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Economic Empowerment of Women in Rural Nepal Through Renewable Energy Access

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This thesis focuses on the socio-economic and electrification status in one of the rural municipalities (RM) of Nepal. The primary data for the research was collected on the field visit to Dharche Municipality in Gorkha District. 10 household surveys were conducted and focus group discussion (FGD) was held in two of the wards in the Dharche rural municipality. The Dharche rural municipality is one of the low HDI ranked RM in Nepal with partially electrified status.

The project design was based on the premise that lack of access to sustainable, reliable and affordable clean energy services for lighting, cooking, and heating has been resulting low socio-economic status, among several other reasons. The project also attempted to cover the economic growth and opportunities that have been hindered for women empowerment and women's potential for undertaking various livelihood activities. Furthermore, this thesis studies will foresee the use of energy and energy services as an economic empowerment tool for locals of Dharche RM, especially women. It also addresses the key development challenges of gender disparity and women's unequal access to economic resources and assets, including environmental goods and services, underemployment and low levels of participation in decision-making.

Thus, this thesis provides an initial report on the socio-economic and electrification status based on the household surveys and community meetings held and recommendations on how the status can be improved if electricity is provided.

Keywords	Dharche rural municipality, Gorkha district, women empowerment, renewable energy for rural livelihood

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Acknowledgments

It was a tough decision for me to fly to Nepal for this short time project. I anticipated that this thesis-based project could be a good learning curve and a professional experience working on a project under UNDP would be worth it. It was very rewarding for me to be with the family and complete the thesis journey.

The field visit especially, made me feel proud that it was not the wrong decision to take leave from ongoing work here in Finland and fly to Nepal for this project. I got to learn how to initiate a project and validate it in real-time from UNDP Nepal and RERL team. This thesis journey also made me realize that one can learn in so many ways, all it takes is willingness. I would like to thank everyone who was involved and helped me during thesis work.

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List of Acronyms	
AEPC	Alternative Energy Promotion Centre
BRI	Belt and Road Initiative
DDC	District Development Committee
DHI	Diffuse horizontal irradiation
DNI	Direct normal irradiation
ELC	Electricity Load Controller
FGD	Focus Group Discussion
GTI	Global tilted irradiation
GHI	Global Horizontal Irradiation
HDI	Human Development Index
HH	Households
HPI	Human Poverty Index
HDI	Human Development Index
LPG	Liquefied Petroleum Gas
MPI	Multi-Dimensional Poverty Index
MEP	Municipal Energy Plan
MHP	Micro Hydro Power
MSMEs	Micro Small and Medium enterprises
MHP	Micro Hydro Power
NEA	Nepal Electricity Authority
PE	Partially Electrified
PU	Partially Unelectrified
RERL	Renewable Energy for Rural Livelihood
RM	Rural Municipality
SUDIGGAA	Sustainable Distributed Generation and grid access to all
SSCAF	South-South Cooperation Assistance Fund
T & D	Transmission and Distribution
UNDP	United Nation Development Programme
U	Unelectrified
VDC	Village Development Committee

1 Introduction

Nepal is one of the least developed countries in Asia and is among the countries with the least per capita energy consumption in the world. However, Nepal has made significant progress in increasing access to clean lighting. According to Multi-Tier Framework Survey conducted by World Bank Nepal [1], 94.7% of the population has access to electricity and, 74% of the households still rely on solid biomass fuel for cooking according to report published by United Nations Development Programme (UNDP) Nepal [2]. In rural areas, almost all households use traditional firewood stoves for cooking, which not only are thermally inefficient but also a health hazard due to indoor air pollution. Women's and children's health are particularly vulnerable as they are exposed to indoor smoke for extended periods every day.

Being a mountainous country, Nepal has both advantages and disadvantages. Mountains make Nepal one of the most beautiful countries in the world but cause an immense problem with the transportation infrastructure which hinders the other developmental aspects, for example, education and health. This directly or indirectly limits the full potential of governmental actions. Far western region is one of the most suffered areas, which naturally affects the inhabitants.

With a long-time working experience in rural areas, the Renewable Energy for Rural Livelihood (RERL) project together with the Belt and Road Initiative (BRI) promoted by China is focus on making positive impact within four priority areas of China's external development strategy: poverty, equity and governance; energy and the environment; disaster management; and South-South cooperation. This thesis is part of RERL's initiatives together with United Nations Development Programme Nepal (UNDP) to evaluate the present situation of electrification in rural areas and how the situation has influenced the socio-economic status of local people, especially women.

Based on Nepal's status and RERL's objectives to gain economic empowerment of women through renewable energy access, this thesis provides an overview of one of the Rural areas of Nepal, Dharche Rural Municipality from Gorkha District. With the major objective to study the socio-economic status and electrification status, a detailed study was conducted on the present status and future potential of renewable energy sources to improve the socio-economic status will be answered within the research questions in

the following sections of this thesis. The scope of the project and the project concept are explained in chapter 2. Chapter 3 gives an overview of the implementation plan and methodology followed by chapter 4 that reports the results of the field visit. In chapter 5, this thesis strives to support and answer the research questions. Finally, with some field visit based recommendations are made in chapter 6, and the conclusion is drawn in chapter 7.

2 Background

2.1 Project Concept and Objectives

The comprehensive project design promoted by China and executed by UNDP Nepal together with RERL is based on the premise that lack of access to sustainable, reliable and affordable energy services for lighting, cooking, and heating as well as for enterprises hinders women's empowerment and their potentials for undertaking various livelihood activities. Women's empowerment and access to energy services are interlinked. Considering the prevailing energy and resource poverty, poor health conditions and gender inequality in Nepal, this thesis focuses on women's empowerment with energy as an entry point.

On the basis of the findings and recommendations of the thesis, the larger project will consider the role of women at two levels.

- **Energy supply end:** Women can contribute to the energy value chain, for example, conservationists, stove producers, briquette makers, skilled workers, and as promoters and suppliers of efficient renewable energy technologies and operation and maintain energy systems.
- **End-user:** Women can use energy for income generation focusing on productive uses.

This thesis focuses on using energy and energy services as an economic empowerment tool for women. It will also address the key development challenges of gender disparity and women's unequal access to economic resources and assets, including environmental goods and services, underemployment and low levels of participation in decision-making in ten rural municipalities in five remote districts.

Renewable Energy for Rural Livelihood Project

This thesis is only an initial study for the larger Renewable Energy for Rural Livelihood (RERL) project. The RERL project attempts to align with three out of the four priority areas of China's external development strategy to Nepal: poverty, equity and governance; energy and the environment; disaster management; and South-South cooperation. Likewise, the project has taken into consideration the tenets of China's 13th Five-Year Plan mainly energy and environment-related activities. In line with the White Paper on China's Foreign Aid published in 2011 and 2014 [2], the project ultimately aims at improving the livelihoods of the local people while also being a change-oriented catalyst for similar interventions all over the country. Furthermore, China has always been a close ally in Nepal's development and in the last few years, the biggest source of Foreign Direct Investment (FDI) in the country which will be further enhanced as Nepal is a partner in BRI promoted by China. [3].

One of the most effective and growing demands for a renewable source of energy for Nepal has been solar energy. The solar energy systems and equipment in the Nepalese market are predominantly imported from China. This aims to promote cross-border cooperation with China through business-to-business and institution-to-institution contacts. The energy sector in Nepal stands to learn considerably from these experiences especially regarding technology development and adaptive research for wider scale solar energy promotion and technology up-scaling, for example, smart grid, microgrid, hybrid systems, and energy storage technologies.

The RERL project aiming to improve the socio-economic status of rural parts of Nepal has been designed based on over two decades of experience working in the rural energy sector in Nepal. Although the promoted energy systems benefit both genders of the local population, the necessity for a dedicated project focusing on women has been felt as the learnings and experiences have shown the need for improved energy services is felt more by women than men in rural Nepal. However, given the patriarchal social systems in Nepal, they have a limited role in deciding the type of fuels used, for example, cooking, heating and food processing. Experiences have indicated that women have a greater affinity to collaborate for the provision of common goods and are more likely to participate in energy projects if given an opportunity. However, women get much less opportunity than men to engage in community activities in spite of mandatory requirements in most of the rural development projects. Furthermore, men are more likely to migrate to urban

areas for employment and take their skill and knowledge with them hampering the sustainable operation of energy systems. Thus, it is imperative to enhance women's skills and capacity to establish and govern institutions responsible for the smooth operation of energy projects and energy-based enterprises. Considering the remoteness of the proposed areas, the project has yet to update available socio-economic information.

Hence, this thesis is conducted as a pilot study to generate baseline information before project initiation through front-loading of non-South-South Cooperation Assistance Fund (SSCAF) project funds. The overall solar mapping of the country has already been carried out, and a technical feasibility study of potential sub-projects for various services shall be conducted during the preparatory phase.

As the larger project is in a preliminary validation phase, one of the rural municipalities (RM) was selected as this thesis' Pilot RM to validate the working methodology. The aim was to answer the following research questions.

1. What is the gender equality status in the region?
2. How is the socio-economic status of the people in the region?

   The aim was to collect basic details of, for example, the primary income source, health, education, the source of lighting, and cooking.

3. What are the electrification status in past, present and future plans?

   The objective was to observe and explore the possibility or existence of electrification status or any future projects from a local or governmental level.

4. Regarding the system design and feasibility, which of the renewable energy (RE) is more feasible?

   In spite of focusing on a Solar mini-grid, a brief study was to see the other potential RE. The research question was also expected to give insight into the previously existing hydropower and its feasibility.

5. Possibility of Rehabilitation of Bhut Khola micro-hydropower plant (MHP) (45kW)?

   The focus of this question was on giving brief information about the previously source of electrification, Bhut Khola MHP and will discuss the feasibility of rehabilitation of the MHP.

6. Willingness/commitment of villages or RM

   The Renewable Energy for Rural Livelihood project will require local's involvement and willingness, which was raised during the focus group discussion (FGD) and community and RM meeting.

7. What are the possible Women Empowerment opportunities and challenges?

   The aim was to study the ongoing status of women empowerment to determine how this project could support women empowerment along with potential local level business opportunities electrification could bring.

2.2 Scope of the Thesis

The purpose of this thesis was to identify and collect information from two potential rural municipalities in each of the five different districts in Nepal with one pilot location to initiate the larger picture of the project. With a lean methodology concept, initially one out of the 10 RMs was to be chosen for the desk study and field visit. That would help the validation of the working concept, which is explained in detail later in this report. The established model of working methodology would be then replicated in the larger project implementation.

