

**Linkage between Renewable Energy Uses and Rural Livelihood in Dho Tarap
Valley, Dolpa, Nepal**

A DISSERTATION

Submitted to the Central Department of Rural Development
Tribhuvan University, Kirtipur, Nepal
for the Partial Fulfillment of the Requirements of the Degree of
Master of Philosophy in
Rural Development

by

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Declaration

I, Mr. Bibek Kanta Neupane, a student of Master of Philosophy in Rural Development at the Central Department of Rural Development, Faculty of Humanities and Social Sciences, Tribhuvan University, declare that my dissertation entitled “Linkage between Renewable Energy Uses and Rural Livelihood in Dho Tarap Valley, Dolpa, Nepal” is the result of my own research work, except where due reference has been made. This document has not been submitted, published, or printed elsewhere in Nepal or abroad. Additionally, I will not use this dissertation for obtaining any degree other than the one stated above. I also confirm my readiness for the presentation and evaluation of the dissertation at the earliest convenience. I fully understand that if my statement is found to be incorrect at any stage, including after the award of the degree, the University has the right to revoke my MPhil degree.

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This dissertation entitled “Linkage between Renewable Energy Uses and Rural Livelihood in Dho Tarap Valley, Dolpa, Nepal” is submitted by Mr. Bibek Kanta Neupane for the partial fulfillment of the requirements for the degree of Master of Philosophy in Rural Development under my supervision. I am fully satisfied with his work and would like to recommend it for evaluation and acceptance.

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Abstract

This study explored knowledge through understanding the changes brought about in various aspects of rural life by the use of Renewable Energy (RE) in the Dho Tarap Valley, Dolpa. With three specific objectives, the study aims to (i) explore the existing renewable energy practices and their benefits on rural life, (ii) identify enablers and barriers to RE adoption, and (iii) understand the demands for RE usage in the area.

The mixed-method approach with pragmatic philosophical views was employed for the study. Data collection involved both quantitative and qualitative methods, including a household survey, field observations, interviews, and focus group discussions. Primary data from 250 households was collected. Most of the surveyed households relied on traditional fuels for cooking, while the uptake of imported LPG is increasing despite its high cost (approx. NPR 10,000 per cylinder) due to the scarcity of biomass-based fuels, particularly firewood. In terms of electricity, the majority of households have Solar Home Systems. Enabling factors for successful RE implementation include local participation, technological adoption, capacity-building, strong local government, partnerships, market opportunities, and subsidies. However, barriers such as infrastructure limitations, high upfront investment and capital costs, low population density, maintenance challenges, policy obstacles, and harsh climate pose significant challenges.

By addressing these challenges, the sustainable development and use of RE systems can be promoted, ultimately enhancing the livelihoods of the rural population in the Dho Tarap Valley. Access to reliable and affordable energy not only improves daily living conditions but also supports agricultural productivity, economic activities, and overall community well-being, thereby fostering a more resilient and prosperous rural livelihood.

Key words: renewable energy, last-mile, livelihood, participation, sustainability.

Acronyms /Abbreviations

AEPC	Alternative Energy Promotion Centre
Avg.	Average
B.S.	Bikram Sambat
CMSS	Crystal Mountain Secondary School
CO ₂	Carbon Dioxide
CREF	Central Renewable Energy Fund
CSO	Civil Society Organizations
DE	Decentralized Energy
DHM	Department of Hydrology and Meteorology
DPs	Development Partners
eCooking	Electric Cooking
FGD	Focus Group Discussion
FY	Fiscal Year
GoN	Government of Nepal
Ha	Hectare
HHs	Households
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
ISPS	Institutional Solar Photovoltaic Systems
IWM	Improved Water Mill
KIIs	Key Informant Interviews
km	Kilometer
kW	Kilo Watts
kWh	Kilo Watts hour

KWp	Kilo Watts Peak
LG	Local Government
LGOA	Local Government Operations Act
LPG	Liquefied Petroleum Gas
m ²	square meter
m ³	Cubic meter
masl	meters above sea level
MICS	Metallic Improved Cookstove
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoF	Ministry of Finance
MW	Mega Watts
N	Number
NDC	Nationally Determined Contribution
NEA	Nepal Electricity Authority
NGOs	Non-Governmental Organizations
No	Number
NPHC	National Population and Housing Census
NPR	Nepali Rupees
NSO	National Statistics Office
Prof.	Professor
PV	Photovoltaic
Qual	Qualitative
Quan	Quantitative
RE	Renewable Energy
RETs	Renewable Energy Technologies

RM	Rural Municipality
S.N.	Serial Number
SDGs	Sustainable Development Goals
SEforALL	Sustainable Energy for All
SHS	Solar Home System
SMG	Solar Mini-Grid
SPSS	Statistical Package for the Social Sciences
Std	Standard
TV	Television
TWM	Traditional Water Mill
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WECS	Water and Energy Commission Secretariat
Wp	Watt Peak
%	Percent
<	Less than
>	Greater than

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Chapter I

Introduction

This chapter explores the linkage between renewable energy use and rural livelihoods in the Dho Tarap Valley of Dolpo Buddha Rural Municipality (RM) in Dolpa. Essential background information on the study area is provided first, followed by an outline of the research problem, and objectives. Additionally, the significance and delimitations of the study are discussed. The first chapter ends with an overview of the dissertation structure for easy navigation.

Background of the Study

Access to energy remains a challenge in many developing nations. Since ancient times, humans have utilized renewable energy, starting with wood as biomass fuel and progressing to animal fats and vegetable oils for oil lamps in early civilizations (IPCC, 2008). "Renewable energy resources" encompass a wide array of sustainable technologies aimed at harnessing natural resources, mitigating pollution and climate change, and providing affordable services (Twidell & Weir, 2015). Developing a more sustainable energy system is crucial to reduce carbon dioxide emissions. Renewable energy technologies are expected to play a pivotal role in fueling the development of both large and small emerging nations (IPCC, 2008).

The Sustainable Development Goals Report 2023 highlights that 675 million people, mainly in rural areas, lack access to electricity globally. Governments and development partners have launched projects to help off-grid communities (Delloso & Barocca, 2021). Tackling the urgent issues of limiting global warming to 1.5 °C and promoting inclusive socioeconomic development is vital. These challenges should be

addressed together, not in competition. The energy transition aims for independence, affordability, reliability, and efficiency.

The study by Vanegas Cantarero (2020) included expectations for social inclusion, economic growth, and environmental sustainability, particularly in developing countries. The skills, resources (including financial and social resources), and activities necessary for livelihood are together referred to as a livelihood. A livelihood is sustainable if it can withstand stresses and shocks, recover from them, and retain or improve its capacities and assets without compromising the natural resource base (Chambers & Conway, 1992). The key elements in developing green technologies in nations like Nepal are creative subsidies and tax incentives, proper entrepreneurial assistance, strengthened institutional arrangements, and the promotion of community-based groups like cooperatives. Nepal (2012) emphasized that decentralized renewable energy solutions in less developed economies needed to expand rapidly and become more affordable. These necessitated international elements such as large-scale investment and adequate technology transfer.

In Nepal, there is a gradual shift from traditional biomass to commercial and renewable energy sources, such as solar, wind, biogas, and micro-hydropower. Despite abundant potential, only a fraction has been tapped. The Energy Sector Synopsis Report (2022) highlighted micro-hydropower plants generating 38 MW, serving 344,000 households in remote areas. Biogas has potential too, with 1.9 million households suitable for installation, primarily in the Terai and Hilly belts. Wind energy potential stands at 3,000 MW, but only 113.6 kW had been utilized by 2022, with ongoing projects adding 5 MW. Solar and wind hybrid mini-grid systems had reached 1500 kW by 2022, diversifying Nepal's renewable energy portfolio (WECS, 2022).

In December 2020, Nepal submitted its second Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC), outlining targets for reducing greenhouse gas emissions and adapting to climate change by 2030. The NDC aims for a minimum 15% increase in clean energy use and 23% reduction in CO₂ emissions by 2030, primarily through biogas and improved cooking systems (Suman, 2021). The constitution of Nepal has marked a political shift, introducing federalism and decentralized governance. It established a three-tier structure of government (federal, provincial, and local), each with the power to enact laws, prepare budgets, and mobilize resources. Local levels can independently develop projects up to one megawatt (LGOA, 2017).

Access to energy is crucial for societal and economic development. Without modern electricity, efforts to alleviate poverty are hindered, limiting opportunities for income generation and community advancement. Many in remote, economically challenged areas, known as the "last mile," face significant obstacles to energy access due to difficult terrain and low incomes (Bhattacharya, 2012). Sustainable Development Goal (SDG) 7 aims to ensure "access to affordable, reliable, and modern energy for all by 2030," emphasizing the importance of energy access in global development efforts.

Traditional sources remain dominant in the energy sector (fuelwood, agro-residue, and animal waste). However, there is a noticeable shift to commercial energy (coal, petroleum products, and electricity), and the use of renewable energy sources is growing as well. Electricity usage appears to be increasing at a rapid pace nowadays (WECS, 2022).

Around five percent of the Nepali rural population currently lacks access to electricity. This hampers both economic development and access to information and education, particularly in rural areas. Among electrified households, 91 percent have

access to electricity through the national grid, while the remaining seven percent have been electrified through off-grid energy technologies (AEPC, 2022). Nepal Electricity Authority (NEA) and Alternative Energy Promotion Center (AEPC) have agreed to work together by specifying their respective areas of work according to local level selection (MoEWRI, 2022).

The lack of reliable electricity in Nepal is a barrier to the economic growth of the nation. RE systems have emerged as a promising solution to address the energy needs of rural communities, especially in regions where access to modern energy is limited. Dolpa, a remote and mountainous region in Nepal, is one such area where the use of traditional energy sources is prevalent due to the lack of reliable and affordable electricity. The district's predominantly agrarian population heavily relies on natural resources and environmental conditions for their livelihoods, making them vulnerable to the impacts of climate change. Therefore, the potential linkage between renewable energy uses and rural livelihood in Dolpa presents an essential study area to investigate. This study explores the current energy practices, potential demand of renewable energy systems, and their roles on the economic, social, and environmental dimensions.

Statement of the Problem

Renewable Energy Technologies (RETs) such as mini/micro-hydro, solar mini-grids, biogas, improved cooking stoves, solar PV home systems, and solar water heaters are in various stages of commercialization (AEPC, 2024). Despite significant progress in expanding access to electricity, many rural communities in Nepal, especially in the Karnali province, still lack reliable and affordable energy sources (NEA, 2023). Access to renewable energy in Nepal, including hydropower, solar, wind, biomass, and hot springs, holds promise for meeting diverse energy needs. However, their implementation faces challenges in remote rural areas due to weather dependence, maintenance costs, and high

upfront expenses. The benefits of decentralized rural electrification in Nepal, leveraging abundant renewable resources, are hindered by the absence of fossil fuels and the challenging geography for grid expansion (Mainali & Silveira, 2012).

Renewable Energy (RE) has emerged as a crucial element in the sustainable development of rural areas, offering potential benefits in terms of energy access, economic growth, and environmental protection. However, despite these advantages, the integration and effectiveness of RE in enhancing rural livelihoods remain underexplored, especially in remote regions such as Dolpo Buddha RM in Karnali, Nepal. Challenges related to infrastructure, socio-economic conditions, and geographic isolation impedes the successful deployment of RE initiatives, thereby affecting the livelihoods of the rural population (Bhusal, Banjade, & Paudel, 2018).

This study addresses the significant gap in understanding the intersection between renewable energy and rural livelihoods in isolated and marginalized communities. Dolpo Buddha RM represents many similar rural areas in Nepal where conventional energy sources are scarce, and RE could potentially transform the socio-economic landscape. By focusing on this area, the study aims to generate insights that can be applied to other similar contexts, ultimately contributing to broader sustainable development goals.

Addressing the problem of energy poverty in rural areas like Dolpo Buddha is crucial for several reasons. Firstly, it directly affects the quality of life of residents, influencing health, education, and economic opportunities. Secondly, enhancing energy access through RE can contribute to environmental sustainability by reducing dependence on biomass and fossil fuels (Adhikari, Techato, & Jariyaboon, 2024). Thirdly, understanding the socio-economic impacts of RE can inform policy and program design, ensuring that such initiatives is tailored to the needs and circumstances of rural communities. The affected population includes not only the residents of Dolpo but also

similar communities across Nepal and other developing countries facing comparable challenges.

Despite the growing body of literature on renewable energy and rural development, there is a noticeable gap in studies focusing on remote and high-altitude regions like Dolpo. Existing research often overlooks the unique socio-economic and environmental contexts of such areas, leading to a one-size-fits-all approach to RE deployment (Ha & Kumar, 2021). This study aims to fill this gap by providing a detailed analysis of the impact of renewable energy on the livelihoods of residents in Dolpo Buddha RM, considering the specific challenges and opportunities present in this region. The primary objective of this study is to evaluate the impact of renewable energy initiatives on the livelihoods of the residents of Dolpo Buddha RM. The specific impacts and benefits of RE technologies on rural life in Dho Tarap Valley have not been broadly studied. Therefore, this study aims to investigate the role of renewable energy applications in enhancing rural livelihoods and improving quality of life in Dho Tarap Valley, Dolpa using mixed method approach. This study attempts to answer the following research questions:

1. What are the current energy practices and their benefits on rural life in study area?
2. What are the enablers and barriers to the wider uptake of RE systems in the study area?
3. Why is renewable energy development essential to meet the demand for last-mile electrification in Nepal, particularly in remote regions like Dolpo Buddha RM?

