrefugeecommission.org/.

ANNEXES

Annex I: Questionnaire for Assessment of Solar Cooker

General Information

1. Name of respondents: Location =
2. Family size (No of benefited user's): Cost of installation =
3. How often do you use the solar cooker?
   Daily = ☐ Occasionally= ☐
4. How much time the solar cooker is being operated in ☐ day? hrs/day
5. How much day do you utilize the solar cooker throughout the year? (In 100 days) days……..
6. In which time do you use the solar cooker mostly?
   Before 9am= ☐ 9amto12noon= ☐ 12noonto3pm= ☐ After 3pm= ☐
7. What are the main purposes of using solar cooker? (Refugee/Non-Refugee)
   Cooking food = ☐ Heating water= ☐ Preparation of animal feed= ☐
   Boling water for disinfestations=. ☐ Other Specify=…..
8. Mainly who involved in cooking?
   Women = ☐ Men= ☐ Old = ☐ Children= ☐ All= ☐
9. Do you share the solar cooker?
   If yes mention the no of sharing family. =
10. What are the energy sources is being used for cooking?
    Fuel wood, = ☐ kerosene= ☐ Bio- briquette= ☐ LP Gas= ☐
    Electricity = ☐
11. Which type of cook stove has been used?
    Traditional stove = ☐ Kerosene stove = ☐ ICS= ☐ Gas stove= ☐

User's Attitude and Satisfaction

12. Do you think cooking on a solar cooker requires much attention during cooking in traditional stove?

Yes=☐ No= ☐ Nothing Difference=☐

13. Do you think there is any improvement in taste of solar cooking item?

Yes=☐ No= ☐ Nothing Difference=☐

14. Do you like to cook outside the house?

Yes = ☐ No= ☐ Nothing Difference= ☐

15. If no, why you don't like this?

Cultural factor ☐ Pollution (dust ☐ = ☐ clination=…

Other=…

16. Are fuel wood, kerosene, briquette etc conveniently distributed/ available?

Yes= ☐ No= ☐ Hardly= ☐

17. Time require for cooking in traditional stove and solar cooker.

SN	Item cooked	Time taken in traditional stove	Time taken in LP gas/ kerosene stove	Time taken in solar cooker

18. What are the difficulties and demerit of solar cooker during operation?

Cooking is time consuming = ☐ Can't be used regularly= ☐

Regular alignment toward the light= ☐ Other specify=

19. Which is the better month for operation of solar cooker?

(5=excellent 4=goods, 3=satisfactory, 2=poor, 1=Very poor)

Baishk	Jestha	Ashad	Shrawan	Bhadra	Aswin	Kartik	Mansir	Poush	Magh	Falgun	Caitra

20. Can you express the satisfaction regarding your solar cooker? (5=excellent 4=goods, 3=satisfactory, 4=poor, 5=Very poor) ... …… …….

16. Do you have any idea or recommendations for the construction or designing of solar cooker to make better for operating? (If have mention) ……

21. Do you want to install any more solar cooker?

    If yes, why? .....

    If no, why? .....

Annex: Snaps of Field Work

Photo 1: Preparing animal feed

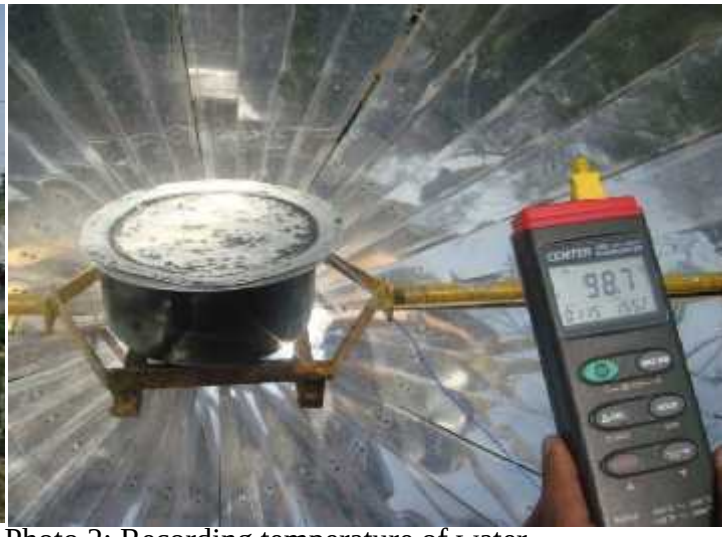

Photo 2: Recording temperature of water

Photo 3 Observing boiling water

Photo 4 Collecting data in camp about cooker

Photo 5 Respondent keeping pot in solar cooker

Photo 6 cooker under the shaded part

Photo 7 Protracting cooker in camp

Photo 8 Asking questioner in camp