The thesis project also included a field visit whose objectives are listed below:

- Identify risk and mitigation tools with both technical and policy level supports, and verify existing enterprises and other potential micro, small and medium enterprises (MSMEs).
- Identify and suggest appropriate solutions to existing problems and challenges
- Observe the status of transmission and distribution (T&D) lines from previously existing Bhut Khola MHP

- Conduct meetings with community and RM

Sustainable Development Goals or Global Goals

Sustainable development goals (SDGs) have been adopted by all the United Nation members as a universal move to end or at least minimize poverty, promote, ensure and implement actions towards better earth for all [4]. This thesis focuses on the following SDGs:

- SDG 3: Good health and well being
- SDG 5: Gender Quality
- SDG 7: Affordable and Clean Energy

The findings of this thesis should give an insight into the present status and potential for the larger project completion which aims to highlight these SDGs as a major outcome.

2.3 Limitation of the Thesis

Major limitations during the thesis project are listed below:

- **Phase 1**: **Desk Study**
  - Shortage of data

    Due to limited data available for the assessment, the analysis focused more on qualitative information.

  - Tight deadline

    Within less than three weeks, the basic outline of the study and inception report was to be submitted which was a challenge mainly because related information on the web was very limited to make an effective desk study in such a short timeframe.
- **Phase 2: Field Visit**
  - Rugged terrain to reach the location

    As shown in Figure 1, transportation was a hurdle and thus resulted in comparatively less effective fieldwork as the location of the field visit could only be reached on foot. If the transportation would have been easier, we would have at least one more day which could have been invested in FGD rather than hiking up to the point where transportation was possible.

Figure 1. Road status between Soti Khola to Machhekhola (no vehicles allowed)

- Lack of local human resource for consultation.
- Change of governmental pattern

  As of March 10, 2017, the local Village Development Committee (VDCs) were restructured after the promulgation of the constitution in 2015 resulting in lower reliability of the internet data as most of the available data had not been updated accordingly.

- Variation in information gathered from the internet and from the field visit.

  Since the available data were not recent (mostly from 2011), the variation in the data was obvious. That affected both the demographic and topographic information.

2.4 Project Coverage

The comprehensive project will be implemented in five high mountain districts of Nepal bordering China namely Gorkha, Rasuwa, Dhading, Mustang, and Dolpa. The HDI status [3] can be seen in Table 1. This thesis highlights the Dharche Rural Municipality of the Gorkha district. Lapsibot and Keraujabesi were selected as the wards to study in the Dharche RM. The selection method will be explained later in this thesis. The thesis was conducted in three phases: **Desk study**; **Field visit,** during which household surveys, focus group discussions (FGD) and local ward level meetings among the RM were conducted; and **Result analysis and recommendation** for the project.

Table 1. HDI of respective districts

Districts	HDI
Dhading	0.461
Dolpa	0.401
Gorkha	0.481
Mustang	0.508
Rasuwa	0.461

Selected project districts are literally very 'far' from the capital city Kathmandu; therefore, development has not been able to gather any significant momentum in these areas. Access to health, education and economic activities in these districts is very limited thus resulting in a very low HDI within a low HDI country. It is also characterized by high incidences of poverty. These districts are also among the most remote in terms of access to infrastructures such as road, electricity and other basic services, and suffer from extreme climatic conditions with high vulnerability to climate change. Due to limited livelihood opportunities, to supplement their income, most of the men work as unskilled laborers in other parts of the country or India.

The Himalayan region with its difficult terrain and rugged landscape makes transportation pretty challenging and extension of the national electricity grid exorbitantly expensive. The aim of the Renewable Energy for Rural Livelihood (RERL) project is to utilize air and road transport systems, porters and animals (mules and yaks) for transportation of goods and equipment to the project sites, but not in the monsoon season.

Alternative Energy Promotion Centre (AEPC) as key Stakeholder

The Constitution of Nepal 2015 has given most of the responsibilities for the promotion of renewable energy and electricity distribution systems to the municipalities. AEPC is the federal institution responsible for renewable energy promotion in the country and is in the process of formalizing Memorandum of Understanding (MoU) with municipalities and local governments. As part of specific needs identification and potential technological solutions, the project shall support the local governments to prepare the women-centric Municipal Energy Plan (MEP). Similarly, AEPC will coordinate with other governmental agencies for the implementation of the project activities. AEPC has already consented to work with UNDP to implement the project.

The project does not envision the development of heavy infrastructure. The nature of projects only foresees environmentally friendly community-led micro civil works such as water tanks and solar PV mounting structures. Hence, the environmental impacts will be very limited and taken care of during construction following AEPC's Environmental and Social Safeguard Guidelines.

UNDP Nepal is already present and carrying out activities related to climate change in rural districts of Nepal. Thus, necessary conditions for the smooth implementation of this project is, to a large extent, already ensured.

3 Implementation Plan and Methodology

Specific elements integration methods and means of realization are to be proposed for each output or activity. The main factors include human resource development, material supply plan, intellectual support, technical service and transfer, management cooperation, and provision of engineering services. Emphasis should be placed on the rationality and feasibility of the implementation plan, and the depth of preparation should meet the requirements of investment estimation. The content of human resources development (taking training as an example): includes but is not limited to training scale, duration, profession, number of people, location, teachers, rent, equipment, and teaching materials. The content of the materials supply plan includes but is not limited to specifications, quantity, and after-sales service. The implementation of other content should be as reasonable, feasible, and as detailed as possible, and correspond to the content of the investment estimate.

Figure 2 will give a brief view of the methodology adopted during this phase of the project.

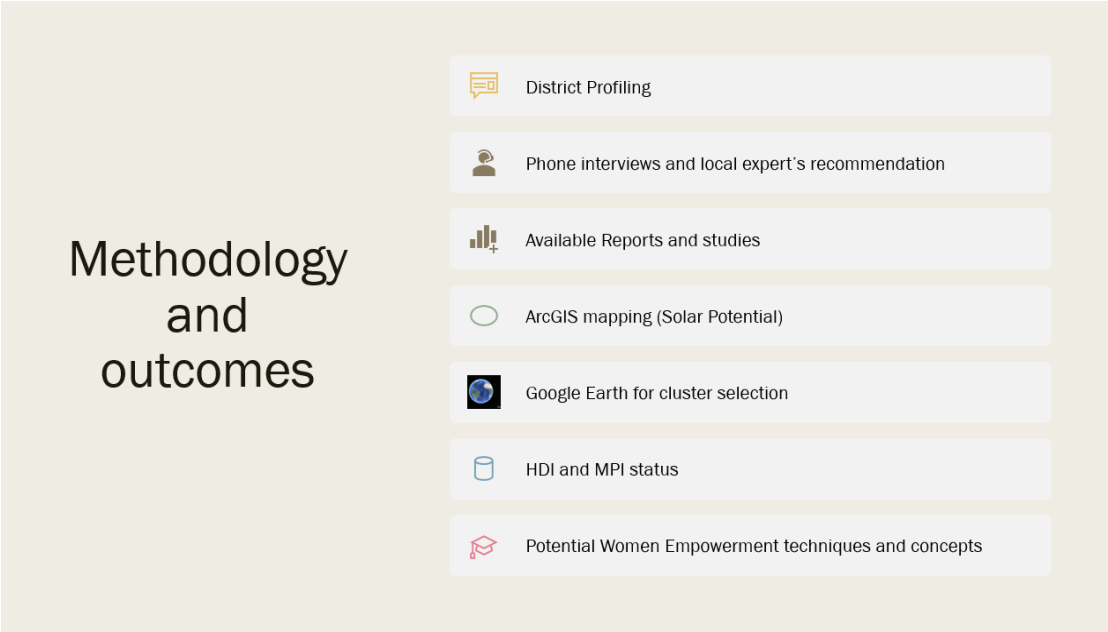

Figure 2. Methodology and outcomes

The Renewable Energy for Rural Livelihood (RERL) project will be implemented in five high mountain districts of Nepal bordering with China in the North – **Gorkha, Rasuwa, Dhading, Mustang, and Dolpa** as shown in Figure 3. These districts are among the remote areas in terms of access to infrastructures such as road, electricity and other basic services, suffer from extreme climatic conditions with livelihood options and rank high on climate vulnerability index.

Figure 3. Selected districts

The comprehensive project started with an inception meeting in which the implementing partners in Nepal and China agreed on the details and approaches in implementing the project activities for the entire period of the project implementation. An inception workshop will be organized to inform the stakeholders including the key government counterpart at the federal government as well as at the local governments about the objectives, goals, proposed activities and the intended results of the project. The Inception Workshop will garner support and endorsement from the stakeholders and commitment to supporting the realization of the project goals.

The project shall follow four distinct strategies to achieve the envisioned goals of the project:

- **Transfer of Technology:** Collaborating and partnering with NCSC in adopting the latest renewable technologies
- **Human Resource and Capacity Building:** Building capacity of women in target communities to establish institutions and manage the supply of clean energy services and operation of green enterprises
- **Management Cooperation**: Building capacity of local governments and financial institutions to promote women-friendly renewable energy operated businesses through the provision of credit and grant
- **Policy Support:** Adaptive research for identifying the most effective policy direction for the promotion of women supplied renewable energy services best suited to women in remote areas.

For achieving the project objectives, the project shall adopt a **phase-wise approach** in empowering women through Energy Access

- Providing access to sustainable, reliable and affordable energy services to meet the basic needs of women for lighting, heating, and cooking; and,
- Productive application of energy services for creating economic opportunities through the promotion of green businesses and enterprises owned by women.

To ensure these objectives are met and are validated in the comprehensive project, this thesis is limited to Dharche Rural Municipality in the Gorkha district to collect all possible information and conduct surveys in order to validate the working methodology.

3.1 Selection of Districts

Five districts among fourteen China bordering districts have been finalized based on the criteria.