Objectives of the Study

The prime objective of this study was to increase the knowledge by understanding the changes brought in various aspects of rural life by RE systems. This study focused to identify the specific benefits that RE applications brought to rural households, such as

improved access to clean and affordable energy, enhanced economic opportunities, and better social and environmental outcomes. Thus, the specific objectives of the study were:

- 1) To explore the existing energy practices and their benefits on rural life.
- 2) To identify the enablers and barriers to the wider adoption of RE systems in study area.
- 3) To find out the demand of RE systems in the study area.

Significance of the Study

This study makes significant contributions to the realm of RE literature and provides guidance for further studies in this specific area. The role of RE systems in remote rural areas of Nepal remains poorly understood. To the best of current knowledge, there is a noticeable gap in research and studies concerning RE technologies and their impact on improving rural livelihoods in remote hills of Nepal. This study holds substantial implications for both the community and individuals adopting RE systems in the study area.

The selection of Dolpo Buddha RM in Dolpa District for this study was strategic because the area heavily relied on farming and raising animals, both vulnerable to climate change and natural disasters. As a researcher, field observations made over ten years ago revealed significant challenges in accessing energy, such as limited mobile phone charging and reliance on traditional sources like dung cakes for cooking and kerosene for lighting. This scenario motivated me to conduct the study to explore how RE applications are being promoted, operated, and supported to improve rural life in Dolpo Buddha RM. Still, the study area lacked a national grid connection. By examining local people's perceptions and site observations, this study aimed to understand how RE uses could support rural life and guide efforts to bring sustainable energy solutions to these communities.

The comprehensive review and empirical evidence generated by this study will serve as a valuable resource for academia and researchers, particularly in the realm of last-mile electrification and its impact on livelihoods. This study aims to help policymakers, investors, and practitioners in Dolpa District understand how to effectively promote and implement the RE systems to support sustainable rural development by highlighting both challenges and opportunities.

Delimitations of the Study

This study is a cross-sectional analysis, specifically limited to the geographical area of Dolpo Budda RM in Karnali Province. The focus on Dolpo RM allows for a detailed and context-specific examination of several key aspects related to RE uses. Firstly, the study investigates the existing energy practices within the community and their benefits on rural life, providing insights into how current energy solutions impact daily living and economic activities. Secondly, it identifies the enablers and barriers to the wider adoption of RE systems in this remote area, shedding light on the factors that facilitate or hinder the integration of sustainable energy solutions. Thirdly, the study assesses the demand for RE systems, evaluating the community's needs and preferences regarding renewable energy.

Theoretically, the study does not encompass all domains of rural areas, as it primarily focuses on selected last-mile villages in Dolpa, particularly Dho Tarap Valley. The survey data relies on perception-based data, and the information obtained regarding income, expenditure, education, and occupation might be skewed because respondents were sometimes reluctant to reveal actual information, even though data triangulation was done. Data limitations affect the scope and depth of the study findings. This study is solely conducted as part of academic research for the fulfillment of an MPhil course in Rural Development. By concentrating on Dho Tarap Valley, the research ensures a

thorough and nuanced understanding of these issues within a specific and unique context, enabling targeted recommendations and interventions.

Organization of the Study

This study is divided into seven chapters. The first chapter covers the background of the study, statement of the problem, objectives of the study, significance of the study, and delimitation of the study. The second chapter covers the literature review of the present study. Basically, the chapter is concerned with theoretical review and empirical review of the relevant literature which is highly correlated with the study and the chapter attempted to review research gap. The third chapter deals about the study methodology. Similarly, the chapter four, five and six discuss on research problems separately. The last chapter seven deals with major findings. Based on the major findings the study provides a summary, conclusion and recommendations.

Chapter II

Literature Review

To ensure that the study is grounded in a well-established theoretical framework and methodologically focused, a literature review on selected subjects related to the study objectives was conducted. Due to the extensive literature available on RE systems and local economic growth, it was not feasible to review all available literature here. The theoretical, conceptual, policy, and empirical literature related to RE uses and their role in sustainable rural livelihoods were reviewed. This encompassed a variety of sources, including journals, scientific articles, newspapers, dissertations, reports, and relevant books. The literature review conducted during the proposal preparation and for the main dissertation is presented below.

Conceptual Review

RE uses have been gaining importance in Nepal due to the country's abundant renewable energy resources and the need for clean energy to meet growing energy demand. Some of the major RE systems in Nepal include:

Micro and mini hydropower: Micro and mini hydropower systems are small-scale hydroelectric power plants that generate electricity by using the flow of water to turn turbines and produce electrical power. Micro hydropower systems typically have a power output of up to 100 kW, while mini hydropower systems have a power output of up to 1 MW (AEPC, 2022). These systems are typically used to generate electricity in remote areas where grid electricity is not available or is unreliable.

Solar Energy: Nepal has a significant potential for solar energy, especially in the mountainous regions where access to grid electricity is limited. The government has launched various schemes to encourage the installation of solar photovoltaic systems, including the provision of subsidies and tax exemptions. Solar power is becoming

increasingly popular in Nepal, particularly in remote areas that are not connected to the grid. Several solar technologies are currently available in Nepal, including Solar Minigrid, Solar Photovoltaic (PV) Systems, Solar Water Heaters, Solar Pumps, Solar Dryers, and Solar Lanterns. Solar PV systems, in particular, have gained significant momentum in recent years, as they are increasingly being used for off-grid electrification in remote and rural areas. Solar Home Systems are small-scale solar power systems that are used to provide electricity for households that are not connected to the national grid.

Wind Power: Wind power has been identified as a potential source of renewable energy in Nepal, particularly in the western hilly part of the country. However, the development of wind power projects in Nepal has been limited due to technical and financial challenges.

Biomass Energy: Biomass energy, such as biogas and biomass briquettes, is another important renewable energy source in Nepal. Biogas plants are widely used in rural areas for cooking and lighting, while biomass briquettes are used as a substitute for fuelwood and charcoal. Similarly, improved Cookstoves and electric cooktops are being promoted in Nepal.

Geothermal Energy: Nepal has a lot of geothermal energy potential, especially in the western part of the country. The main geothermal springs in Nepal are mostly found near the Main Central and south of the Main Boundary Fault. These geothermal springs have been identified in Nepal, mostly located in the banks of Mahakali, Karnali, Tila, Kaligandaki, Myagdi, Marshyangdi, Trishuli, and Bhoté Koshi rivers.

Rural Livelihood: Rural livelihood is shaped by a range of factors, including the natural environment, access to resources, social and cultural norms, and government policies. In many cases, rural livelihood is characterized by a high degree of diversity and complexity, with individuals and households engaging in multiple activities to make ends

meet. Sustainable development initiatives that support rural livelihood often involve a holistic approach that takes into account economic, social, and environmental factors, and engages local communities in the planning and implementation of development activities.

Theoretical Review

One of the main benefits of RE systems is their ability to provide reliable and affordable energy access to rural communities, which is essential for improving their standard of living. The decentralized RE systems can provide energy access to remote communities that are not connected to the grid. The use of RE systems has the potential to bring significant benefits to rural livelihood, including improved access to energy, income generation, and environmental sustainability. However, to realize these benefits, there is a need for concerted efforts to overcome the challenges and promote the sustainable use of RE systems in rural areas. The implementation of RE systems in rural areas faces several challenges. There are several theories and models that can be applied to the development and implementation of RE systems for sustainable rural livelihood. The following are just a few examples of the theories and models.

Community-based Renewable Energy Systems: This approach posits that communities can work together to develop and manage RE systems to improve their livelihood. It emphasizes the importance of community involvement and ownership in sustainable development. The community based renewable energy is a well-liked idea, and people do find the participatory role appealing. Nevertheless, for many rural communities, local ownership of projects may not be a viable choice. A variety of perceptions and interpretations that center on issues of both process (who is responsible for the project) and outcome (who the project is for) has to be addressed as need of the community. The locals in project development or giving people a direct financial stake through cooperative share issues (Walker & Devine-Wright, 2008).

The idea is an evolving and interdisciplinary field that requires a holistic approach to understand the complex social, cultural, economic, and environmental factors that influence the development and success of community-owned RE systems.

Decentralized Energy Systems: This model suggests that small-scale RE systems, such as solar panels and wind turbines, can be deployed in rural areas to provide reliable and affordable energy. It emphasizes the importance of decentralization and the use of local resources in sustainable development. Energy development includes both the advancement of RE sources and the transition from dirty, centralized power generation to clean, decentralized power generation. A study highlights that the advancement toward a highly sustainable future is exacerbated in large part by the development of Decentralized Energy (DE), which is a key component of the energy and economic strategies being adopted globally (Wu et al., 2021).

Several studies have shown that DE systems adoption is not only a function of technological and economic factors, but also social and cultural factors such as community norms, trust, and social networks. The social and cultural factors that might impact the adoption and success of decentralized energy systems.

Energy Access and Poverty Alleviation: This concept focuses on the role of RE systems in addressing energy poverty and improving the livelihood of rural communities. It emphasizes the importance of ensuring equitable access to energy services. The identification of energy-poor households is a necessary step in mitigating energy poverty and maximizing energy efficiency. However, there is a lack of accepted definitions, and it is also difficult to understand the multifaceted concept of energy poverty. The majority of the existing indicators used to describe the phenomenon relies on complex data that is difficult to gather on a large scale and are too generic to be used effectively. They also ignore the impact of significant influencing factors, such as weather, socioeconomic

conditions, local peculiarities, and health and comfort standards (Doukas & Marinakis, 2020). Studies have shown that women and men have different energy needs and use energy services differently, and that energy access might have differential impacts. Hence, the understanding these gender dimensions is crucial for designing effective policies and programs to promote energy access and poverty alleviation.

Environmental Sustainability: This approach emphasizes the importance of environmental sustainability in developing RE systems for sustainable rural livelihood. It highlights the potential for RE systems to reduce greenhouse gas emissions and mitigate climate change. Furthermore, this school of thoughts emphasizes the need to consider the social and environmental impacts of energy systems, and the importance of promoting social equity in the development and deployment of clean energy technologies.

Harrington (2016) study highlights the disproportionate impacts of environmental degradation on marginalized communities, and the need to promote clean energy access for all. The environmental sustainability concept and the relevant determinants are considered during the study period.

Rural Livelihood: This theory emphasizes the necessity for a comprehensive strategy for rural development that considers the many resources and tactics that rural households rely on. Although no single "theorist" for the rural livelihood theory, Gordon Conway, Ian Scoones, and Robert Chambers are some of the major contributors to the discussion. A livelihood is made up of the resources (natural, physical, human, financial, and social capital), the activities they support, and the assessments made on them (facilitated by institutions and social relations), all of which combined to govern the living standards by the individuals or households (Ellis, 2000).

In 1997, the UK Department for International Development (DFID) developed a "Sustainable Livelihood Framework" (SLF) to integrate development cooperation

programs. The SLF is based on Chambers Conway's definition of livelihood, which includes capabilities, assets, and activities needed to make a living. A sustainable livelihood allows individuals to cope with and recover from stresses and shocks, while also maintaining or improving their capabilities and assets for the present and future, without harming natural resources. According to Scoones (1998), the SLF emphasizes a comprehensive and dynamic approach that prioritizes people over resources, recognizing that individuals have inherent potential and strength to overcome challenges and achieve prosperity at both micro and macro levels.

Empirical Review

Many studies have explored the connection between RE uses and rural livelihoods. As the world focuses more on sustainable energy, it is crucial to understand how renewable energy impacts rural life. These studies examine how using cleaner energy sources affects both the energy infrastructure and the lives of people in rural areas. The aim of this review is to investigate study that uncovers the links between RE uses and the livelihood of people in rural settings, particularly in the Dho Tarap Valley of Dolpa District.

The renewable sources contribute significantly to the energy mix but also pose challenges within the power generation system. While the integration of RE has made a notable impact, the reliability of the power system remains a critical factor in achieving de-carbonization objectives. A study reveals that the more literatures require in-depth discussions on the challenges and technological solutions associated with this integration, making the attainment of these targets vulnerable to setbacks (Erdiwansyah et al., 2021). Therefore, the review also emphasizes the necessity for further study to delve into specific needs and enhance transparency in the integration of renewable energy, especially in the study area, to better inform future initiatives.

A study by Dong et al. (2023) highlights three crucial points: firstly, it identifies energy poverty as a primary contributor to the escalating greenhouse effect, emphasizing the urgent need for resolution. Secondly, the study reveals a significant asymmetric effect within the full sample, indicating that the impacts of energy poverty and its determinants vary across different quantiles. Lastly, aside from the direct effect, the study identifies decreasing economic scale, enhancing energy intensity, and promoting the transition of the industrial structure as valid transmission pathways amplifying carbon emissions through the exacerbation of clean fuel poverty. This critical review emphasizes the integral role of addressing fuel poverty in the broader context of achieving carbon neutrality and highlights on the subtle dynamics and varied effects associated with energy poverty and its determinants.