I. Criteria set by the donor
   a) Nepal- China bordering districts
   b) Province requirement
II. Local-level expert's recommendations and previous working experiences in the areas by RERL.
III. Existing, ongoing or planned Grid extension and any other Renewable Energy projects
IV. Electrification status (Partially electrified, Unelectrified and Partially Unelectrified, based on Sustainable Distributed Generation and Grid Access to All (SUDIGGAA) report and road accessibility
V. Human Development Index (HDI) and the Multidimensional Poverty Index (MPI) rank and Economic activities
VI. Photo Voltaic (PV) Power potential

Table 2. Selection and reference for selection of RMs

Province	Districts	Rural and municipalities (in red)	Selected RMs	Selection references (referred to the above-mentioned criteria)	Status
3	**Dhading**	1) Rubi Valley	Netrawati Benighat Rorang	➢ Criteria set by the donor ➢ National Grid extension plan or any nearby future plan ➢ Electrification status	PU
		2) Ganga Jamuna			
		3) Khaniyabas			
		4) Tripura Sundari			
		5) Netrawati			
		6) Jwalamukhi			
		7) Nilkantha (M)			
		8) Galchi			
		9) Siddhalek			
		10) Benighat Rorang			
		11) Gajuri			
		12) Thakre			
		13) Dhunibesi			

	Rasuwa	1) Gosainkunda 2) Parbati Kunda 3) Uttargaya 4) Nakunda 5) Kalika	Gosain-kunda Parba-tikunda	➢ Criteria set by the do-nor ➢ 1200-1600 kWh/kWp per year PV out [Source: Global Solar Atlas] ➢ Previous Field Visit ➢ National gridline ➢ Other ongoing Pro-jects	PU
4	**Mustang**	1) Lomanthang 2) Dalome 3) Barhagaun Muktichhetra 4) Gharapjhong 5) Thasang	Barhagaun Muktichhetra Dalome	➢ 1900-2200 kWh/kWp per year PV out; Global Solar Atlas ➢ Existing projects ➢ A study by the Na-tional Planning Com-mission (NPC)	U
	Gorkha	1) Chumnubri 2) Dharche 3) Ajirkot 4) Sulikot 5) Aarughat 6) Bhimsen 7) Siranchok 8) Palungtar 9) Gorkha 10) Sahid Lakhan 11) Gandaki	Darche Chumnubri	Dharche ➢ Suddiga Report ➢ Recommended by Previous working experts ➢ Location feasibility(Lapsibot) ➢ Kasigaun ➢ Local advice ➢ Sulikot (phone interview) ➢ Ajirkot (gird extension going on)	PE
6 and 7	**Dolpa**	1) Se phoksundo 2) Jagadulla 3) Mudkechula 4) Tripurasundari M 5) Thulibheri M 6) Kaike	Tripu-rasundari Thulibheri Jagadulla Kaike	➢ Criteria set by the donor ➢ Electrification status ➢ PV Power Potential ➢ Recommendation by a third party (existing projects)	U

		7) Dolpa Buddha			
		8) Chharka Tang-song			

In Table 2 selection and reference for selection of RMs were presented.

Sudiggaa Report

SUDIGGAA report by NEA Engineering Company Ltd [5] presents the study and analysis of optimal distributed generation for access to grid electricity from the local government level. The SUDIGGAA report covers the study of all the 753 municipalities and the identification of the optimum extension path of the T&D network. The report also explores and illustrates the finding on the economic and financial aspects of distributed generation development and grid extension. Even though the report emphases that the hydro project is more feasible in Dharche RM, due to the landscape, telephonic validation on the recent status and huge loss after the earthquake in April 2015, a study on a solar project has initially been carried out by RERL.

This also links the socio-economic development that comes with Energy access and is thus a relatable reference for this project.

3.2 Selection of Rural Municipalities

Gorkha on the basis of road accessibility was finalized as the chosen district for this phase of the project, **Economic Empowerment of Women through Energy Access** among Dolpa, Mustang, Dhading, Rasuwa, and Gorkha. The idea was to apply the Lean methodology in one or two rural municipalities in Gorkha as a Pilot RM. Depending upon the findings and their assessment from energy and socioeconomic point of view, the same methodology would be applied for the rest of the districts to find the two RMs in each district.

3.3 Research Methods

- **Desk Study**

Within the desk study, district profiling based on demographic and topographic status, HDI and MPI were taken into account to gain detailed information about the potential sites. Also, on the basis of the SUDIGGAA report (See Appendix 1), the RMs with poorly electrified or unelectrified were chosen, and the list of 14 districts were narrowed down.

- **Phone Interviews and Telephonic Validation**

Since the list of RMs was narrowed down to a few, a phone interview was carried out with the Chairperson from each RMs as a second step. Being local level experts, the chairpersons gave a good briefing on the grid electrification, road accessibility, ongoing projects, and future projects.

It was found that there can be a major difference between the findings from the desk study and actual status. For instance, with the report and desk study based on the previous existing reports, Aarughat RM was listed among the Partially electrified (P.E.) status. However, after the phone interview with the Chairperson of Dharche RM, Mr. Santa Bahadur Gurung [6], it was understood that Aarughat is Partially unelectrified (PU) status.

- **Others**

Along with the phone interviews, GIS mapping was taken into consideration. GIS mapping as shown in Figure 4, gave an overview of PV potential in the areas.

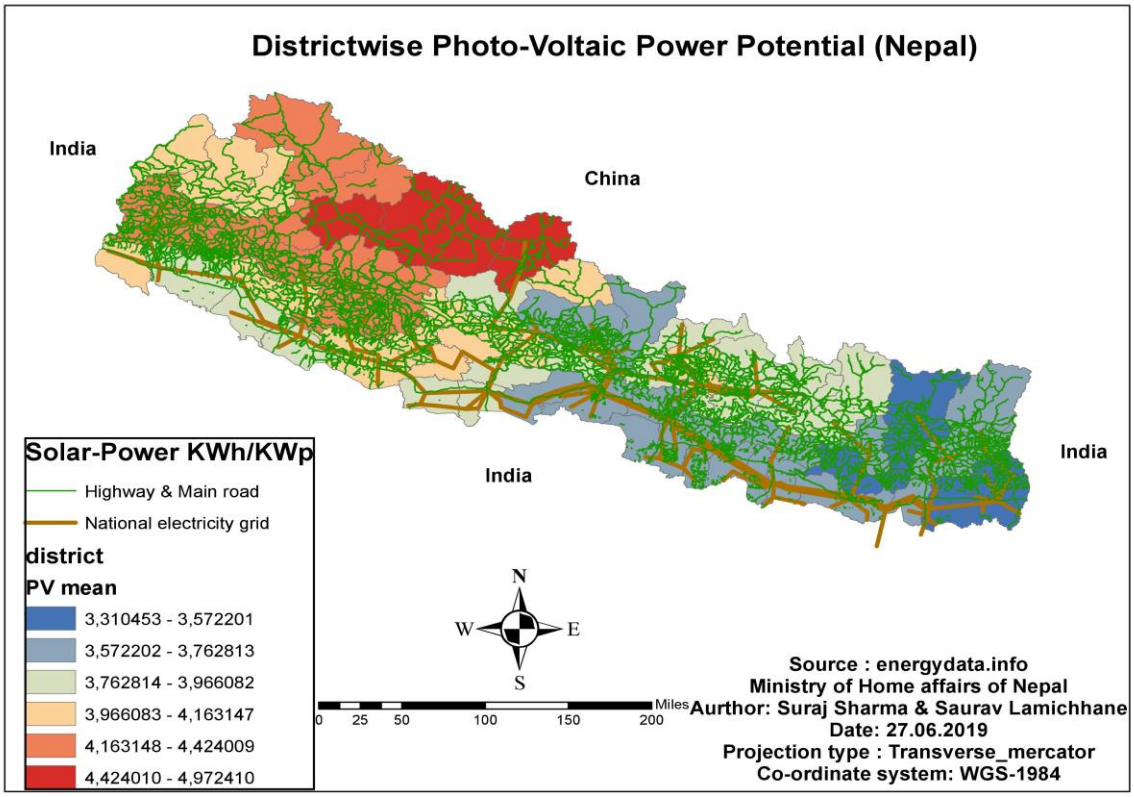

Figure 4. Map of Nepal with solar power potential including highways and main roads and the national electricity grid

(a) Transportation feasibility

Considering the rainy season, the selection was made significantly based on the fact that they are less than 150 km away from Kathmandu Valley and road status. That would shorten the potential risk of landslides, and days-long trekking routes.

(b) Cluster selection

For the population cluster selection, Google Earth and Google Map were also considered. The Google results were not up to date; however, some information about the location, schools and health posts (if any) and similar information were gathered. Consequently, it was decided that R studio should be used as the results would be more precise.

Potential Risk and Mitigation for the Project implementation

In Table 3, potential risks have been studied during the desk study.

Table 3. Potential risks and mitigation

Risks	Description	Proposed Mitigation
Data/Statistics	The project is highly dependent on the recent data and statistics from the rural areas of Nepal. Thus, it is very tough to analyze and process the implementation plans unless there is enough data to process it digitally. Having the data from 2011 will be less effective.	Reaching to local offices at the district level to get the recent statistics before the project kicks in.
Local involvement	With the available limited resource, it is very important to communicate with local people to people in their communities for the assessment.	Local team involvement as volunteers would make it easier.
Internet accessibility for data management	Access to the Internet is needed to keep all data updated within project management using tools such as Trello to keep the tasks updated and completed in time.	If possible, having at least one device connected to the internet.
Coordination with Local authority	The project certainly requires coordination with stakeholders and local authorities.	Having a good network and collaboration beforehand would be a win-win situation for both the Project Team and the local authorities.
Others	Besides delay in the release of money for the project, transportation risks, poor maintenance and defaulting in tariff payment may be other potential risks during and post phases of the project.	Higher skilled technicians could be hired, or local technicians could be trained for quality maintenance. Handling bills and invoices should be strict so that defaulters could be immediately disconnected from the grid or charged with penalties for reconnection. The worst-case could also be handling that legally.

4 Field Visit and Results

After a 4-day field visit, the following information was gathered in a different location.

4.1 Dharche RM

Dharche was finalized as a selected rural municipality based on the methodology mentioned above. The local unit as Dharche RM became operational from May 2017. Kerauja, Uiya, Laprak, Gumda, Kashigaun and Lapu VDCs were incorporated to form Dharche. The headquarter of this RM is located in Machhekhola, Gorkha district. It is surrounded by Dhading District and China on the East, Chumnubri RM on the North, Barpak Sulikot RM on the west and Dhading District on the South. [7]

Figure 5 shows the map of the Gorkha district showing the Darche RM.

Figure 5. Map of Gorkha District [8]

According to the population census of 2001, the total population of the RM was 13,553. The population trend slightly had a downfall to 13,264 as per the census of 2011 with a change of 0.21% per year. With an area of 652 sqm, the population density of Dharche is 20.36/km^2.[9]

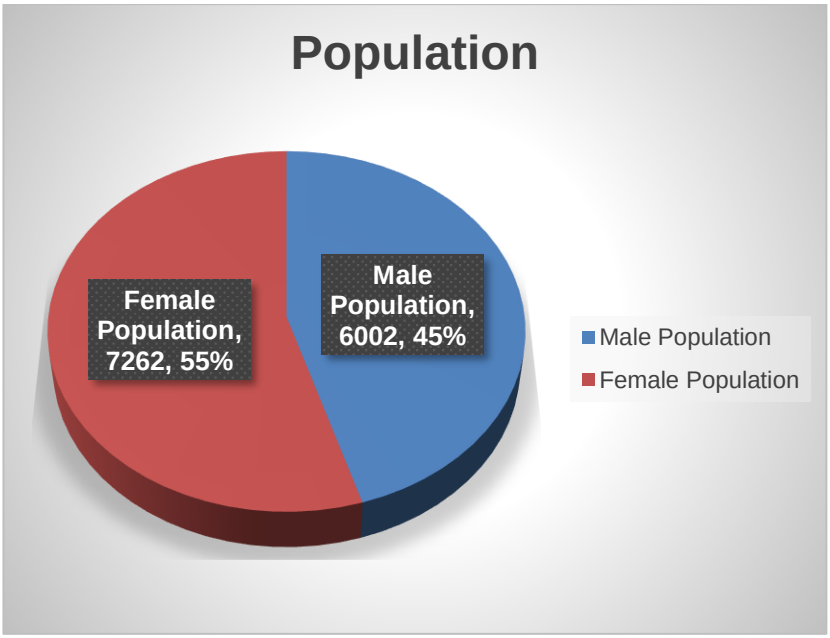

Figure 6. Gender-wise population in Dharche RM

Population distribution by wards

Table 4 below gives the population details in the VDCs level before being restructured to RMs with respective to Wards, according to the District profile from the Central Bureau of Statistics Nepal. [10]

Table 4. Population distribution by Wards of Dharche RM

Ward No.	Dissolved VDCs	Wards	Population
1.	Kerauja	7-9	1000
2.	Kerauja	1-6	2248
3.	Uiya	1-9	1857
4.	Laprak	1-9	2192
5.	Gumda	1-9	2303
6.	Kashigaun	1-9	1837
7.	Lapu	1-9	1827

Population distribution by ethnicity

According to the National Population census 2068 B.S (2011 A.D), 82.74% of the population distribution was Gurungs whereas Ghale with 39% were second most common in the RM. Janajati were found to be least with 4.97% of total Dharche's population as shown in Table 5.

Table 5. Population distribution by ethnicity

S. N	Type	Population	Percentage (%)
1.	Chettri	33	0.25
2.	Brahmin	46	0.35
3.	Janajati (kami)	659	4.97
4.	Rai	23	0.17
5.	Gurung	10975	82.74
6.	Ghale	1498	11.29
7.	Others	30	0.23
Total		13,264	100

Source of drinking water

According to the National survey 2068 B.S (2011 A.D), 90.47% of the household in Dharche RM depend on tap water. Whereas 0.16% of the HH depends on unmanaged or unsafe well water, 5.21% depends on Community tap water and 3.64% depends on river water, as illustrated in Table 6 below:

Table 6. HH by source of drinking water

S. N	Source of Drinking water	Household	
		Number	Percentage
1.	Tap water	2830	90.47
2.	Unmanaged well water	5	0.16
3.	Community Tap water	163	5.21
4.	River	114	3.64
5.	Others	16	0.52
Total		3128	100.00

Source of cooking fuel

According to the National Survey 2068 B.S (2011 A.D), 99.17% of the households in Dharche RM depend upon firewood for cooking purposes. Very few households, 0.16%, depend on LPG or other fuels (0.16%, see Table 7).

The results of the field visits showed that the locals use approximately 20-30kgs of fire-wood every day and at a time of collection they collect 1 *bhari* i.e. 1000 Nrs (~8 euros).

Table 7. HH by source of Cooking fuel

S. N	Source of cooking fuel	Household	
		Number	Percentage
1.	Firewood	3102	99.17
2.	LPG	5	0.16
3.	Others	5	0.16
4.	Not mentioned	16	0.51
Total		3128	100.00

Recently, the use of liquid petroleum gas (LPG) has been significantly increased. Most of the houses have been using LPG as a secondary source in Lapsibot. However, fire-wood is still the most used source of cooking fuel.

Source of lighting

According to the National survey 2068 B.S (2011 A.D), 46.42% of the households in Dharche RM depend upon the national grid for electricity, 12.42% use Kerosene as a source of lighting, 2.33% use Biogas and 14.39% depend on a solar home system (see Table 8)

Table 8. HH by source of lighting

S. N	Source of Lighting	Household	
		Number	Percentage
1.	Electricity	1452	46.42
2.	Kerosene	401	12.42
3.	Biogas	73	2.33
4.	Solar home system	450	14.39
5.	Others	736	23.53
6.	Not mentioned	16	0.51
Total		3128	100.00

Major Source of Income

Even though the locals depend highly on agriculture and animal husbandry, the area is also the trekking route to Manaslu and to the most graceful 8000-meter giants, Anna-purna to the west and Ganesh Himal to the east.

Manaslu Circuit Trek

Manaslu Circuit Trek (elevation 5106m) is one of the best treks in Nepal. The 14 days trek route starts from Soti Khola and ends in Besisahar.

With the jaw-dropping natural beauty of flora, rivers, and forests, the Manaslu circuit trek has been a major aspect of income generation for the local people. In addition to the flora, there is abundant wildlife such as mountain goats (tahr), blue sheep (agali), pikas (the highest living mammal), Himalayan marmots and snow leopards living in the area.

Mainly in the Machhekhola, there is a good number of hotels and lodges where women are active in the business. Furthermore, trekking guide in such could be a very practical profitable business as the area has been also a good touristic destination for foreigners. This has been helping locals to increase the profit through transportation as well. Locals use hinnies for transportation and earn their living by carrying the goods of the trekkers.[11]

Others

Besides, rearing of animals, producing cash crops, working for a wage in construction and agriculture and livestock have been other sources of income to people. A minority of the population is also involved in economic activities like small businesses and services and foreign employment.

Summary

The field visit started on the 3rd of July 2019. The author of this thesis and consultant from RERL, Ms. Shrijana made a field visit to validate the results of the desk study. It took about 7 hours of drive to reach Soti Khola, Gorkha. Since it was monsoon time, the road ahead of the military camp at Soti Khola was very unsafe. With the strict prohibition from the military camp, the Jeep had to be left at the camp and the journey was continued by trekking. During trekking it became evident why driving there was not safe, as shown in Figure 7:

Figure 7. Road status between Soti Khola and Machhekhola

With a recent landslide, the road was inaccessible even to any emergency vehicles. A police van was permitted to drive past the camp and two seats in the van were offered. However, as soon as the van reached the landslide zone where a rock as large as it was obstructing the road, the van had to return as there was no way the road could be cleared any time sooner. After almost 6-7 hours of trekking, the author of the thesis and Ms. Srijana reached Machhekhola, where the Dharche Rural Municipality was located. It was the most urban place in that area. After a long tiring day, a decision was made to spend the night in a hotel.

In the evening, a meeting was held with the representative from the RM and he promised to provide a local as a guide who was supposed to take us to the Potential location for

the project i.e. Keraujabesi, which was almost 2 hours uphill hiking and Lapsibot which was almost 4 hours of uphill trekking. The next day, Keraujabesi, ward no 2, was the first location of the field visit and the second was for Lapsibot, ward no. 5.

On the last day, the field visit ended with a meeting with a representative from both wards and the chairperson and his RM team (see Figure 8).

Figure 8. Final day meeting/presentation with Ward representatives and Dharche RM

4.1.1 Keraujabesi

With uphill trekking about 2 hours from Machhekhola, Keraujabesi is a new settlement after the Mega-earthquake, 2015. With about 90 households, the village is located on the steep hill in northern Gorkha.

Community Questionnaire:

Based on the targeted results, a questionnaire was designed to have an insight into the socio-economic aspect of the locals and a basic overview of future possibilities of potential income sources, if any. Table 9 is the outcome of the community meetings, household surveys and Focus Group Discussion (FGD). Among the 90 households, the survey was carried out for 1 in every 10 houses (see Figure 12).

Table 9. Community Survey outcomes for Keraujabesi

Community Questionnaire: Keraujubesi	
Date	4th July 2019
District	Gorkha District
Rural Municipality	Dharche
Ward no, Tole	2, Keraujaubesi
Location Coordinates	N 28.239016
	E 84.892296
	North Facing
Total number of households	90
Source of drinking water	Community tap via Gravity Flow
Source of cooking fuel	Firewood. 20-30 kg per day = 1-time collection (1 *bhari*) = 1000 Nrs (~8 euros)
Major Ethnicity	Gurung and Janajati
Schools	None
Health posts	None
Land Availability for Solar Mini grid	Possible. Private land from Villagers
Major source of income of residents	Agriculture
Average annual income per HH	5000 Nrs/month 40.47 Euro (as of 20 July 2019)
Nearest NEA distribution line	Machhekhola, 28.232799, 84.874693
Is there any possibility of NEA line extension or micro-hydro in the near future?	Nothing any sooner.
Distance from nearest road head and market center	Machhekhola, approximately 2kms
Source of lighting and mobile charging at present	☐Diesel Generator ☒Solar Battery Charging station ☒ Kerosene ☒Dry Cell ☐Biogas ☐others specify
Potential commercial consumers (for example, MSMEs, hotel, shop)	Groceries Local bars (Bhatti)
Types of public service centers	None.
Transportation	Not available except for walking trails. Hinnies are used for carrying goods uphill at the cost of 26Nrs (21 cents as of 7.20.2019) per kg
After installation of the mini-grid system, is there any possibility of business enterprise development? If so, mention the type of business.	Refer to Table 9

Table 10. Business enterprise possibility

Business Type	Size (micro/small/medium)	Comments
Metalworks (*aaran*)	Small	One existing.
Groceries Stores	Medium	
Making of Improved cooking stove	Small	Requires training through our project.

Site Details

According to the results of the field survey, Keraujabesi needs to be electrified and be provided with basic services as soon as possible. The socioeconomic status is the worst even in comparison to that of other parts in Nepal. Schools and health centers are at a distance of 2 hours of walk to Kerauja, making inhabitants suffer in any severe health conditions.

However, due to a north-facing land structure in the hill and the project would need super expensive batteries to cover the low peak sunlight hours, a solar mini-grid was thus not feasible to be proposed in the location.

SITE INFO

Site name:	**Kerauja, Gandaki, Nepal**
Latitude:	28.239453°
Longitude:	84.891734°
Altitude:	1752 m a.s.l.