Energy communities play a central role in shaping sustainable settlements. Besides their vital contribution to de-carbonization, they can yield economic and social benefits for the end-users (Dorahaki et al., 2023). RE uses have gained increasing attention in recent years as a potential solution for sustainable rural livelihood. Several numbers of empirical studies have explored the effectiveness of RE systems. The term “Renewable Energy System” refers to various techniques for harnessing renewable energy, transforming it into electricity, gas, or liquid fuel, as well as their benefits and drawbacks. In order to gather and transform energy from non-diminishing natural energy sources, RE systems employ a wide range of technologies (Jenkins, 2019).

Having electricity is important for making life better. Many buildings in cities are connected to a grid for power. But in small and remote villages, it is difficult to connect to the grid because of the rugged topography and remote locations (Kazem et al., 2023). Ammari et al., 2022 study asserts that a robust energy management strategy is indispensable, serving the dual purpose of meeting energy demand and extending the

lifespan of system components. This approach is framed as pivotal in minimizing operating costs, optimizing the utilization of renewable sources, reducing energy output expenses, and shielding components from overload damage.

The study by Buechler et al. (2020) highlights that women play crucial roles as decision-makers and laborers in household and small-scale energy use, actively participating in the adoption of small-scale solar energy technology. While some projects effectively support women in meeting both household and livelihood needs, aligning with broader sustainability initiatives, their success depends on the policy and institutional framework. This agenda significantly influences women's access to training and technologies. Unfortunately, the politicization of funding hampers the impact of certain projects, resulting in a failure to reach the intended populations. In essence, a comprehensive study necessitates a detailed understanding of gender dynamics, institutional contexts, and equitable resource allocation for optimal outcomes.

In recent years, there has been growing recognition that access to modern energy services is crucial for sustainable development. This understanding forms the basis of Sustainable Development Goal (SDG) 7, which aims to ensure universal access to reliable, affordable, and modern energy services by 2030. One of the initiatives supporting this goal is Sustainable Energy for All (SEforALL), an international organization collaborating with governments, the private sector, and civil society to accelerate progress toward SDG 7 and the goals of the Paris Climate Agreement. Nepal, alongside other United Nations members, has committed to the SDGs under Agenda 2030. The Government of Nepal has established an institutional framework and incorporated the SDGs into its 14th Periodic Plan, demonstrating its dedication to achieving these goals. The National Planning Commission of Nepal has outlined national targets for all 17 SDGs, including SDG 7, in its Status and Roadmap: 2016-2030

document. This roadmap sets specific targets for 2019, 2022, 2025, and 2030, with 2015 as the baseline year.

Target 7.1 of SDG 7 aims to ensure universal access to affordable, reliable, and modern energy services by 2030. By 2019, 80.7% of the population had access to electricity, increasing to 99% by 2030. Efforts to reduce reliance on solid fuels for cooking are progressing, with the percentage expected to decrease from 74.7% in 2015 to 30% in 2030. Meanwhile, the use of cleaner fuels like LPG is rising steadily. Target 7.2 focuses on increasing the share of renewable energy in the global energy mix. The renewable energy share in total final energy consumption has grown from 11.9% in 2015 to 50% projected for 2030. Installed capacity of hydropower has also increased significantly, from 782 MW in 2015 to an anticipated 15,000 MW by 2030. Target 7.3 aims to double the global rate of improvement in energy efficiency by 2030. Efforts include increasing the adoption of higher efficiency appliances in residential and commercial sectors, which is projected to rise from 10% in 2015 to 60% by 2030. Similarly, the percentage of electric vehicles in public transport systems is expected to increase from 1% in 2015 to 50% by 2030, contributing to overall energy efficiency gains.

Although expanding the electricity grid is still the most common method of giving access, it is now understood that the national grid is unlikely to reach many remote areas in the near future. Individual solutions, such as Solar Home Systems (SHS), have a tendency to offer consumers very few services. By combining the benefits of grid-based solutions with the potential to harness renewable energy sources locally, mini-grids provide a choice (Bhattacharyya & Palit, 2014).

Rural electrification will encourage young people to reside in their places and participate in productive endeavors like farming and non-farming activities. Moreover,

networks between rural-urban communities and several interactions would be enhanced. The development of small industries would increase the outputs and boost income. So, by strengthening the close relationships between rural and urban areas, youth migration would inevitably come to an end (Melkior, 2018). Experts contend that despite some progress in expanding access to energy, the initiatives are neither sustainable nor adequately boosting development (Bhattacharya, 2012).

According to a study by Cherni et al. (2016), Solar Photovoltaic Systems can produce enough electricity to operate medical facilities, enhance living conditions, and safeguard the environment and atmosphere while also increasing the survival rates of people.

According to recent studies, several developing countries have invested in hydropower projects in an effort to accelerate economic growth. Decisions on the development of the hydropower plan have been made in accordance with global initiatives seeking to reduce the carbon intensity of electricity to accomplish Sustainable Development Goal 7 (SDG-7) on access to affordable and clean energy (Bazzana et al., 2020).

The study by Addis Alemayehu (2015) highlighted that concerns regarding cooking traditions, household finances, health, and the management of agricultural and forestry resources, as well as global greenhouse gas emissions, have become a transformative opportunity to enhance sustainable livelihoods and the environment. More decentralized energy production from renewable sources might be crucial in reducing the use of traditional biomass resources.

Researchers explored alternatives due to energy crises, increased demand, and rural populations in isolated remote areas. They focused on studying local RE sources to find solutions. This change recognized the necessity for sustainable systems to meet

rising energy needs in remote places. The development of local RE systems shows promise in addressing the complex challenges of energy sustainability in those areas (Saini et al., 2022).

Several empirical studies have explored the usefulness of RE systems for sustainable rural livelihood in Nepal. The RE systems such as micro-hydro, solar, and biogas have improved energy access in rural areas and reduced reliance on traditional biomass fuels. Renewable energy sources are crucial for reducing the present energy crisis and can aid Nepal in achieving energy independence by supplying dependable and secure electricity (Poudyal et al., 2019).

The use of RE system is more appropriate for providing electricity in isolated and remote rural areas. Because the RE systems are small, they can be implemented in more sparsely populated rural areas. Subsidies have been proven to improve affordability and facilitate access to energy in scattered rural communities (Gurung et al., 2012). Researchers claim that in addition to being economically viable options, RE systems like solar, wind, and biomass are suitable for remote and rural areas in developing countries like Nepal. The constraints on the development of RE sector are generally categorized as social, policy and political, technological, economic, administrative, and geographic (Ghimire & Kim, 2018).

In Nepal right now, 95% of people have access to electricity. Four percent of them still rely on alternative energy sources other than hydropower, while 91 percent of them are connected to the national power grid. Nepal wants to make sure that renewable energy sources can meet 15% of its total energy needs. Nepal also intends to generate a total of 15,000 MW of electricity by 2030, of which five to ten percent will come from mini- and micro-hydropower, solar, wind, and bio-energy projects (AEPC, 2022). According to AEPC data; nearly a million solar home systems, micro and mini hydropower projects

with a combined capacity of 37.7 MW, 439,547 domestic biogas plants and few numbers of solar mini-grid systems were already installed.

Nepal has more than 60 years of successful experience in the development of household biogas technologies. Despite the fact that Nepal has been promoting biogas for many years with little noticeable technological advancement, there is still a need for indigenous technologies that can handle multiple feedstock and changing ambient temperatures. A household bio-digester is one feasible way to create nutrient-rich digestate (bio-slurry) and a clean energy source (biogas) at the same time (Lohani et al., 2021).

Notwithstanding this progress, a review of off-grid electrification possibilities reveals that there are still several obstacles to scaling up. The main obstacles to the development of the nation's off-grid power sector include a lack of clearly defined policy objectives, poor institutional arrangements, low load factors, a shortage of funding, and general regulatory concerns (Sarangi et al., 2014). In order to make the optimum use of the energy produced by RE-based mini grids, productive local applications required on a sustainable basis. In a rural area, potential consumers show a strong willingness to pay (WTP) for a reliable electricity supply (Timilsina & Steinbuks, 2021).

Climate hazards disproportionately impact disadvantaged communities, increasing their vulnerability. In rural areas of developing countries, climate-induced shifts have redirected livelihoods from agriculture to diversification. However, planned responses to climate change, including adaptation and mitigation, often have adverse effects on rural livelihoods, especially for communities relying on land and forests. The impacts of climate change on mountain livelihoods directly affect agriculture, water resources, livestock, forests and other resources (Piya et al., 2019). Mountain communities are adjusting their livelihoods in response to a complex interplay of social, political, and

economic transformations, along with associated risks. While the recognition of adaptation to various changes is prevalent in sustainable livelihood and crucial climate change literature, the risks linked to the biophysical impacts of climate change are gaining prominence. As a result, diversification is advocated as an adaptive strategy to mitigate these risks (Lama et al., 2019).

The empirical evidence suggests that RE systems have the potential to contribute to sustainable rural livelihood. However, the success of these systems depends on a range of factors, including local context and community involvement, effective policies and financing mechanisms, and appropriate technical design and maintenance.

Relevant Organizations Working in the RE Sector of Nepal

The government's continued support and investment in RE projects is crucial to achieving the country's energy goals while also addressing environmental concerns. The Government of Nepal has launched various initiatives to promote the installation of RE systems in the country. There are several organizations working in the RE sector of Nepal.

Alternative Energy Promotion Centre (AEPC): AEPC is a National focal agency promoting renewable energy technologies in Nepal. After its establishment in 1996, AEPC has been promoting renewable energy systems through different programmes and projects to meet the energy needs of the peoples as well as improving the living standard, increasing employment and productivity, and reducing dependency on traditional energies for the sustainable development. Under the AEPC, various programs and projects have been initiated to promote RE systems in Nepal. The major programs and projects under AEPC include the Scaling Up Renewable Energy Program (SREP), South Asia Sub-Regional Economic Cooperation (SASEC), Renewable Energy for Rural Livelihood (RERL), Promotion of Energy Efficiency and Renewable Energy-Component

2, Promotion of Solar Energy in Rural and Semi-Urban Regions of Nepal, Renewable Energy for Rural Areas (RERA), Micro Hydro Debt Fund, Biogas Credit Fund, Nepal Renewable Energy Program (NREP), and Nepal Private Sector-Led Mini Grid Energy Access Project (MGEAP). Over the past 26 years, AEPC has actively promoted renewable energy through various technological measures in both rural and urban areas, supporting more than 14 million people across Nepal by providing technical support, subsidies, and credit financing. It is important to note that a single beneficiary may have been counted up to four times based on the number of different RE systems provided (AEPC, 2022).

Nepal Electricity Authority (NEA): NEA is a government-owned utility that is responsible for the generation, transmission, and distribution of electricity in Nepal. NEA has been involved in the development of several large-scale hydroelectric projects in the country.

Center for Energy Studies (CES): CES is a research center at the Institute of Engineering, Tribhuvan University that focuses on renewable energy and energy efficiency. The center conducts research, provides training, and offers technical assistance to renewable energy projects.

Winrock International: Winrock International is a non-profit organization that works on environmental and social issues. It has been involved in several RE projects in Nepal.

Practical Action: Practical Action is a non-governmental organization, it has also implemented several RE projects in Nepal, including the installation of Improved Cook Stoves and Solar Irrigation PV Pumping Systems.

International Centre for Integrated Mountain Development (ICIMOD): ICIMOD is an intergovernmental organization that focuses on sustainable mountain

development in the Hindu Kush Himalaya region. It has been involved in various RE projects in Nepal, including the installation of solar water heaters and the development of biomass briquettes.

The abovementioned organizations are just a few examples of the many groups working in the RE sector in Nepal. Their work is crucial to the development and promotion of RE system in the country.

Policy Review

As a worldwide commodity and the basis of socioeconomic progress, energy is crucial. Access to clean; inexpensive energy has continued to be a major discussion point, given the role that energy plays in the economy and general well-being of society. International negotiations may be able to alter the emphasis of climate change financing in favor of adaptation in exchange for policy changes in developing countries that will improve mitigation. Future negotiations should center on new financial structures because there is little evidence that mitigation-related finance having wider implications on energy production. Aid agencies should also concentrate their efforts on reforming regulatory requirements to encourage private investment (Buntaine & Pizer, 2014).

In Nepal, the seventh plan (1985-1990) included alternative energy in the framework for national planning and enacted a policy to support alternative energy sources. The plan developed a working policy of using the private sector and giving customers grants or loans for efficient marketing of such technologies in order to achieve the policy aims. The subsidy was first introduced for RE technology. Following the restoration of democracy in Nepal in 1990, the eighth plan (1992-1997) serves as the first program of the country's democratic government. The plan maintained the alternative energy agenda set forth in the preceding plan and recognized the necessity of establishing an alternative energy agency to carry out and coordinate various projects linked to energy.

The development of rural energy was acknowledged by the Ninth Plan (1997-2002) as a way to improve employment opportunities with the goal of building economic foundations, improving rural living standards, and maintaining environmental sustainability. To collect and maintain information on renewable technology, the plan established the AEPC. In the interim, the plan also adopted a policy to institutionalize AEPC as the focal agency for development of alternative energy in Nepal and envisioned decentralized energy planning. The tenth plan (2002-2007) embraced a long-term vision of speeding economic development, expanding employment possibilities, and maintaining environmental sustainability.

The RE sector had acquired the required institutional, organizational, and execution foundation for its implementation in Nepal by the time the Three-Year Interim Plan (2007-2010) was developed. Sectoral targets for various forms of renewable energy were established. More significantly, the Central Renewable Energy Fund (CREF) was designed to be established for the efficient and long-term development of rural energy. The three-year plan (2010-2013) set a long-term objective to ensure that 10 percent of the energy mix would come from renewable sources so that 30 percent of the population would have access to power.

The research, development, and management of energy efficiency measures in renewable energy technologies were all part of the Thirteenth Plan (2013-2016). The goal of the 14th periodic plan (2016-2019) was to provide electricity from solar, hydro (small and micro), and wind resources to an additional 9% of the population. The 14th plan also sought to promote 1.065 million units of upgraded cooking stoves and 0.2 million units of biogas digesters. The GoN had implemented the fifteenth plan during FY 2019/20 and through FY 2023/2024. The plan aimed for a 12 percent contribution of renewable energy in the total energy. According to NPC (2023), the Approach Paper of the 16th Five-Year

Periodic Plan (2024/25-2028/29) has been prepared and will more focus on strategic development.

The Constitution of Nepal has introduced federalism as the foundation of its political governance and established a governmental structure consisting of federal, provincial, and local levels. The local level governments have been given the responsibility of implementing RE and other local development projects. The Constitution has also emphasized the importance of RE as a crucial development priority. With the aim of achieving universal energy access by 2030 and meeting internationally agreed goals such as Sustainable Energy for All (SEforALL), Sustainable Development Goals (SDG), Nationally Determined Contributions (NDC) related to the Paris Climate Change Agreement, and national Periodic Plans, there is a significant opportunity for the further development of RE in Nepal.

The key message of Nepal's Energy Sector Vision 2050 is to ensure access to reliable, affordable, and sustainable energy for all Nepalese people. The vision aims to develop a diversified energy mix that includes renewable energy sources, such as hydropower, solar, wind, biomass, and others, to meet the increasing energy demand of the country. The vision also highlights the need for modernizing the energy infrastructure, improving energy efficiency, and promoting energy conservation. Additionally, the Energy Sector Vision 2050 emphasizes the importance of regional energy integration and cooperation to enhance energy security and foster economic growth. Overall, the vision sets out a comprehensive strategy for Nepal to achieve energy security and sustainability in the long term.

The Constitution of Nepal ensures that the government will take the policies relating to protection, promotion and use of natural resources (Part 4 Article 51 g). The constitution directed that the government will take the policy to ensure reliable supply of

energy in an affordable and easy manner, and make proper use of energy, for the fulfillment of the basic needs of citizens, by generating and developing renewable energy. This has mandated the government to develop and implement the policies and strategies related to renewable energy promotion in the country.

Recently, GoN has brought revised Renewable Energy Subsidy Policy 2022. The overall goal of this subsidy policy is to ‘contribute to rural poverty reduction and environmental conservation by ensuring access to clean, reliable and appropriate energy in the rural areas. Its objectives are to reduce dependency on traditional energy, increase employment and productivity and the living standards of the rural population. The revised policy mainly focuses on gradually replacing subsidy by credit in the long-term. Similarly, it focuses on further scaling up of RETs and achieving the objectives of the UN's “Sustainable Development Goals” and “Sustainable Energy for All”. The subsidy to be provided for the construction and installation of different RE systems as per the Renewable Energy Subsidy Policy, 2022 shall be disbursed through the CREF on the recommendation of AEPC. The GoN and various Development Partners have been providing financial and technical support to increase access to clean energy. The Renewable Energy Subsidy Policy 2022 has supported in bringing down costs of RETs, ensuring quality and increasing beneficiary trust on technologies. But majority of the population living in the rural areas under poverty level remain without access to clean energy have been deprived of basic energy solutions due to high initial upfront cost of the RE systems (MoEWRI, 2022).

Because of its extreme poverty, high rate of illiteracy, social inequality, and reliance on natural resources for existence, Nepal is particularly vulnerable to the consequences of climate change. Nepal, a party to the Paris Agreement on Climate Change, has already submitted the schedule for its Nationally Determined Contributions

(NDC). At a time when Nepal has ratified the Paris Agreement, Sustainable Development Goals, and Sendai Framework for disaster management, the National Climate Change Policy 2019 was envisioned to make the most of the opportunities for financial, technical, and other types of assistance through the framework of conventions for the purpose of managing climate change in line with the national priority and local needs while adhering to international obligations (NLC, 2020).

Methodological Review

RE systems have been identified as a key component for sustainable rural livelihood, as they can provide access to clean energy and promote economic development. This methodological review aims to provide an overview of the methods used to assess the implications of RE systems on rural livelihood, as well as to identify gaps and areas for future research.

Small-scale and community-based renewable energy initiatives in particular are acknowledged as significant development aid strategies for assisting those who lack access to energy. The standardized evaluation offers useful insights on the underlying variables that contribute to the success or failure of these small-scale local energy interventions. These conditions include renewable energy sources (solar, wind, biomass, hydro), user needs (electricity, food preparation, lighting, productive uses), community management models, finance mechanisms, and geographic locations (Terrapon-Pfaff et al., 2014).

The Sustainable Rural Livelihood Framework can be used to analyze rural livelihood results at various scales, including individual, household, household cluster, extended kin grouping, village, province, and even country. So, it is crucial to specify the scale of analysis and examine how different levels interact in terms of net livelihood consequences, both positive and negative. The idea of sustainable livelihood is a

combination of numerous concepts and viewpoints, bringing together a variety of distinct development discussion forums. The term is always a negotiating point, and it is a crucial understanding. Consequently, it is necessary to continually be aware of inconsistencies and trade-offs between various components of the composite definition. The priority indicators will inevitably be viewed in various ways, and where conflicts are highlighted, decisions must be made. The framework can be applied to study at various scales, which may expose certain important dilemmas and trade-offs (Scoones, 1998).

Research Gap

Numerous literature sources are available that highlight on the scope of RE systems and their impact on rural livelihoods. Various theoretical concepts and methodologies exist for the study of both RE systems and sustainable livelihoods. However, there is a notable scarcity of literature specifically addressing the linkage between RE uses and rural livelihoods in the upper Dolpa area. After an extensive review of the vast literature, a comprehensive understanding of different RE sources and their associated technologies was attained. Theoretical concepts related to decentralized energy systems, community-based RE systems, energy access and poverty alleviation, environmental sustainability, and rural livelihood were critically examined. Additionally, the most recent scientific articles pertaining to RE systems and livelihoods were empirically reviewed.

Throughout the literature review, various programs and projects aimed at promoting the RE sector in Nepal were identified. Moreover, the history of RE sector development in Nepal, including national periodic plans, strategies, different acts, the current RE Subsidy Policy for 2022, and other pertinent documents, were scrutinized. Based on the available literature and accessed information, this study for the particular area can serve as a foundational document for academia and policymakers to some extent.

Karnali Province is one of the most remote and underdeveloped regions in Nepal, with a large portion of the population living below the poverty line. RE systems have the potential to improve the livelihood of rural communities in the Province, but there are several key research gaps that need to be addressed. There are not sufficient empirical studies to enhance knowledge by understanding the changes brought about in various aspects of rural life by RE systems.

There was a need for more pragmatic research that explores the specific ways in which RE systems influence the daily lives of rural people, such as changes in household chores, time use, and economic activities. While some studies have identified factors that influence the adoption of RE systems in other contexts, there was a need for more context-specific study on the factors that influence the adoption of RE systems in the study area, which is a remote and underdeveloped region. Furthermore, there is a need for study that examines the institutional and policy frameworks that shape the development of RE for last-mile electrification, and identifies strategies for overcoming barriers to implementation. The unanswered few questions are explored under this study. This study primarily focused in Dolpo Buddha RM where many ideas are to be explored yet.

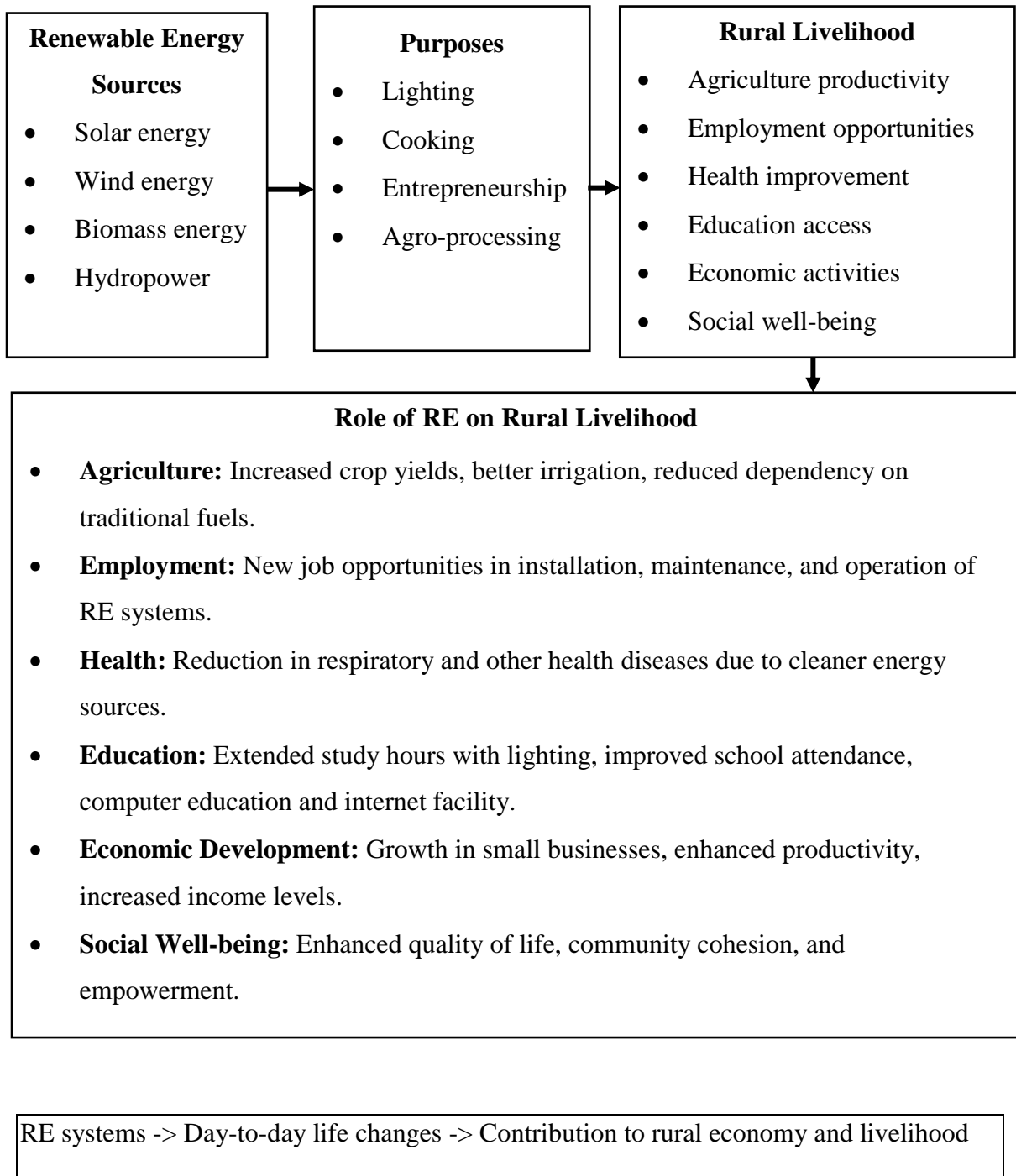
Conceptual Framework

The theoretical lens of this research is the Sustainable Livelihood Framework (SLF), which provides a comprehensive approach to understanding how renewable energy systems impact rural livelihoods (DFID, 1999). In this study, renewable energy applications such as solar power, wind energy, biomass energy, micro-hydro power, and energy efficiency technologies are examined for their role in enhancing various capital assets integral to rural livelihood. By aligning with the SLF, the framework illustrates how these renewable energy systems contribute to improved human capital through better health and education, social capital through community development and social well-

being, natural capital through increased agricultural productivity, physical capital by supporting infrastructure for economic activities, and financial capital by creating employment opportunities and stimulating economic activities. The linkages between renewable energy uses and rural livelihoods reveal a pathway to sustainable rural development, showcasing the transformative potential of clean energy solutions in enhancing the quality of life, economic stability, and social cohesion in the Dho Tarap Valley, Dolpa.