SOLAR RESOURCE AND AIR TEMPERATURE

Long-term yearly and daily averages

Global horizontal irradiation [kWh/sq m]:	1520 per year (4.164 per day)
Direct normal irradiation [kWh/sq m]:	1121 per year (3.071 per day)
Diffuse horizontal irradiation [kWh/sq m]:	761 per year (2.085 per day)
Global tilted irradiation [kWh/sq m]:	1676 per year (4.592 per day), for surface tilted at 30° facing 180°
Air temperature [°C]:	11.7

PHOTOVOLTAIC POWER OUTPUT

Photovoltaic system of size 1 kWp with modules facing 180° tilted at 20°, long-term yearly and daily averages

Photovoltaic electricity [kWh]:	**1268 per year (3.475 per day)**
Global tilted irradiation [kWh/sq m]:	1631 per year (4.468 per day)

Figure 9. PV power details for Kerauja [12]

During the post desk study, the proposed site is windy, a small-case study on wind power potential was done. The study suggested that, at height 50m, with an average wind speed of 8.94 m/s and 608 W/m^2, wind power would be a smart choice (see Figures 9, 10 and 11).

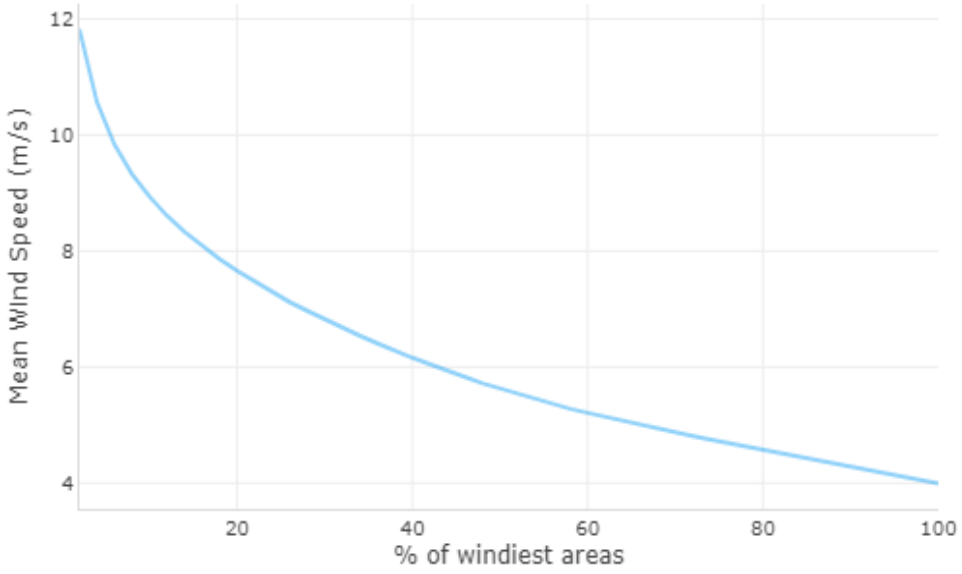

Figure 10. Wind speed [12]

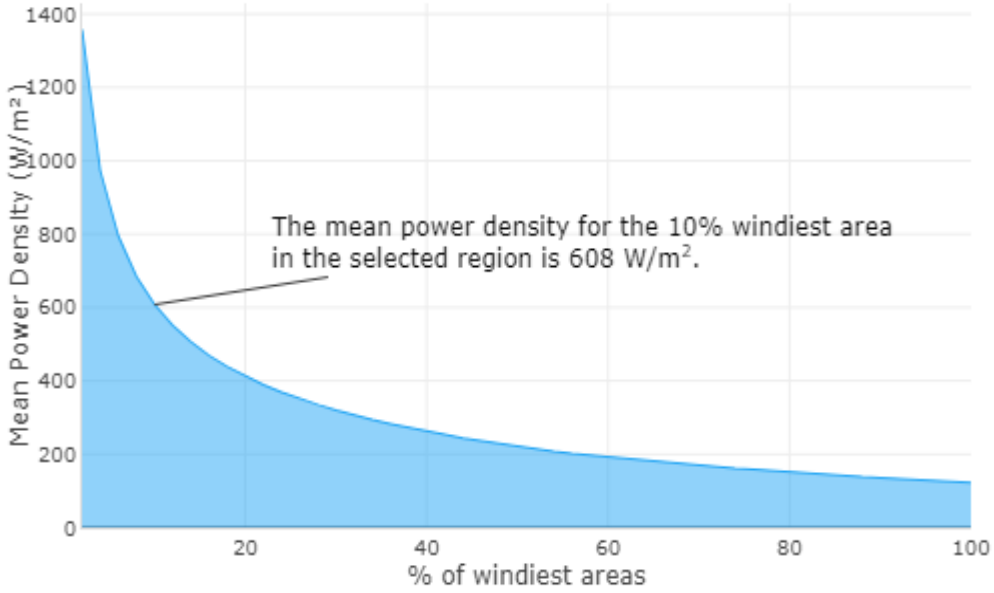

Figure 11. Wind power density [12]

4.1.2 Lapsibot

The following table 11 will give an overview of socio-economic aspects and basic information on Lapsibot.

Table 11. Community survey outcomes

Community Questionnaire: Lapsibot	
Date	4th July 2019
District	Gorkha District
Rural Municipality	Dharche
Ward no, Tole	5, Lapsibot
Location Coordinates	N 28.211546
	E 84.860249
	Southeast Facing
Total number of households	105
Population	~700
Major Ethnicity	Gurung
Source of drinking water	Community tap via Gravity Flow
Source of cooking fuel	LPG 1700 Nrs per cylinder (13/14 Euros) Firewood. 20-30 kg per day = 1-time collection (1 *bhari*) = 1000 Nrs (~8 euros)
Schools	None
Health posts	None
Land Availability for Solar Mini grid	Possible. Private land from Villagers
Major source of income of residents	Agriculture (maize, millet, potato, soybeans
Average annual income per HH	12000 Nrs/month 97.12Euro (as of 7.20.2019)
Nearest NEA distribution line or if possible, in near future (within <5 years)	Gumda, Gorkha (1.5-2 hours walking distance) Machhekhola, Gorkha (1.5-2 hours downhill) The NEA
Is there any possibility of NEA line extension or micro-hydro in the near future?	Nothing any sooner. Bhut Khola Micro-hydro grid was the major source of electricity until the mega-earthquake however after the earthquake the hydropower has been out of order ever since. The maintenance cost is calculated to be really high that it does not seem feasible to rehabilitate it.
Distance from nearest road head and market center	Machhekhola, approximately 2kms
Source of lighting and mobile charging at present	☐Diesel Generator ☒Solar Battery Charging station ☒ Kerosene ☐Dry Cell ☐Biogas ☐others specify
Potential commercial consumers (for example, MSMEs, hotel, shop)	Groceries Local bars (Bhatti) Hotels and lodges Bakeries
Types of public service centers	None.
Transportation	Not available except for walking trails Hinnies are used for carrying goods uphill at the cost of 26Nrs (21 cents as of 7.20.2019) per kg

Willingness for the Solar Mini-grid	7/10 houses, based on our HH survey, were willing to be connected to the potential Solar mini-grid Remaining households preferred lighting solutions with the existing installed solar system with 3-5 bulbs.
After installation of the mini-grid system, is there any possibility of business enterprise development? If so, mention the type of business.	Refer to Table no 12

It was found that most of the households had rooftop solar panels ranging from 10W to 50W lighting 3 to 5 LED bulbs. The average lighting hour was found to be 6 hours. Likewise, most of the houses had Metallic Improved Cook Stoves (MICS) that cost around NRS 4500 (36.42 euros).

With no secondary and higher secondary schools or health centers in the village and low-income generation, it is negatively affecting the socio-economic status of the people. Transportation is making it even worse as it takes 1.5-2 hours of walk to reach a nearby market, i.e Mache Khola or Gumda, the nearest location where the health centers and schools are.

Table 12. Business possibilities for Lapsibot community

Business Type	**Size (small/medium/large)**	**Comments**
Mushroom farming	Micro	Requires training through our project.
Grinding and processing mill	Medium	
Groceries Stores	Medium	Basic calculation skill
Making of Improved cooking stove	Small	Requires training through our project.
Carpentry	Medium	Skilled manpower is available.

Site Details

With the help of Global Solar Atlas [12], the following site details (Table 13) for solar resource were concluded:

Table 13. Site details for Lapsibot for the solar possibility

Long-term yearly and daily averages			
	Unit	Per day	Per year
Global horizontal irradiation	kWh/sqm	4.159	1518
Direct normal irradiation	kWh/sqm	2.989	1091
Diffuse horizontal irradiation	kWh/sqm	2.197	802
Global tilted irradiation (for surface tilted at 31 and facing 180)	kWh/sqm	4.575	1670
Photovoltaic Power output			
Photovoltaic electricity	kWh	3.498	1277
Global tilted irradiation	kWh/sqm	4.493	1640

Figure 12. Field visit activities

Lapsibot's proposed locations are shown on the map in Figure 13.

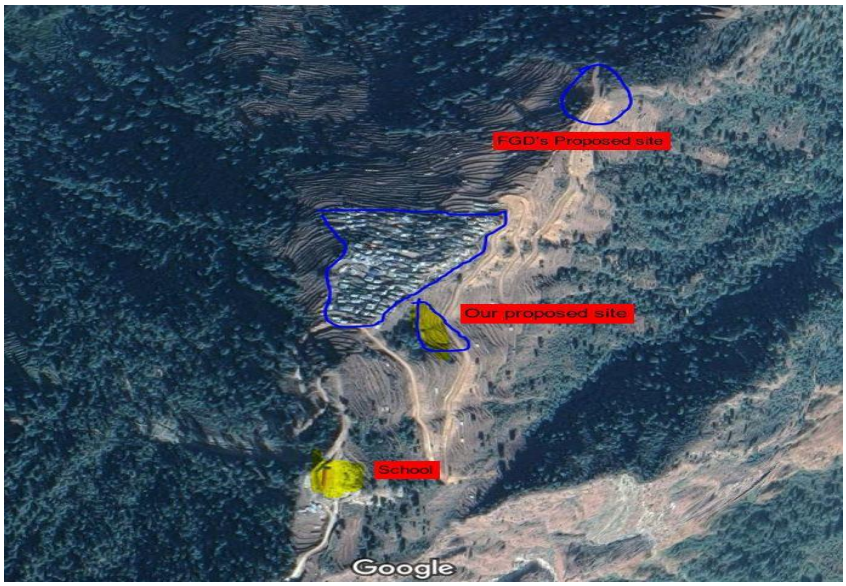

Figure 13. Proposed location of solar power based on the field visit [13]

4.1.3 Potential Environmental and Social Impact for the Purposed Site

The field survey also included a basic preliminary study on the possibility of anticipating any environmental or social impacts. The issues briefly include ecology, land availability and requirement, project construction and equipment, environmental health and safety and certain purposed mitigation method in the following table.