Figure 1

A Conceptual Framework for the Study



The framework suggests that the adoption of RE systems in study area can bring about changes in the daily lives of rural people, contributing to the rural economy and livelihood.

Chapter III

Methodology

This chapter provides an in-depth explanation of the research methodology used in this study, emphasizing the importance of methodological choices in maintaining the reliability and validity of the study outcomes. It details the philosophical perspective, approach, design, data collection techniques, and analytical methods applied to address the research questions and objectives. By thoroughly presenting the methodology, this chapter ensures a clear understanding of the systematic process followed to collect, analyze, and interpret data, thus upholding the study's strength and credibility.

Philosophical Standpoint

The philosophical standpoint of this research on the linkage between renewable energy uses and rural livelihood in Dho Tarap Valley, Dolpa, is rooted in pragmatism. Pragmatism, as a philosophical approach, emphasizes the practical application of ideas by acting on them to test their validity and examining the outcomes to understand their implications (Creswell & Creswell, 2018). This approach is particularly suited to the study as it focuses on real-world applications and solutions to address the challenges and opportunities associated with renewable energy systems in rural settings.

Pragmatism does not demand adherence to any specific methods or tools, allowing for a flexible and adaptive research design that can incorporate both qualitative and quantitative techniques as needed (Morgan, 2014). The primary objective of this research is to explore the existing energy practices and their benefits on rural life. This entails a practical investigation into how current energy sources are utilized and their impact on various aspects of rural livelihoods, such as agriculture, health, education, and economic activities. The pragmatic approach allows for a thorough examination of these practices through empirical data collection and analysis, providing a concrete understanding of

their effectiveness and areas for improvement. The second objective is to identify the enablers and barriers to the wider adoption of renewable energy systems in the study area. By adopting a pragmatic lens, this research aims to uncover the practical factors that facilitate or hinder the implementation of renewable energy solutions. This involves assessing the socio-economic, cultural, and infrastructural contexts that influence the adoption process, providing actionable insights that can inform policy and decision-making. The third objective is to find out the demand for renewable energy systems in the study area. This requires a practical assessment of the community's needs and preferences regarding energy solutions.

By engaging with local stakeholders and gathering data on their energy requirements and aspirations, this research aims to provide a realistic evaluation of the demand for renewable energy systems, thereby guiding future interventions and investments.

Research Design

The research design refers to the overall strategy that the researcher chooses to integrate the different components of the study in a coherent and logical way, ensuring relevance to the study purpose and procedures to effectively address the research problem. This study employed a mixed-methods approach, dominantly quantitative and applied through a sequential exploratory approach. Therefore, the research design is both descriptive and analytical because it aims to determine the status of the RE sector and how it influences rural livelihoods in last-mile communities. Following Creswell and Plano Clark's (2011) recommendations, this mixed-method approach was chosen for several reasons:

- The research problems encompass both subjective and objective realities, including perceptions, experiences, and practices related to opportunities and

challenges, energy access, employment creation, social benefits, economic development, and livelihoods.

- Triangulation of the results, both during data gathering and analysis, was achieved by employing tools from both qualitative and quantitative methods.

The mixed research design involved collecting quantitative data on the adoption and use of RE systems and qualitative data on the experiences and perspectives of rural households who have adopted these systems. To systematically present the collected data during the study, a descriptive research design was employed. This design provided a comprehensive description of various aspects of the available data and information. The study relied mainly on primary information and to a lesser extent on secondary information to fulfill its objectives. All the results and outputs are presented in tables and suitable diagrams, such as bar charts, pie charts, and line graphs, to make the information more visible and easily understandable.

Rationale of Study Area Selection

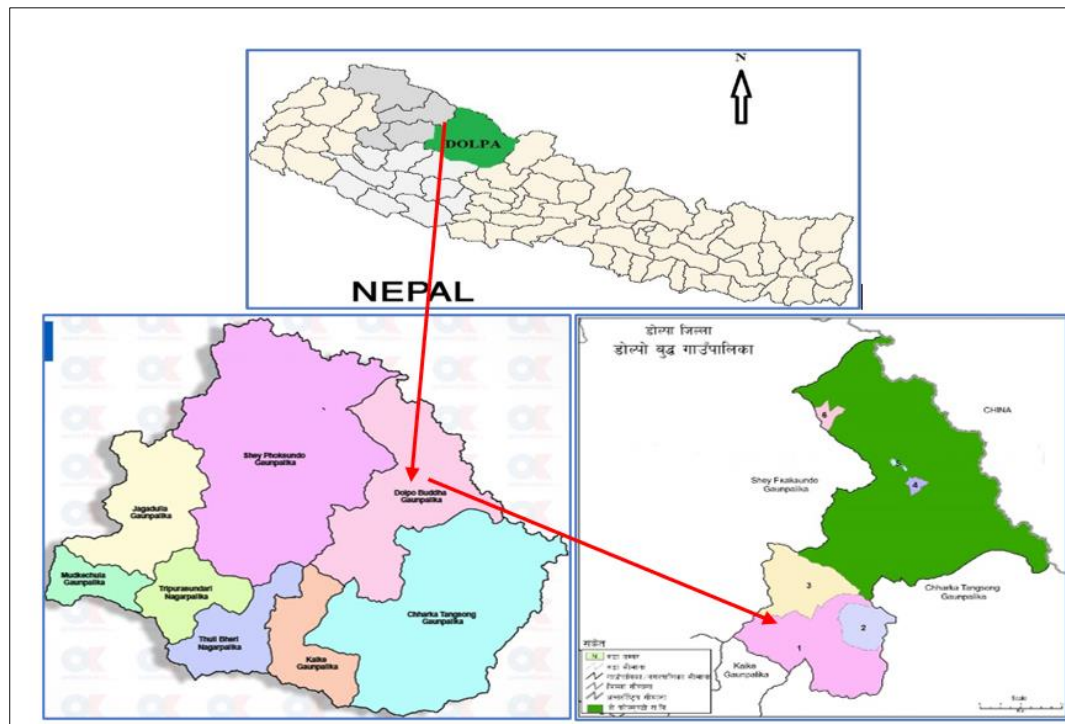
Dolpo Buddha RM was established in 2017 (B.S. 2073) as a local government of Nepal. It is situated in Dho Tarap valley, in the High Mountains physiographic region of Dolpa District, Karnali Province, at an average altitude of 4,150 meters above sea level. This RM is geographically situated in the northern part, bordering Tibet of China, Chharka Tangsong RM and Kaike RM to the south, Mustang District and Chharka Tangsong RM to the east and Shey Phoksundo RM to the west. The total area of this RM is 377.38 square kilometers and it comprises 6 Wards.

The total population of Dolpo Buddha RM as reported by the RM office is 2,045, and it comprising 543 households. The primary source of livelihood in this area is subsistence agriculture, including livestock rearing and rain fed cultivation. To reach this location, one must take a foot trail from Dunai, which takes approximately three days to

cover a distance of about 80 km. The Dolpo Buddha RM is not connected to the national grid. The researcher chose it for the study because he believed the RM relies heavily on RE systems for electrification and other purposes.

Figure 3

Map of Dolpa and Dolpo Buddha RM



Source: Shey Phoksundo National Park, 2022.

Nature and Sources of Data

In this study, the nature and source of data encompass a combination of both qualitative and quantitative data. Both primary and secondary sources of data are used to collect the information required for the study. This study mainly based on primary data collection in Dho Tarap valley of Dolpo Buddha RM. All households in the selected wards were queried to respond a brief structured questionnaire to collect information. The primary information was collected during the field survey in June and July 2023 with help of a questionnaire, interview and field observations. To collect the qualitative

information, key informant interviews and FGD were conducted with those who provided their opinion on different subtopics.

Similarly, the secondary information was collected from all the materials related to the RE promotion in upper Dolpa region such as books, journals, newspaper, published and unpublished reports and web portals. The relevant data were also collected from various sources: National Statistics Office (NSO), AEPC, NEA, Ministry of Finance/Economic survey, Water and Energy Commission Secretariat (WECS), and other sources which are perceived to be relevant and reliable.

Universe, Sampling Procedure and Sample Size

In my study exploring the linkage between renewable energy uses and rural livelihoods in Dho Tarap, a valley within the Dolpo Buddha RM of Dolpa District, Karnali Province, Nepal, I opted for a complete enumeration, also known as a census approach, due to the village's relatively small population size (268 households). This method aimed to gather data from all households for a comprehensive understanding of the area's socio-economic conditions.

The Dolpo Buddha RM office provided population data (110 in Ward 1, 33 in Ward 2, and 125 in Ward 3), which, despite minor discrepancies with the NHPC 2021 report by the NSO Office, was considered reliable for this study.

While attempting a complete enumeration, limitations arose. Eight households were inaccessible due to geographical constraints, four households declined participation, and six consisted solely of elderly individuals and children who might not accurately represent decision-making regarding renewable energy adoption. These limitations are acknowledged. Despite these exclusions, the final data collection included 250 households, representing a significant portion of Dho Tarap's population and offering valuable insights into the local context.

The census approach aimed to achieve a high degree of accuracy by including almost the entire population (250 out of 268 households). The comprehensive data provided a deeper understanding of the role of renewable energy on rural livelihoods in Dho Tarap. However, the data collection, especially in remote areas like Dho Tarap, was resource-intensive and time-consuming due to the effort required to reach all households. The census approach, though faced with limitations, allowed for a detailed examination of the relationship between renewable energy uses and rural livelihoods in Dho Tarap Valley, one of the world's highest human settlements.

Data Collection Methods, Techniques and Tools

For the study, the primary data collection tools and the sampling design on the basis of specific objectives (as specified in Chapter 1; Section 1.3) have been summarized in the Table 1 discussed in detail in the following sections.

Table 1

Summary of Methodological Approach for the Study

The Approach and Design		Rationality and Operationalization	
Research design: Mixed (QUAN-Qual)		Objective and Subjective realities, perceptions, experiences and practices	
Data collection tools to be employed			
Quantitative	Individual Survey	250	Census
	Semi-structured interviews	15	Purposively selected
Qualitative	KIIs	12	LG persons, Key persons of social/public institutions
	FGD	1	Women group/marginalized people
	Field Observation Notes	-	As required

Quantitative Tools

Questionnaires and checklists were prepared. The questionnaire was pre-tested on May 23, 2023 to ensure a complete understanding of the survey guidelines and to identify foreseeable problems that may occur during the field visit. After finalizing all tools/methodologies, the researcher, along with data enumerators, mobilized to conduct field surveys in the selected RM.

The research team initially visited the RM office to gather precise information on the number of existing households within Dho Tarap Valley. Following the census approach, households were visited for the survey purpose in each selected ward. In cases where an eligible respondent (aged 16 and above) was absent in a visited household, the survey team promptly moved to the next household nearby to ensure the smooth operation of the survey. The field assessments, including the household survey, were conducted from June 10, 2023, to July 15, 2023. Similarly, a thorough check of the questionnaires filled out by the enumerators was conducted during the field survey, and any inconsistencies were corrected immediately.

A structured questionnaire was administered to the respondents during the household survey. The questionnaires were administered to either the head of the family or the primary cook person of the household. In the absence of both, other matured family members were interviewed. A survey covered a total of 250 households aiming to gather information on various aspects, such as the socio-economic conditions of sample households, motivational factors, user satisfaction, gender roles, implications of RE systems, and more.

Qualitative Tools

The following tools of qualitative were endorsed to collect the primary data along with open ended questionnaire.

Semi Structured Interviews: For this study, a semi-structured interview approach was employed to gather in-depth insights from participants. A purposive sampling method was used for the selection of participants, who possess relevant knowledge and experience regarding the role of RE uses on rural livelihoods in the Dho Tarap Valley, Dolpa, Nepal. This sampling technique ensured that the chosen participants could provide rich, detailed information aligned with the research objectives. Participants included local community members, renewable energy experts, and stakeholders involved in the implementation and utilization of renewable energy systems. This approach facilitated the collection of diverse perspectives and comprehensive data essential for understanding the multifaceted impacts of renewable energy on the local community.

Key Informant Interview (KII): Key informant interviews were employed to obtain relevant and realistic information for the study. A key informant interview is a loosely structured conversation with individuals who possess specialized knowledge about the topic. This method was particularly used to gather information about the experiences of local beneficiaries and sector experts. Key social leaders, local elected representatives and energy experts were also included in the KIIs. These KIIs were conducted with elected representatives of Dolpo Buddha RM, the Senior Chief Conservation Officer of Shey Phoksundo National Park, Lama Gurus, local entrepreneurs, Amchi Gurus, school teachers, AEPC persons and other relevant individuals.

Focus Group Discussion (FGD): The purpose of conducting Focus Group Discussions (FGD) was to utilize a specified checklist to obtain more in-depth, detailed, and interactive information on various aspects of RE systems and their

implications for sustainable rural livelihoods. The researcher prepared tools and a guideline to facilitate FGD with local beneficiaries.

The FGD participants represented a diverse group in terms of caste/ethnicity and employment/entrepreneurial backgrounds. FGD played a key role in collecting information and perspectives on various factors related to socio-economic development, including livelihoods, income generation, entrepreneurship, and contributions to local economic development. Only one FGD session was conducted in a public place at the Dolpo Buddha RM office premises, involving 12 participants in a group.

Field observations and notes: Observations made during the field visits, focus group discussions, and key informant interviews were promptly noted in the field notes. Relevant photographs and audio/video recordings were also captured with the consent of the respondents/participants.

Reliability and Validity

The reliability of this study was ensured through rigorous research methodologies and careful data collection processes. Using both primary and secondary data sources confirmed the dependability of the findings. The primary data, gathered directly from the field study in Dho Tarap Valley, Dolpa, through methods like questionnaires and face-to-face interviews, added to the authenticity of the research. This systematic and transparent approach to data collection increased the reliability of the information, making it possible to replicate the study under similar conditions.

The validity of this study was grounded in the research design and its alignment with the study's objectives. The research questions were carefully crafted to capture the nuances of the relationship between renewable energy use and rural livelihoods in the specific context of Dho Tarap Valley, Dolpo Buddha RM, Dolpa. Validity was ensured

through the careful selection of participants, focusing on primary cooks and women's groups to provide relevant insights. Diverse perspectives were included by selecting participants from various backgrounds within the study area. Triangulation was used by cross-verifying focus group discussion data with surveys, interviews, and secondary data from various sources, including the RM office.

Methods of Data Analysis and Interpretation

The results are interpreted using various data collection methods. The data were processed in an academic manner using a computer and other data analysis tools. Using statistical tools from SPSS or EXCEL, additional procedures like editing, coding, processing, and tabulation were also used to analyze and interpret the collected data. Relevant data are displayed with the aid of tables, charts, and graphs. Thematic words and concerns were transcribed and coded in order to examine the qualitative data.

In this study, some tabular analyses were done for processing and analyzing the data. Simple statistical methods such as mean, range, and percentage were used for the analysis of quantitative data, whereas descriptive method is used for the analysis of qualitative data. However, information gathered and findings from the field study are presented through appropriate graphics (diagrams, photographs, etc.). The qualitative data was used in structured argument and interpretation.

Ethical Considerations

Ethical considerations are particularly significant in the field of social science. Sharing information about a respondent with others for purposes other than study was strictly avoided, meaning that information was collected without revealing its source (Kumar, 2005). Consent was obtained before conducting interviews and before recording personal information for analysis. Participants' personal information was kept confidential, and measures were taken to ensure their anonymity in any published or

disseminated study findings. The researcher was sensitive to the cultural norms and practices of the local community, working to build relationships of trust and respect with community members. Care was taken to ensure that vulnerable or marginalized groups were not exploited or unfairly targeted. As a researcher, all processes complied with relevant ethical guidelines and regulations for the protection of human subjects, including obtaining necessary approvals and permissions from relevant authorities.

Chapter IV

Existing Energy Practices and Their Benefits

This section focuses on analyzing the importance of RE uses in the day-to-day life of rural people. It presents a comprehensive assessment of the changes that have occurred in various aspects of their lives following the implementation of Renewable Energy Technologies (RETs). The availability and utilization of energy resources in rural areas play a pivotal role in shaping the socio-economic landscape and overall well-being of the communities residing in the Upper Dolpa region. Understanding the prevailing energy sources and their impact on the daily activities of rural inhabitants is essential for fostering sustainable development and addressing the unique challenges faced by these areas. The section observes the relationship between current energy practices and their benefits to the rural people.

Socio-economic Characteristics of the Study Area

In the realm of rural development, a profound understanding of the socio-economic dynamics within a study area was paramount for devising real strategies that catered to the needs of its inhabitants. This subchapter deals with general characteristics of respondents, which include demographic, social and economic characteristics of surveyed households. A variety of primary data was obtained during the field visit, providing significant insights into the complex social structure.

Settlement Patterns

Dolpo Buddha RM of Dolpa District consists of several villages and toles scattered across its diverse geographical terrain. The settlements are dispersed, with houses and farms scattered across the slopes, a reflection of the region's agricultural essence, where families engage in subsistence farming on their own lands. Conversely, valleys and plains feature clustered settlements, forming small villages or market center.

These settlement patterns are shaped by various factors such as access to water sources, agricultural land, and transportation routes. In essence, the settlement patterns in Dolpo Buddha RM exemplify a harmonious integration of local inhabitants with the surrounding natural environment, fostering social cohesion and supporting economic activities within the local community.

Types of Houses

Understanding the types of dwellings and roof structures can provide essential information about the community's living arrangements, cultural customs, and financial status. These architectural characteristics are not merely physical structures; they also represent the people's way of life, historical customs, and adaptation to the environment.

The National Population and Housing Census (NPHC), 2021 report reveals that the majority of households in Dolpo Buddha RM, which is 543 in number, have houses with a foundation made of mud bonded with stones. This traditional construction method is common in rural areas and represents an essential aspect of the cultural heritage and historical practices in the Himalayan region.

Out of the total 250 households surveyed, 245 were found to have walls made of stone. The remaining five households were observed to have walls made of concrete. The presence of concrete walls indicates some level of urban influence or access to modern construction methods and materials for those particular households. A 60-year-old male respondent mentioned that

Due to climate change and varying weather patterns, people in mountainous regions are increasingly opting for concrete structures. Traditional mud-and-stone houses are no longer effective against the more frequent bouts of rainfall and droughts, compelling locals to seek alternative options (concrete structures).

Table 2*Number of Households by Type of Materials Used for the Walls*

Type of Wall of the		
House	Number	Percentage (%)
Concrete Wall	5	2.00
Stone and Mud Wall	245	98.00

Source: Field Survey, 2023.

Similarly, the prevalence of mud roofs (245 households) showcases adherence to traditional building methods, while the presence of galvanized sheet roofs (5 households) indicates some level of modernization and access to alternative roofing options within the area.

Table 3*Number of Households by Type of Roof of Housing Unit*

Type of Roof Used at		
House	Number	Percentage (%)
Corrugated Sheet	5	2.00
Mud and wood	245	98.00

Source: Field Survey, 2023.

Demography

According to the census data (2021), with a total population of 2420 individuals, the male population accounts for 47.4%, while females make up 52.6% of the total. The sex ratio is reported as 90.25 males per 100 females, indicating a slightly higher proportion of females in the population.

Gender

Initially, the researcher and survey team made purposive efforts to interact with more than fifty s of women. However, they were only able to attain nearly 25 percent of

female respondents. As a result, male respondents still dominate the survey inquiry process. Out of the 250 households surveyed, only 62 respondents were female.

Table 4

Gender Composition of Surveyed Respondents

Gender of Respondents	Dho Tarap Valley	
	N=250	Percentage (%)
Male	188	75.00
Female	62	25.00
Total	250	100.00

Source: Field Survey, 2023.

The Table 4 the skewed gender distribution indicates that males are the primary source of survey information in the rural community of Dolpo Buddha RM. Such a pattern may be attributed to cultural norms, where males typically engage with outsiders more frequently, while females may not participate in such interactions as often.

Family Size and Age of Household Head

Understanding the composition and age distribution of household heads sheds light on surveyed households. In this study, a household head was defined as the individual responsible for household affairs. The average household size, 5.94 persons, slightly exceeds the national average of 4.37 persons per household.

Table 5

Average Size of Family and Female Headed Households

Average Size of Family	
Surveyed results	National Average
5.94	4.37
Female headed households	
Surveyed results	National average
17.86%	31.55%

Source: Field Survey, 2023 and NHPC, 2021.

Female-headed households accounted for 17.86%, lower than the national average of 31.55%, as per the NPHC 2021 census report by the NSO. Most of the household head (93.20%) fell within the 18 to 70 age range, indicating a predominantly active population. This group, crucial for managing households, shows significant interest in clean energy solutions like clean cooking and lighting facilities. Only 6.8% of respondents were above 70 years old.

Table 6

Age Structure of Household Head

Age Group	Number	Percentage (%)
26-40	40	16.00
41-55	119	47.60
56-70	74	29.60
71 and Above	17	6.80
Total	250	100.00

Source: Field Survey, 2023.

Literacy and Education

The study explores the critical role of literacy in local community development, focusing on the literacy rate of 45.3% (NPHC, 2021) within Dolpo Buddha RM. With a breakdown indicating 54% literacy among males and 37.3% among females, potential gender disparities in education and awareness were highlighted. The study, based on a field survey of 250 households, unveiled significant educational gaps, with 129 respondents unable to read or write and only 4 possessing high school or intermediate qualifications.

Table 7*Literacy Level of Respondents*

Education Level	Number	Percentage (%)
Can't read or write	129	51.60
Can read or write	92	36.80
School level	25	10.00
High school (10+2) or Intermediate	4	1.60

Source: Field Survey, 2023.

A follow-up question related to the highest education level of the family members was asked of the respondents. The study data revealed the educational attainment of family members within the surveyed 250 households. The majority of families (115) can read and write, which is a positive indication of basic literacy. However, a concerning number of 71 respondents reported that their family members cannot read or write, highlighting the need for improved literacy initiatives in the community. The data also show that 46 respondents claimed their family members have completed school-level education, indicating some access to formal education. Additionally, 15 respondents claimed that their family members have achieved high school (10+2) or intermediate qualifications, and two individuals have obtained a Bachelor's degree. Interestingly, only one person among the surveyed population has attained a Master's degree or higher, suggesting that advanced education is relatively limited. The education level of family members influences the choice of cooking fuel as well as the use of clean energy applications.

Table 8*Highest Education Level of the Family Members*

Highest Education Level of Family	Number	Percentage (%)
Can't read or write	71	28.40
Can read or write	115	46.00
School level	46	18.40
High school (10+2) or Intermediate	15	6.00
Bachelors	2	0.80
Master or higher	1	0.40

Source: Field Survey, 2023.

Occupation

Occupation serves as a source of livelihood, and typically, individuals in the active age group engage in various occupations to fulfill their daily necessities. The choice of occupation is influenced by people's lifestyles and their day-to-day expenses. In rural households, women predominantly undertake domestic tasks on a daily basis, including cooking, cleaning, washing dishes and clothes, and preparing animal feed. The different types of occupations were mainly categorized as agriculture, business, industries, government jobs, private sector jobs, daily wage labor, and other occupations, which also encompassed foreign employment.

Table 9*Main Occupation of Surveyed Households*

Main Occupation	Number	Percentage (%)
Farming	180	72.00
Business	52	20.80
Government Job	3	1.20
Private Service	8	3.20
Others	7	2.80

Source: Field Survey, 2023.

As expected in rural Nepal, subsistence agriculture emerged as the primary occupation in the study area. A significant majority of the respondents, 72% (180 households), depended on agriculture as their main source of livelihood. Major crops grown in the upper Dolpa region include barley, wheat type locally called *Uba*, and potatoes. Additionally, 20.80% (52 households) of local residents engaged in small business activities to sustain their livelihoods. This category also includes individuals involved in Yarsha collection and trade, which holds economic importance for communities in the Upper Dolpa region, providing a major source of income. Due to the minimal academic qualifications of local people, there were fewer individuals in service-oriented jobs.

The data from the Migration Profile of the country in 2019 reveals that almost half of all Nepali households have at least one family member currently abroad or living in Nepal as a returnee migrant. However, the number of local people seeking foreign employment remains minimal, with only seven individuals in total.

Table 10

Relationship between Education Level and Main Occupation

Highest Education Level of Family	Main occupation					Total
	Farming	Business	Government Job	Private Service	Abroad	
Can't read or write	57	14				71
Can read or write	82	24		4	5	115
School level	32	10		3	1	46
High school (10+2) or Intermediate	9	3	2	1		15
Bachelors		1	1			2
Master or higher					1	1
Total	180	52	3	8	7	250

Source: Field Survey, 2023.

Table 10 presents the association between the highest educational attainment of families and their primary occupations. Among families where the highest education level is illiteracy, 57 are engaged in farming and 14 in business, totaling 71. Families with basic literacy skills have 82 members in farming, 24 in business, four in private jobs, and five in foreign employment, totaling 115. For those with school-level education, 32 are in farming, ten in business, three in private jobs, and one in abroad, totaling 46. High school graduates (10+2 or Intermediate) include nine in farming, three in business, two in government jobs, and one in private service, totaling 15. Among bachelor's degree holders, one is in business and one in government jobs, totaling two. Only one family with a master's or higher degree is employed in abroad. The overall total across all education levels and occupations is 250.

Table 11

Chi-Square Test of Independence between Education and Main Occupation

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	106.963 ^a	20	0.000
Likelihood Ratio	40.947	20	0.004
Linear-by-Linear Association	15.015	1	0.000
N of Valid Cases	250		

a. 23 cells (76.7%) have expected count less than 5. The minimum expected count is .01.

The chi-square test of independence is a statistical method used to determine whether there is a significant relationship between two categorical variables. In this study, the two categorical variables are the education level of family members and their occupations. The chi-square statistic is 106.963, with 20 degrees of freedom, and the p-value is less than 0.000. In this case, a chi-square statistic of 106.963 indicates a statistically significant difference between the observed and expected data. The p-value represents the probability of observing a chi-square statistic this extreme, or more

extreme, if the null hypothesis were true. The null hypothesis posits that there is no relationship between education level and occupation. Given that the p-value is less than 0.000, the null hypothesis is rejected.