Table 14. Potential environmental and social impacts

Environmental Parameter	Level of Impact	Description	Proposed Mitigation measures
Water	Low	Water will be used for the construction phase and post-construction phase in a regular interval to clean the modules. However, water has not been the problem in Lapsibot, so the impact is low. Also, since there is agricultural land downhill, the wastewater could be utilized for the crops.	A community tap water source can be used. Wastewater can be used for irrigating the field.
Air	Low	Insignificant air emission can be predicted during or after the construction phase. Since no vehicle transportation is possible in the village, the construction activities would be manual.	Proper handling of soil excavation.

Land	Medium	The proposed land is a cultivable land that would result in impacting the agricultural crops.	The municipality could compensate with a similar land area for agriculture as there is an availability of such Municipal land in the area.
Noise	Low	School is quite close to the area so noise should be controlled. However, the location of the school as shown in figure 13 is uphill so the noise will not be minimal.	Noise monitoring could be done in a regular interval.
Ecosystem	Low	No ecologically sensitive areas are nearby that would be by any means affected. No deforestation of vegetation will be affected. But the panels will be in open land. Cases have been encountered that the birds assume the panel to be water resource and might even result in the deaths of some birds. But with local experts' advice, no endangered birds migrate in the areas, so it is predicted to be minimal.	
Socio-economic	Low	The project will hire locals thus employment would help to have a positive impact. The project will make sure no harm in livelihood will be done in any way. On the contrary, training will be provided to raise the livelihood status.	Local Employment Training

5 Findings

The field visit to two of the wards in the Dharche Rural Municipality was intended to gather as much information as possible via surveys, interviews and community meetings.

On the basis of the research questions and thesis' objectives, outcomes of both the location, Keraujabesi, ward no. 5 and Lapsibot Ward no. 2 can be outlined as:

5.1 Needs and Demands

Based on the field visit, FGD and RM meeting's outcomes and the chairperson Mr. Santa's following needs and demands based on his expertise in his locality and available resources were assessed:

- **Solar Street Lights**

  Solar lights' need was obvious. As the area is a touristic place for the trekking route, solar streetlights would be a very reasonable investment to facilitate the tourists' trekking. Namely, Machhekhola, Laprak (NRN village) Gumda, Khorla-besi, Lapubesi, Yarubagar and Doban to start with.

- **Biogas Plant in Laprak**

  Despite being a rural municipality, the locals were aware of how the renewable source is sustainable and a better means of energy source. A biogas plant was already proposed to the central government by Mr. Gurung [6] for 600 Households in the Laprak Village.

- **MSMEs**

  The objective of the project is to enhance the livelihood of rural villages through energy access, with women empowerment as a tool. Thus, with the focus group discussion, certain possibilities and interests were identified.

  - Grinding and processing mills
  - Baking training for women to run solar-powered Bakeries
  - Existing hotels to be powered by Solar power
  - Portable solar bags for shepherds
  - Training and opportunities focused on women
    - Training for mobile repairing, sewing, and knitting, the making of Improved cooking stoves.
    - Training as a local guide

Besides the needs and demands, some other interesting findings were made and are presented in the following subsections.

5.2 Gender Inequality

According to SAHAS Nepal's report, social discriminatory practices, such as domestic violence, Chhaupadi, and dowry system. have been still prevailing in most of Dharche RM's region. This certainly results in gender inequality and sends a negative message to new generations and thus discourages the social and political capacities of women.

Active women participation in meetings, training, and involvement in the decision-making process both in their house and in the local bodies as Ward members or RM representatives have been an effective way to minimize gender inequality throughout Nepal.

With MSMEs, more women can be mainstreamed into income-generating activities which build harmony in the social structure where men have been enjoying most of the rights and women being discriminated group.

The cycle below in Figure 14 shows the components that help the women empowerment:

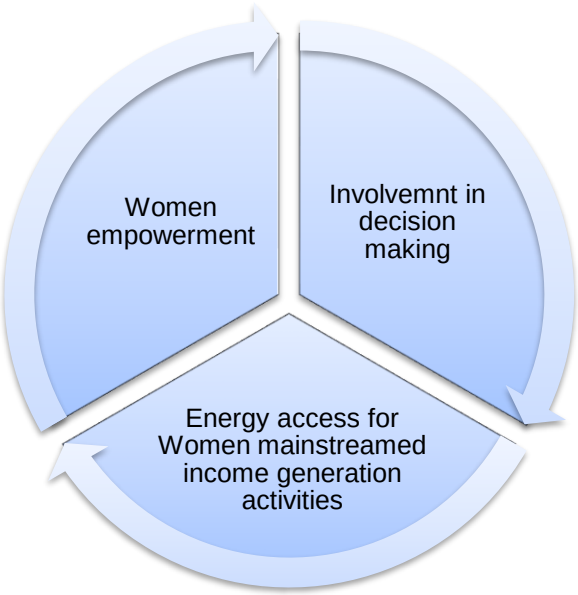

Figure 14. Three fundaments for women empowerment

5.3 Community Data and Survey

One of the major outcomes of the field visit was three different surveys: ***Household Surveys, Community Questionnaire, and RM Questionnaire*** which were designed for the project and can be found in Appendix 4. The questionnaires were designed to collect the socio-economic aspects of the region, which resulted in an efficient way to collect all the required information. The main outcomes of the data collection and survey covered three major aspects:

- Socio-economic status
- Present Energy Status
- Energy needs and demand
- Willingness for the Project

5.4 National Grid Status

Another outcome of the visit cleared another major confusion. During the visit it was noticed that electricity poles were being extended to Machhekhola, it was suspected that the poles would be extended to the proposed wards, which was obviously a happy problem. However, with the meeting with the RM, it was clear that the poles were bought by RM hoping to be electrified by the national grid. However, no particular project would cover both the wards any time sooner. Thus, the solar mini-grid would be a perfect and much-needed project RM would collaborate with.

Figure 15 shows the electricity pole which was carried by individuals to the uphill located village.

Figure 15. Electricity Pole at Keraujabesi carried uphill by individuals

5.5 Energy Demand and System Design

With the energy demand assessment done in post-study analysis, it was found that for the basic HH uses such as light bulbs, mobile charging, radio, TV, DTH, refrigerator and rice cooker and the penetration factor ranging from 5 to 100%, 15,775 Wh/Day electricity was in demand. It was assessed that with the electricity provided, people would open poultry, hotels and restaurants, carpentry and household small scale productions such as traditional *muda*, carpet knitting, sewing, and knitting.

Including the control powerhouse demand, the total required energy demand was found to be 48,375 Wh/day. The demand and design here are based on a case study and result analysis previously done by AEPC.

Likewise, with 61% efficiency for the PV system was designed considering all the significant power losses assumptions such as temperature loss (T) 8%, cable loss (C) 2%, dust and reflection (D&R) 1%, power degradation 0.50% per year, series and parallel loss due to the difference in module specification 0.50%, T&D loss 5% , other electronics loss 0.5% and efficiency of the inverter to be 90% and that of battery efficiency considering 85%.

The whole efficiency of the PV system,

= 1* (1- Power Degradation per year * 10 years * (1 – T%) * (1- Series and parallel loss due to the difference in module specifications) * Efficiency of inverter * (1- C%) * (1- D&R %) * (1- Electronics loss) * Battery Ah efficiency * (1- T&D %)

= 1* (1-0.50% per year * 10 years* (1- 8%) * (1- 0.50%) * 90% * (1- 2%) * (1- 1%) * (1- 0.5%) * 85% * (1- 5%)

= 61%

An average of 4 hours was considered as peak sun hours and the system voltage of 48 volts is taken as optimal numbers. The number is justified as the average peak sun hour in the area is approximately 4 hours and 48 volts are chosen for the system voltage as it optimizes the wire expenses and for such a system 48 Volt is ideal. The selection was based on previous working experience of RERL.

The current of the solar PV module is calculated as the capacity of the selected solar PV module and is divided by open-circuit voltage. A 250 Wp of PV module of 24 Volt was selected (purposed) with 56 connected in parallel and 2 of them connected in series and the size of 28 solar arrays. As shown in the Excel file in Appendix 3, 48 batteries are purposed for the design and a 12.36 kVA inverter.

$$Number\ of\ Solar\ PV\ Module\ in\ Parallel = \frac{Efficiency\ corrected\ total\ AH\ required\ per\ day\ AH/day}{Peak\ sunhours(\frac{H}{D}) * Current\ from\ Selected\ Solar\ PV\ Module(A)}$$

$$= \frac{1{,}652}{4 * 7.34}$$
$$= \sim 56$$

And the total number of battery required in series = $\frac{\text{System Voltage } (V)}{Output\ Voltage\ of\ the\ sleceted\ battery(V)}$

$$= \frac{48}{2}$$
$$= 24$$

And the total number of battery required in parallel= $\frac{\text{Total Ah required per day}}{Storage\ Capacity\ of\ the\ sleceted\ battery}$

$=\frac{48}{24}$

$=2$

$Size\ of\ array\ =$

$$\frac{Capacity\ of\ selected\ Solar\ PV\ Module\ (Wp) * No.of\ solar\ PV\ module\ in\ parallel * No\ of\ module\ in\ series}{1000}$$

$$=\frac{250\ Wp * 56 * 2}{1000}$$

= 28 kW

The total number of batteries is calculated as the product of batteries in parallel and series = 24 * 2 = 48

Likewise, the size of the battery is the product of storage capacity of the selected solar battery in AH, output voltage and a total number of batteries i.e 2000 Ah * 2V * 48 = 192,000 Wh.

5.6 Proposed Site Details and Conflicts

As shown in Figure 13, FGD's purposed land for the Solar Mini-Grid and the maintenance and security house, was economically not feasible. Considering that as an option, Plan B was purposed for the location for which as the land was private, we had to convince the owner that in need we may have to use the land, but the owner was not completely happy to give away the land. The issue was resolved during the combined meeting with the ward and RM, as they agreed that with RM's cooperation, the land would not be an issue for the project at all.

5.7 Present Status of MHP in Machhekhola, Bhut Khola MHP

The Bhut Khola Micro Hydropower is a 45kW MHP in the Gorkha District which is out of operation and completely shut down since 2015 due to the earthquake in 2015.

Table 15. Load centers of Bhut Khola MHP

S. N		Load centers name	No of HH
1.		Yamgaun	40
2.		Lapsibot	100
3.		Machhi Khola	70
4.		Khanibesi	12
5.		Keraujabesi	40
		Total	262

(Yamgaun has been connected to electricity from another 14kW MHP)

From the study done by Universal Consultancy Service Pvt Ltd [14] in March 2019, Table 16 presents the status of the MHP:

Table 16. Status of the civil structure at Bhutkhola MHP

Civil Structure	
Structures	Status
Intake	Completely damaged
Desilting basin	Damaged
Headrace canal	Completely damaged
Forebay	Completely damaged
Anchor blocks and Support Pipe	Almost 50% damaged
Penstock and bend pipe	Almost 65% damaged
Powerhouse	Completely damaged
9.4.1 Machine foundation	
Tail Race	Damaged
Electro-mechanical Component	Found buried Would work but not a sustainable option
Generator (90kVA, Synchronous, 3 Phase, 400/230Volt, 50HZ, 1500rpm, 0.8 power factor, Brushless generator)	Satisfactory but damaged Requires function test
Turbine	Satisfactory (external appearance only as it was found partially buried so could not be assessed)
Electricity Load Controller (ELC)	Partially buried and damaged
Ballast Tank	Satisfactory condition
Tools and Spare parts	Not found.
T&D	Transmission from powerhouse to Machhikhola has been completely collapsed. Few poles are found in a safe condition. Step down transformer in Lapsibot was also found completely damaged.
Lightning Arrestor and Earthing System	All damaged.

The plant has been shut down completely from June 2015 due to the landslide and debris collected during the road construction after the earthquake. Since the MHP rehabilitation

would be very expensive, it was found that due to financial inability the community was not willing to rehabilitate the project either.

5.8 Women Empowerment Opportunities and Challenges

Dharche RM has a higher female population than the male population. The FGD and the community meeting including the RM's representatives' presence suggested that training shall be provided to help them with skills. The willingness was impressive from the women.

Especially, training in agriculture, poultry, sewing, and knitting, grinding and processing mills and making of improved cooking stove would help them raise the standard of living. This requires electricity and that has been the hurdle to carry out the above-mentioned activities. If the project provides electricity, women are willing to start the grinding and processing mills, sewing and knitting centers and poultry. Some of the male population highlighted the need for furniture manufacturing would be another major necessity in the area and stated the men are skilled, but their only hurdle has been the electricity.

Barefoot Engineering

Barefoot Engineering for women was also introduced during the FGD, and some of the women were curious about and wanted to learn more. Women Barefoot Solar Engineers' concept can be practical where the local women will be handling the installation and maintenance. The concept started in India and has been proven successful engineering training in over 25 countries in Africa, Asia, and Latin America. The idea of barefoot engineering is to produce skilled local women by providing basic solar engineering training that would provide them with skills for the installation, operation, and maintenance and other phases of this project. Local women could be employed in after-sales and marketing and thus have a sound economic source.[15]

5.9 Potentialities of MSMEs

As mentioned in Table 12 and the Recommendation chapter below, many opportunities in MSMEs have good potential in both areas. One of the main hurdles has been the electricity itself.

Given that people have access to electricity, there would have been several MSMEs, several business opportunities as bakeries, poultry, mushroom, hotels, grocery shop, and tourist information and guidance services would be started for which the Dharche RM has assured full support.

6 Recommendations

On the basis of studies, surveys and local understanding the following recommendations were made:

6.1 Thadi Gaun as Another Potential Site for the Solar Mini Grid

With 105 houses in Lapsibot, the project would be of higher cost than the expected target 30-50 HH. However, with the RM's willingness the project can be initiated with a detailed feasibility study done for the technical aspects to be covered.

Meanwhile, with 19 HHs and SE facing locations, Thadi Gaun can be an alternative potential site for the project. It was said by the local authorities that national grid extension is not planned within the next 5 years in the area. Leaving Thadi Gaun to be by far inaccessible to any other services by governmental or private facilities as well.

6.2 Status of Bhut Khola MHP

Since the plant is completely damaged, it is not feasible to rehabilitate the MHP. Nevertheless, there are existing and functioning T&D lines and some electro-mechanical component as shown in Table 15. Thus, reusing these would save a decent investment as well as be practicable.

With the status, it is a good idea to carry out a feasibility study for rather a new location in the area near the Machhe Khola bazaar. With the presence of streams coming from villages in the uphill, it might be less expensive than rehabilitating the existing one or even having a solar mini-grid in different locations.

6.3 Collaboration With Similar Projects

Group of Helping Hands (SAHAS) Nepal is a non-profit, non-governmental and social development organization that was founded in 1996. The organization has good

experience in working in remote areas and has been focusing on the socially excluded, vulnerable and marginalized groups with several community-based approaches.

One example of SAHAS's work is the **Enhancing Livelihood through Local Efforts (ELLEP)** [16] project that has been implemented in 12 former villages, including Dharche RM. The main objective of the project is to improve socio-economic status by improving food and nutrition, income, health, education, environment condition, and security by providing training (bookkeeping and organizational development training) which would align with our objectives. The project focuses on women empowerment by involving them in pro-active participation in the decision-making process which secured their position in decision making.

Thus, with the perfect alignment, this initiative would be a win-win situation for both organizations to meet the mutual KPIs.

6.4 Potential Wind Power for Keraujabesi

The statistics provided in figures 10 and 11 wind power could be the way to uplift the living status of people of Keraujabesi.

Given that there is no plan on electrification of Keraujabesi any time sooner, and the solar mini-grid is not feasible as the village is a North facing village, a detailed study on Wind Power Potential can be carried out.

6.5 Proposed Income Generating Activities

To summarize, as the project focuses to improve the livelihood of locals, especially women and training and support being part of the project by providing access to clean and affordable energy, following income-generating activities can be suggested:

- **Tourist Guide Training and Centers**
  Being a trekking route to Manaslu and Ganesh II (mountain), a tourist guide could be a good income-generating activity.

- **Training for Skills**
  Training such as knitting and sewing, mobile repairing, stove producers and briquette makers could also remarkably help to the rural women.

- **MSMEs**

  As there are already women doing good business in Machikhola with Hotels and lodge, bakeries were another idea suggested by the Dharche RM's chair-person. Besides, locals were showing the need and demand for grinding and processing mills, furniture manufacturing, to which they are skilled, and electric-ity was found to be the hurdle.

  For example, a small move as blacksmith support would also help the minority of the families to raise their economic status.

- **Poultry and Mushroom Production**

  With the FGD, women were excited about the electrification. Given the electricity, poultry and mushroom would be something women would be interested in using their leisure time.

6.6 Environmental and Social Safeguard

The main principle of the environmental and social safeguard is to ensure all the project actions that have a negative and adverse impact on the environmental and social impact are avoided, minimize, mitigated and offset or compensated. The following mitigation hierarchy is based on the principle.

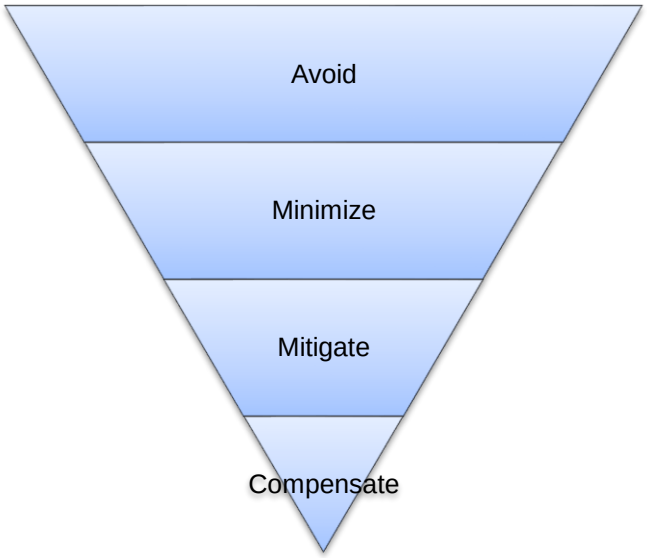

Figure 16. Mitigation Hierarchy based on Safeguard Principle

As per this project, the cultivable land will be avoided if possible. If not, the impacts must be at least minimized and complied with the appropriate social and environmental standards which per need should be discussed with locals to find a solution where the locals agree with. Compensating is the last option which shall not be limited to money but if possible, by compensating with governmental land in return so that it would not minimize the agricultural production of the landowner.

It is recommended to follow the safeguard principles and have the least impact on the environment.[17]

7 Summary and Conclusion

Starting from the desk study, the thesis had several components, meetings with stakeholders, guidance, and study-plan build-up, field visit and result sharing via presentation. Overviewing the objectives and findings, it is safe to say that the field visit was successful. The results were presented among the RERL team.

To summarize based on the findings and within targeted SDGs in Keraujabesi, even though there is a worse socio-economic condition and zero electrification status there, a solar mini-grid is not economically feasible especially due to north-facing location and less solar peak hours. However, wind power can be further studied and could be a good solution. In case of Lapsibot, with our project goal of providing 200kW of solar energy per house on average for existing 105 houses, and with the target to provide electricity for commercial purposes and thus to have a substantial rise in women empowerment, the demand seems high but doable as proposed earlier in this report.

In the nutshell, despite the study here focuses on solar power, micro-hydropower seems to meet the huge demand of electricity in the area targeting at least the major villages, Machhekhola, Lamabesi, Lapsibot, Keraujabesi, and Khanibesi. This is because a solar mini-grid would fulfill the partial demand in any of the particular areas only. Moreover, the study shows that demand is higher than the project aims and in a scattered cluster of different locations.

Meanwhile, the status of Bhut Khola MHP, 65% of the penstock is completely or partially damaged, the powerhouse is completely damaged and most of the T&D lines are also

impaired; therefore, it is irrational to rehabilitate the Bhut Khola MHP. However, an alternative site could be assessed with a detailed feasibility study for power generation.

References

1. World Bank Nepal, viewed on July 2019, <https://www.worldbank.org/en/country/nepal>

2. China Civil Society Portal, *China's Foreign Aid*, viewed on 26 July 2019, <https://www.eu-china.net/upload/pdf/nachrichten/2011-04-21Chinas-ForeignAid-WhitePaper.pdf>

3. UNDP Nepal, viewed on July 2019, <http://www.np.undp.org/content/nepal/en/home/our-focus.html>

4. UNDP 2019, *Sustainable Development Goals,* viewed on 15 August 2019, <https://www.undp.org/content/undp/en/home/sustainable-development-goals.html>

5. NEA Engineering Company Ltd. February 2018, 'Universalizing Clean Energy in Nepal, A plan for Sustainable Distributed Generation and Grid Access to All by 2022', National Planning Commission

6. Santa Bahadur Tamang, 25 June 2019, Phone Call Interview and Nagendra P. Chaudhary, 1 July 2019, Phone call

7. *Collegenp*, Dharche Rural Municipality, Available at: https://www.collegenp.com/institute/dharche-rural-municipality/ (Accessed 23 July 2019)

8. *Gorkha District.* Wikipedia Commons, 19 July 2019, Available at: https://upload.wikimedia.org/wikipedia/commons/9/96/Gorkha_District_.png.