Overall, the results of the chi-square test of independence indicate a statistically significant relationship between the education level of family members and their occupations. This suggests that the distribution of occupations varies across different education levels. For instance, individuals with higher education levels are more likely to be employed in government jobs or private services, whereas those with lower education levels are more likely to be engaged in farming or local business.

Household Income and Expenditure

During the field study, a comprehensive examination of the financial aspects, specifically household income and expenditures, was conducted for the surveyed households. The study aimed to gain a deeper understanding of the economic conditions and financial behaviors of the respondents and their families.

Household Income

Household income serves as a measure of the combined incomes of all individuals residing in a specific household. It encompasses various sources of income, such as salaries, wages, allowances, daily wages, and earnings from agricultural activities, including the sale of Yarsha, sheep, goats, Yaks, and food grains. During the survey, each household was asked to estimate their monthly income, considering all sources. To validate these estimations, respondents were also asked to specify any additional income sources they receive on a seasonal, monthly, or yearly basis. Based on this data, the total average monthly income for each household was calculated. The Table 12 provides an overview of the income situation in the study area.

Table 12*Average Monthly Income of Surveyed Families, NPR*

Minimum	Maximum	Mean	Std. Deviation
12000.00	250000.00	53762.00	33339.14

Source: Field Survey, 2023.

Table 12 provides data on the average monthly income of surveyed families in NPR (Nepalese Rupee). The minimum recorded income is NPR 12,000.00, while the maximum is NPR 250,000.00. The mean monthly income among these families is NPR 53,762.00, with a standard deviation of 33,339.14, indicating significant variability in income levels across the surveyed households.

Table 13*Household Income Range per Month*

Avg. Income-NPR	Number	Percent
<28000	38	15.2
28000- 50000	109	43.6
>50000	103	41.2
Total	250	100.00

Source: Field Survey, 2023.

Surveyed households have been grouped into three categories on the basis of monthly income i) less than NPR 28,000.00, ii) NPR 28,000.00 to NPR 50,000.00 and iii) more than NPR 50,000.00. This category aims to find out the affordability of households to install domestic RE applications and their capacity to pay for energy costs.

Among the respondents, the highest proportion (43.6%) fell within the household income range of 28,000-50,000, followed by 41.2% in the more than 50,000 range. Conversely, 15.2% of users had a household income below 28,000.

Table 14*Occupation and Household Income Level among the Surveyed Households*

Main Occupation	Household income per month			Total Households
	<28000	28000- 50000	>50000	
Farming	38	101	41	180
Business		7	45	52
Government Job			3	3
Private Service		1	7	8
Abroad			7	7
Total	38	109	103	250

Source: Field Survey, 2023.

The SPSS output shows a contingency table with income categories (<28000, 28000-50000, >50000) in the rows and occupation categories (farming, business, government job, private service, abroad) in the columns. The Table 14 also shows counts of how many people fall into each category. Out of the 250 households surveyed, 180 were engaged in farming, including Yarsha collection, making it the most prevalent occupation. Among these farming households, 38 earned less than NPR 28,000 per month, 101 earned between NPR 28,000 to 50,000 per month, and 41 earned more than NPR 50,000 per month. Additionally, 52 households were involved in business, with seven earning between NPR 28,000 to 50,000 per month and the remaining 45 earning more than NPR 50,000 per month. A small number of households, three in total, were in government jobs, all earning more than NPR 50,000 per month. Similarly, eight households in private service occupations had a varied income distribution, with one earning between NPR 28,000 to 50,000 per month and seven earning more than NPR 50,000 per month. Finally, seven households fell under the abroad category, all earning more than NPR 50,000 per month. This data offered an important glimpse into the income dynamics of various occupations within the surveyed households.

Table 15*Chi-Square Test of Independence between Occupation and Monthly Income*

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	91.534 ^a	8	0.000
Likelihood Ratio	103.450	8	0.000
Linear-by-Linear Association	44.439	1	0.000
N of Valid Cases	250		

a. 9 cells (60.0%) have expected count less than 5. The minimum expected count is .46.

The chi-square test of independence was conducted to determine if there is a relationship between income and occupation. The chi-square statistic is 91.534 with 8 degrees of freedom, and the p-value is less than 0.000. A small p-value (less than 0.05) indicates that the null hypothesis, which states there is no relationship between income and occupation, is rejected. Therefore, there is a statistically significant relationship between income and occupation. People in certain occupations are more likely to have specific income levels. For instance, government jobs and business occupations have the most individuals in the high-income category.

Household Expenditure

Information regarding household expenditures has been systematically gathered under categories including food, education, clothing, energy, medicines, rituals, social ceremonies, and other miscellaneous expenses. A comprehensive evaluation of these expenditure items has been conducted to suit the convenience of the respondents in terms of the periods during which these expenses were incurred. The discrepancies in the periods of expenditure among respondents have been incorporated into the monthly expenditure framework for accurate computational analysis.

Table 16*Average Monthly Expenses of Surveyed Families, NPR*

Minimum	Maximum	Mean	Std. Deviation
19500.00	99000.00	38397.02	12609.77

Source: Field Survey, 2023.

Table 16 provided data on the average monthly expenses of surveyed families. The minimum expense was NPR 19,500.00, while the maximum was NPR 99,000.00. The mean monthly expense among these families was NPR 38,397.02, with a standard deviation of 12,609.77, indicating moderate variability in expenditure levels across the surveyed households. Furthermore, the survey indicates that about 21.2 percent of respondents have a negative balance in their household income and expenditure patterns. This high level of negative balance results from higher energy costs and expensive food items in the last-mile village.

Table 17 provides a detailed overview of monthly expenditure patterns across various categories. The data includes minimum, maximum, mean, and standard deviation values for each category, offering insights into the spending habits of the surveyed families.

Table 17*Monthly Expenditure Patterns Across Different Categories*

Categories	Minimum	Maximum	Mean	Std. Deviation
Food	10000	48000	20250.40	7805.03
Cloth	2500	6500	3984.00	1096.79
Education	100	1200	429.87	174.38
Medicine	100	800	341.10	123.10
Energy	2500	15000	8019.20	2542.28
Social ceremonies	5000	25000	13606.10	5487.85
Festival	300	6500	3184.74	1373.22
Miscellaneous	500	55000	15130.80	7757.18

Source: Field Survey, 2023.

The field data provides a range of monthly expenditure patterns across different categories. Significantly, expenditures categorized as "Food" exhibited a range between NPR 10,000 and NPR 48,000, with an average of NPR 20,250.4. Likewise, expenses associated with "Energy" displayed variation, spanning from NPR 2500 to NPR 8,000 and a mean of NPR 8,019.20. Furthermore, a notable disparity was observed in "Other" expenditures, which extended from NPR 500 to NPR 55,000, averaging at NPR 15,130.80.

No education fee is provisioned for students as local schools receive funding support from the Non-Governmental Organizations (NGOs) namely Vision Dolpo and Action Dolpo. The energy costs, especially for Liquefied Petroleum Gas (LPG) purchases, seem remarkably high in Dolpo Buddha RM.

Income versus Energy Costs

The relationship between income and energy expenses is pivotal for comprehending household financial stability. As energy costs increase, they can consume a substantial part of a household's income, especially among lower-income families, resulting in energy poverty. This dynamic highlights the necessity of cost-effective energy options to ensure equitable access to vital services and enhance general living standards.

Table 18

Relationship between Income Ranges Versus Energy Costs

Energy cost in NPR	N	Mean NPR	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum NPR	Maximum NPR
					Lower Bound NPR	Upper Bound NPR		
<28000	38	6842.11	2807.098	455.371	5919.44	7764.78	2500	12000

28000- 50000	109	7602.75	2404.065	230.268	7146.32	8059.18	2500	12000
>50000	103	8894.17	2307.652	227.380	8443.17	9345.18	2500	15000
Total	250	8019.20	2542.275	160.788	7702.52	8335.88	2500	15000

Source: Field Survey, 2023.

The descriptive statistics table 18 provides a detailed summary of energy costs across different income groups. Specifically, it includes the number of individuals (N) in each income group, the mean energy cost in rupees, the standard deviation of energy costs, and the standard error of the mean. Additionally, the table presents the 95% confidence interval for the mean, indicating the range within which the true population mean is likely to fall with 95% certainty. The minimum and maximum values represent the lowest and highest energy costs observed within each group. Notably, the income group >50,000 exhibits the highest average energy cost (NPR 8,894.17), followed by income group ranges 28,000-50,000 was NPR 7,602.75 and the low-range group <28,000 was NPR 6,842.11.

Table 19

One-Way ANOVA Test of Energy Costs and Income Groups

Energy costs in NPR	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	150409529.255	2	75204764.627	12.732	.000
Within Groups	1458918310.745	247	5906551.865		
Total	1609327840.000	249			

Source: Field Survey, 2023.

The ANOVA table tests the null hypothesis, which posits no statistically significant difference in energy costs among the three income groups. The table includes the sum of squares, representing the variability in energy costs, divided into between-group and within-group components. Degrees of freedom (df) are also presented, with

two df between groups (three income groups, minus one) and 247 df within groups (250 total observations, minus three groups). The mean square, calculated by dividing the sum of squares by its respective df, indicates the average variability. The F-statistic, which compares between-group and within-group variability, is also shown; a higher F-statistic suggests greater differences between groups. The significance (Sig.) value, or p-value, is provided to determine the statistical significance of the results. In this case, the F-statistic is 12.732, and the Sig. value is 0.000. Since the p-value is less than 0.05, the null hypothesis is rejected, concluding that there is a statistically significant difference in energy costs among the three income groups.

Table 20

Post Hoc Tests of Energy Costs with Different Ranges of Income Group

(I) Household income Rs. per month	(J) Household income Rs. per month	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
<28000	28000- 50000	-760.647	457.847	.222	-1840.22	318.93
	>50000)	-2052.069*	461.282	.000	-3139.74	-964.40
28000- 50000	<28000)	760.647	457.847	.222	-318.93	1840.22
	>50000	-1291.422*	333.967	.000	-2078.89	-503.95
>50000	<28000	2052.069*	461.282	.000	964.40	3139.74
	28000- 50000	1291.422*	333.967	.000	503.95	2078.89

*. The mean difference is significant at the 0.05 level.

The output results also include a table for post-hoc tests, specifically the Tukey HSD (Honestly Significant Difference) test, which identifies statistically significant differences in energy costs among specific income groups. The post-hoc tests reveal the following: there is no statistically significant difference in energy costs between the income group earning less than NPR 28,000 (mean energy cost: NPR 6,842.11) and the income group earning between NPR 28,000 and NPR 50,000 (mean energy cost: NPR 7,602.75), with a significance value of 0.222. However, there is a statistically significant

difference in energy costs between the income group earning more than NPR 50,000 (mean energy cost: NPR 8,894.17) and the income group earning less than NPR 28,000 (mean energy cost: NPR 6,842.11), with a significance value of 0.000. Additionally, there is a statistically significant difference in energy costs between the income group earning more than NPR 50,000 (mean energy cost: NPR 8,894.17) and the income group earning between NPR 28,000 and NPR 50,000 (mean energy cost: NPR 7,602.75), with a significance value of 0.000.

The results of the one-way ANOVA test and the post-hoc tests indicate that there is a statistically significant difference in energy costs among different income groups. People in the high income group have statistically higher energy costs compared to both the low income and middle income groups. However, there is no statistically significant difference in energy costs between the low income group and the middle income group.

It is important that, despite a statistically significant difference, the descriptive analysis indicates that average energy costs increase with income. A t-test was conducted to compare energy costs between two groups: those who use Liquefied Petroleum Gas (LPG) and those who do not. The test was performed with a 95% confidence interval (CI). The results revealed statistically significant differences in energy costs between the two groups ($p = 0.010$), indicating a 95% probability that the true difference in energy costs between the groups is not zero as shown in table below.

Table 21

Comparison of Energy Costs for LPG Users and Non-Users

Use of LPG	Number	Energy costs in NPR		
		Mean	Std. Deviation	Std. Error Mean
Yes	240	8217.92	2392.70	154.45
No	10	3250.00	677.00	214.09

Source: Field Survey, 2023.

Table 21 summarizes the average energy cost (mean) and standard deviation for each group. The average energy cost for the group that uses LPG is NPR 8217.92, with a standard deviation of NPR 2392.70. The average energy cost for the group that does not use LPG is NPR 3250.00, with a standard deviation of NPR 677. There was a statistically significant difference in energy costs between those who used LPG and those who did not. The average energy cost was higher for the group that used LPG. Other factors besides LPG use might have influenced energy costs.