9. Bhandari Y., (2017), District wise details, *District Profile of Gorkha*, Nepal. [online] Available at: https://cbs.gov.np/wp-content/upLoads/2018/12/District-Profile-of-Gorkha-2074.pdf

10. Malla U.N, November (2012), 'National Population and Housing Census 2011', *National report*, Vol.1

11. Magical Nepal, *Manaslu Circuit Trek*, Available at: https://www.magicalnepal.com/trip/manaslu-circuit-trek/ (Accessed 2 August 2019)

12. Global Solar Atlas (2019), Solar data retrieved from https://globalsolaratlas.info/map?r=NPL&c=28.417271,84.124145,7

13. Google Maps. ”Lapshibot, Nepal”. Accessed August 2, 2019, Available at: https://goo.gl/maps/Mukedkgb7YggygT88

14. Universal Consulting Service Pvt. Ltd, March 2019, *Preparation of Detail Project Report for Earthquake affected Bhut Khola MHP*

15. Barefoot College, (2012), *Women Barefoot Solar Engineers of Africa,* Available at: https://www.barefootcollege.org/women-barefoot-solar-engineers-a-community-solution/ (Accessed 4 August 2019)

16. Group of Helping Hands (SAHAS) Nepal 2017, *Annual report 2017,* Sahas Nepal, viewed 5th August 2019 Available at: https://sahasnepal.org.np/cl_uploads/downloads/774657852563_sahas_nepal_annual_report_2017.pdf

17. Council of Europe Development Bank (CEB) 2016, Adopted on 17 November 2016, *Environment and Social Safeguard Policy,* Available at: https://coebank.org/media/documents/Environmental_and_Social_Safeguards_Policy.pdf

Appendix 1: Sudiggaa Report

All Selected 753 sites.xlsx

Province	District	Municipality	Electrification Status	Project Name	Size (kW)	Capital Cost per kW before Subsidy (NPR/kW)
3	Rasuwa	Parbatikunda	PE			
3	Dhading	Benighat Rorang	PE			
3	Dhading	Gajuri	PE	Chyanduri Khola 1	631	403650.35
3	Dhading	Ganga Jamuna	PE	Aphal Khola 1	1000	313676.94
3	Dhading	Jwalamukhi	PE	Chhargandi Khola 1	502	477640.47
3	Dhading	Netrawati	PE			
4	Gorkha	Aarughat	PE			
4	Gorkha	Dharche	PE	Machha Khola 1	994	222869.98
4	Gorkha	Sulikot	PE			
4	Mustang	Dalome	PE	Ghami Khola 2	1000	211577.75
4	Mustang	Lomanthang	U	Chhauma Khola	1000	259048.04
6	Dolpa	Chharka Tangsong	U			
6	Dolpa	Dolpo Buddha	U	Pan Khola	1000	692564.47
6	Dolpa	Jagadulla	U	Jugdula Khola	1000	426468.17
6	Dolpa	Kaike	U	Yalakot Khola	1000	539144.52
6	Dolpa	Mudkechula	U	Dophu Khola	1000	396795.71
6	Dolpa	Shey Phoksundo	U	Pugma Khola 2	1000	492051.15
6	Dolpa	Thulibheri	PE	Lambar Khola	1000	496901.24
6	Dolpa	Tripurasundari	PE	Chu Gad	1000	437844.19

Appendix 2: Calculations for Energy Demand

Project Name:	Thesis_Economic Emowerment of Women in Rural Nepal through Renewable Energy Access_ an initial report
RM	Dharche
Ward No	5: Lapsibot
District	Gorkha
No of HH	105
Location cooedinates	N 28.211546
	E 84.860249
RM Chairperson	
Santa Bahadur Gurung	9779851019353
	santoshlaprak@gmail.com

	Electricity Users	Energy Demand					
		Units	Watts / Unit	Total Watts	Hours / Day	Penetration Factor	Wh/Day
1	**Households**						
	Average per Household						
	Main Room Light, 3 no. in each HH	315	5	**1,575**	5	85%	**6,694**
	Other Lights, 2 no. in each HH	210	3	**630**	5	85%	**2,678**
	Mobile Charging	105	3	**315**	1	100%	**315**
	Radio	85	5	**425**	2	5%	**43**
	TV	32	40	**1,280**	4	40%	**2,048**
	Direct to Home (DTH) Receiver	32	40	**1,280**	4	40%	**2,048**
	Refrigerator	10	90	**900**	5	10%	**450**
	Rice cookers	50	60	**3,000**	1	50%	**1,500**
	Total Household Uses			**9,405**	**1.7**		**15,775**
2	**PEU Demand**						
	Poultry Farm	5	250	**1,250**	12	1.00	**15,000**
	Hotel and Restrurant	3	500	**1,500**	5	1.00	**7,500**
	Carpentry	1	1,000	**1,000**	8	1.00	**8,000**
	Household small scale productions as traditional Muda and carpet knitting, sewing and knitting etc	15	20	**300**	6	1.00	**1,800**
3	**Control-Power House**						
	Lights	5	5	**25**	6	1.00	**150**
	Total for Control-Power House			**25**	**6.0**	1.00	**150**
	Grand Total			**13,480**	**2,536**		**48,375**

PS: Note that the data here are based on the 10HH survey and community discussion. So the data may not be 100% precise.

Appendix 3: Calculations for System design

Design Assumptions

Total no. of sunny days in a year (Nepal)	**365**	
Efficiency of the components and the losses:		
Power Degradation	**0.50%**	per year
Temperature Loss	**8%**	
Series and parallel loss due to the difference in module specifications	**0.50%**	
The efficiency of the inverter	**90%**	
Cable loss	**2%**	
Dust and reflection	**1%**	
Other electronics	**0.5%**	
Battery Ah efficiency	**85%**	
T&D loss	**5%**	
The whole efficiency of the PV system	**61%**	

Total WH / Day →	**48,375**	

Enter the system voltage (12/24/48 or more volts):	48	
Total AH / day =	**1,008**	
Efficiency Corrected Total WH required / day =	**79,289**	
Efficiency Corrected Total AH required / day =	**1,652**	
Enter typical sun hours available at the site of installation:	**4.00**	peak hours
The capacity of Selected Solar PV Module (Wp)	250.00	
Voltage of Selected Solar PV Module (Volt)	24.00	34.08
Current from Selected Solar PV Module	7.34	
Number of Solar PV Module in parallel	56.00	
Number of Solar PV Module in series	2.00	
Size of Solar Array	**28**	

Enter storage capacity of the selected solar battery in AH @ C10:	2000
Enter the output voltage of the selected battery in volts:	2
Depth of Discharge	0.8
Number of Autonomy Days	1.5
Total AH required per day	3097.24
Total Number of Battery in parallel	2.00
Total Number of Battery in Series	24.00
Total number of battery	**48.0**
Minimum Size of Battery (Watt-hour)	**192,000.0**
Short Circuit Current of the Solar Module	7.3
Total Short Circuit Current	410.8
Correction Factor	1.5
Total Short Circuit Current	607.98
Minimum Size of Charge Controller (Amp)	**607.98**
Minimum Size of Charge Controller (kW)	**29.18**
Total Peak Load (Watt)	13480.00
Diversity Factor	60%
Efficiency of Inverter	90%
Factor of Safety	1.1
Power Factor	0.8
DC voltage of the inverter (Volt)	48.0
Minimum Size of Inverter (kVA)	**12.36**

Minimum DC cable Size (sq. mm)	**76.64**
Length of Cable (one way, meters)	20.0

Appendix 4: Questionnaire

1. Information from Benefited Houses

Consent for the interview:	☑Yes ☐No
Contact Details: Gaila Gurung.	
Willing to connect to the solar mini grid	☐Yes ☐No
Date: 5th July.	

Total Family number	Children (0-5 years)	Male	Female
6	5-18 ⇒ 4	1	1

2.1 Ethnicity

Type	Dalits	Tribal (Janajati)	Brahmin, Chetri, Thakuri	Others
				Gurung.

2.2 Education

No of Family member	Literate	Illiterate	Basic/Primary	Secondary education	High school	University level
				2	1.	

Proximity to Nearest School	- 1 km
Proximity to Health center	- 1 hour. distance to Gumda.

2.3 Agriculture

What is the area of land HH own? 3-4 ropani

Agricultural Products	Productivity (tons/m2 or ropani)	Total production
Rice		
Wheat		
Maize	5-6 muri	
Oil products		
Potato	1 muri	
Fruits		
Others		
Banda kauli	5-10 kg.	
Soyabeem.	1 muri.	

2.3.1 Agricultural processing

At home or at mills?

How far?

Cost of Processing:

2.4 Agricultural abundance

Whole year + saving	9-11 months	6-9 months	Less than 6 months
		✓	

2.5 Livestock

Cows and buffalos	Goats or Poultry	Poultry only	None
2		—	—
Quantity:			

2.6 Source of Income

Service	Remittance	Business	Agriculture	Others
			✓	

2.7 Monthly Income

Total HH	NRs > 50.000	NRs 25.000-50.000	NRs 10.000-25.000	< NRs 10.000
			✓	

2.8 Communication

No of Cellphones	X

2.9 Primary Source of lighting

	Dry cells	Solar home system	Kerosene	Micro hydro	Others(specify)
Quantity (per month)		✓	✓		
Cost			100/month.		
If connected to the grid how much they can pay:					
Willingness to pay tariff for new project	☐<50	☐50-100	☐100-150	☐150-200	☐>200

2.10 Primary Source of cooking fuel

	Firewood	Agricultural Residue	Biogas	LPG	Kerosene	Others(specify)
Quantity (per month)	✓			✓		
COST				1200 per cylinder.		

Time spent in collecting: 1 day.

Member involved in collection: Himself.

Collection amount/number per visit: 1 bhari. 1 bhari per day.

2.11 Source of Drinking water

Well water	Community tap water	Rivers and open sources	Private tap	Spring water	Others(specify)
	✓				

Time spent in collecting:

Member involved in collection:

Collection amount/number per visit:

2.12 Household appliances used

Appliances	Rice Cooker	Water Heater	Bulbs	TV	Radio	Mobile	DTH Receiver	Computer/ laptop	Others
Quantity			4						
Power(W)			5W						
Hours per day			6hr.						
Priority for future: 1, 2, 3				1					

2.13 Renewable Energy

Improved Water mills	
Improved cooking stove	✓
Solar cooker	
Solar drinking water system	
Solar Irrigation	

Others:

- How do you utilize their spare time?

Male	Female	Children
- Carpenter. (staff)	- Agriculture	- study.

- If electricity is provided, how would that change? Any ideas on Productive End use of Energy?

Male	Female	Children
-	-	Study.

Comments:

Interview by: Sanjeev.