In general, areas with road access are heavily influenced by the use of LPG cylinders in Nepal. However, in the case of Dolpo Buddha RM, specifically the Dho Tarap Valley, which is accessible only after a two-day trek, the adoption of LPG cylinders is notably prudent. This is primarily due to the severe scarcity of fuelwood in the region, compelling residents to rely on low-grade cow dung as an alternative, with no other viable local options available. Additionally, the monthly income levels in this area appear satisfactory, largely due to the community's access to high-value medicinal plants and local business opportunities. Families with higher income levels tend to use more LPG cylinders for cooking purposes. One of the female participants (47) from Takshi village mentioned that: "Every family incurs higher expenses for cooking energy due to the scarcity of fuelwood and the increasing difficulty in preparing dung cakes".

Caste and Ethnicity

In rural areas, ethnicity shapes ways of living and living standards, sometimes acting as a determining factor in the adoption of new technologies or practices. The caste system has historically exerted significant influence in shaping cultural values, occupations, marriage practices, food habits, and other social behaviors within the community. The study area is primarily populated by three prominent ethnic groups: Gurung, Bhote, and Magar, all of which are part of the Dolpo group. Within the Dolpo

Group, these ethnic communities share common customs, languages, and cultural practices. Notably, the Chairperson of Ward 2 comes from the Chhetri community, representing the sole upper-caste household within that community. There was no presence of any Dalit community in the study area.

The study aimed to identify various ethnic groups that have implemented RETs. The study data indicates that nearly all surveyed households have incorporated at least one RE technology into their households.

Language, Cultural, Religious and Historical Sites

The Lhosar festival, an enduring annual celebration that takes place during the harvest season, holds a significant place in the cultural landscape of the Dolpo Group. This celebration encompasses rituals, dances, and musical performances, carrying profound religious and cultural importance for the community. People adorn themselves in traditional attire adorned with intricate jewelry, creating a vibrant and captivating display. The festival serves as a joyous gathering where locals express gratitude for the harvest and seek blessings for prosperity. Furthermore, it serves as a conduit for the transmission of cultural heritage, fostering intergenerational sharing of traditional folk songs, dances, and stories, thereby supporting the Dolpo Group's identity and promoting unity.

Land Use and Ownership

The Dolpo Buddha RM spans an elevation range of approximately 3,800 to 7,050 meters above sea level. The majority of the RM is characterized by rugged terrain, including steep mountains, rocky cliffs, and grassy meadows. The land is typically steep and hilly, with the exception of some flat areas and meadows located mainly within the Dho-Tarap valley. Most agricultural land is affected by rocky, sloping terrain, which limits agricultural productivity.

According to the data provided by the RM Office, the land distribution in the area is as follows: agricultural land covers 265.38 hectares, while the forest area covers 61.28 hectares. Settlements and local roads encompass 89.58 hectares, and an additional 1.4 hectares are categorized as “other areas”, which include *Guthi* land and other barren public land.

Land ownership varies among households, with agricultural practices occupying a significant portion of the land as households engage in cultivation and farming activities. Landholding symbolizes the economic status of the people and has social value in the rural community. Land is generally classified as upland (Bari) and lowland (Khet) depending on irrigation accessibility. About 50 percent of the households own between 0.5 ha and 1 ha of land.

Communication Facilities

In Dolpo Buddha RM of Dolpa District, the communication landscape is primarily shaped by the utilization of GSM mobile phones and V-SAT telephones. These communication tools serve as the main conduits for connecting the community members within the study area. However, internet access remains limited and is mainly concentrated in specific locations such as government offices, particularly the RM office, as well as in a handful of hotels within the region.

Among mobile data users, the majority (over 60%) spend NPR 200 to NPR 400 per month. It is worth noting that the internet is primarily accessed through mobile phones, accounting for 95% of internet users. This shift reflects the growing importance of digital communication and information access in the region. A noteworthy aspect is that a significant portion of the population owns a mobile phone, often equipped with multiple SIM cards, highlighting the widespread integration of mobile technology into daily life.

It is crucial to acknowledge that the operation of these communication systems is intricately tied to solar-generated electricity. Although this eco-friendly energy source has led to substantial enhancements in connectivity and communication, it also presents vulnerability. During adverse weather conditions or periods of limited sunlight, interruptions in the power supply can occur, leading to temporary disruptions in communication services. This dependency on solar power exposes the villagers to challenges when facing unfavorable weather patterns, underscoring the need for further infrastructure development and potential solutions to address these interruptions and ensure consistent communication access for the community.

Food Sufficiency Status and Livestock Farming

When examining the food sufficiency status in Upper Dolpa, a significant aspect to consider is the region's reliance on traditional agricultural practices and local resources for sustenance. The unique geographical and climatic conditions of Dolpo Buddha RM, as one of the last mile villages in Nepal, play a crucial role in shaping the food production and consumption patterns of its inhabitants. This includes the availability of locally grown crops, the utilization of livestock for food, and the overall resilience of the community in ensuring a steady food supply. Understanding these dynamics is essential for assessing the self-sufficiency and well-being of the last-mile population in this remote hill area.

Table 22

Food Sufficiency Status of Surveyed Households

Food Sufficiency Status	Number	Percentage (%)
Up to 3 months	159	63.60
3-6 months	81	32.40
6 to 12 months	10	4.00

Source: Field Survey, 2023.

The study reveals the capacity of households to sustain their families through food production. Among the 250 surveyed households, 159 produce food grains to support themselves for up to three months, while 81 households can sustain their families for up to six months. Additionally, 10 households exhibit food sufficiency for the entire year. However, the study found no households with surplus food production beyond their own requirements within a single year.

Dolpo Buddha RM in the Bhot area is situated in a cold and dry region. Due to its altitude and cold climate, it experiences snowfall and freezing temperatures, limiting crop plantation and harvesting to once a year.

Similarly, livestock is an integral part of rural livelihood. Almost all the surveyed households have livestock of one or more types including cattle such as mules, Yak, sheep, goats and others in the study area. The high level of large animal rearing demands better lighting provision in the Sheds/Stalls.

Table 23

Average Number of Livestock Owned by the Surveyed Households

Livestock	Minimum	Maximum	Mean	Std. Deviation
Mules/Horse	1	20	7	5.124
Sheep/ Chyangra (Mountain Goat)	4	45	13	6.76
Yak/Chauri	1	12	4	2.201
Total livestock	0	51	17	7.96

Source: Field Survey, 2023.

Table 23 shows the average number of livestock owned by surveyed households. Households own between 1 and 20 mules/horses, with an average of 7 (SD = 5.124). They own between 4 and 45 sheep or Chyangra (mountain goats), with an average of 13 (SD = 6.76). Yak/Chauri ownership ranges from 1 to 12, averaging 4 (SD = 2.201). The total number of livestock per household varies from 0 to 51, with an average of 17 (SD = 7.96). A 62-year-old female participant said, “the number of Yak/Chauri is directly

associated with the cooking energy demand, especially for the preparation of dung cakes for the entire period. If we don't have enough animals, we must collect dung from surrounding farmlands during the summer season”.

Amenities in the House

The provision of household amenities in Dolpo Buddha RM indicates the wealth and awareness levels of the residents. During the survey, electric equipment like eCooking technology and other informational amenities were primarily assessed. The table below illustrates the prevalence of basic facilities among households.

Table 24

Availability of Basic Amenities at Household Level

Basic facilities at households	Number	Percentage (%)
Connection of drinking water	239	95.60
Toilet Facility	216	86.40
Telephone/Mobile	247	98.80
Radio/Television	38	15.20
Internet facility/WiFi Connection	5	2.00
LPG Use	240	96.00

Source: Field Survey, 2023.

A substantial majority have access to essential services, with 95.6% having an access to drinking water and 86.4% having toilet facilities. Almost all households (98.8%) possess a telephone or mobile device, while 96.0% use LPG for cooking. In contrast, fewer households have access to entertainment and information technology; only 15.2% have radio or television, and a mere 2.0% have an internet or WiFi connection. This data indicates a high access to fundamental utilities, while access to digital connectivity and media remains limited. A local political leader (52) said

It is evident that solar technology has increased the use of TV and radio, potentially enhancing awareness in various aspects. Limited access to reliable

electricity could be a contributing factor, making it challenging for households to use power-dependent appliances. This situation highlights limitations in essential services and technological advancements, potentially causing hardships for us. The absence of these amenities indicates a lifestyle less reliant on modern technology and emphasizes the need for focused efforts to improve infrastructure and access to basic facilities, ultimately enhancing the quality of life in this region.

Status of Women in the Study Area

Participation of women in household decision-making is essential for improving the status of women in society. Recognizing the pivotal role of women's involvement in such matters for advancing their societal standing, it becomes evident that their engagement in significant household decisions remains limited, often relegating them to domestic chores. To comprehensively gauge the potential impact of RETs on women's empowerment and the democratization process, pertinent data was collected through FGD with local women group.

The scarcity of energy at the household level disproportionately affects women and girl children. As biomass fuel resources become increasingly scarce in Dolpo Buddha RM, women must walk longer distances and invest more time each day in gathering dung cakes. A more profound and enduring implication of the shortage of fuelwood is that children, especially girls are withdrawn from school to assist their mothers in the daily search for dung cakes fuelwood and fodder. In addition to lost opportunities and adverse intergenerational effects, women contend with a range of health issues stemming from fuel scarcities.

Specific inquiries were made to ascertain whether the installation of SHS, ICS, and other clean technologies has induced any notable transformations in household dynamics. The provision of improved lighting and clean cooking technologies has fostered a conducive atmosphere for women's involvement in income-generating activities, thereby potentially amplifying their role in economic pursuits.

The Constitution of Nepal in 2015 has laid down a constitutional framework guaranteeing equal political and civil rights to all citizens, irrespective of gender, religion, or belief. Despite these constitutional safeguards, the practical realization of these provisions remains incomplete. It becomes evident that while legal frameworks have been established to ensure gender equality, there is a substantial gap between these legal stipulations and their tangible manifestation in societal norms and practices. This indicates a critical area of concern that requires closer attention and proactive measures to bridge the gap between policy and implementation, fostering a more inclusive and equitable environment for women's participation and empowerment in the upper Dolpa region.

Migration Rates

Migration rates in the Dolpo Buddha RM reveal a complex interplay of factors contributing to population movement. Geographical remoteness, limited economic opportunities, social disadvantages, lack of education and employment prospects, among others, have led to a gradual decline in the local population as residents seek better prospects in other districts and municipalities. Despite facing challenges in their place of origin, individuals are reluctant to abandon their cultural heritage, traditions, professions, businesses, social ties, and family bonds, which explain their hesitance to settle elsewhere.

Consequently, the RM itself has observed only a few instances where individuals have overcome obstacles to acquire land and establish residences in central areas. However, this form of migration lacks conspicuous official documentation. This prevailing trend underscores the deep-rooted attachment that people have to their birthplace, a profound affinity for their community, and an unwavering connection to the fundamental elements that have shaped their formative years. Even among the privileged elite, this dynamic was evident as they established their households primarily in major urban centers, with a notable focus on Kathmandu.

A particularly fascinating phenomenon emerged within these elite circles, characterized by strategic seasonal migration. Throughout the winter months, they settled towards Kathmandu, capitalizing on the urban amenities and opportunities it offered. However, as the summer and rainy seasons approached, a reverse migration beckoned them back to their villages, nestled within the last mile area.

Social Infrastructures

During the field study, the researcher has collected information about social infrastructures like hospitals/health posts, schools/colleges, communication towers, dairies etc. A summary of the information is presented in Table 25.

Table 25

Numbers of Social Infrastructures/Facilities

Facilities	Number	Remarks
Health center	2	
Primary school	2	
Secondary school	1	
Post office	1	
Provision/ grocery shop	25	
Market	1	
Bank	1	
NGOs	2	Vision Dolpo, Action Dolpo

Facilities	Number	Remarks
Agriculture extension office	1	
Agro processing mills	10	Water mills-mechanical power
Unpaved road	1	Within periphery of RM
Communication tower	1	

Source: Field Survey, 2023.

Table 25 reveals that Dolpo Buddha RM has a minimum number of social institutions compared to the accessible areas of Nepal. Education facilities in the area are limited, comprising two primary schools and one secondary school; the absence of a college or university accentuates the challenges of pursuing higher education locally. In terms of healthcare, Dolpo Buddha RM lacks a hospital within its service area, while even the district headquarters in Dunai possesses only a basic health facility. Emergency health responses rely solely on-air ambulances, presenting the only option for locals; those unable to afford the costly airlift transportation have no alternative. NGOs like Vision Dolpo and Action Dolpo, alongside an Agriculture Extension Office, strive to address specific community needs.

The existence of ten agro-processing mills, which employ mechanical power generated from water mills, showcases an inventive approach to rural livelihood, particularly in agriculture. The presence of a communication tower indicates efforts to bridge communication gaps. However, the absence of paved roads and the limited fair-weather seasonal roads in the periphery hint at potential transportation and connectivity issues. The study findings distinctly advocate for targeted interventions to rectify deficiencies and imbalances in social facilities, propelling inclusive growth and advancement in the study area.

Overview of Existing Energy Practices in the Study Area

The current energy practices in the upper Dolpa region, specifically within Dolpo Buddha RM, encompass a unique blend of traditional and modern methods. The area has relied predominantly on indigenous energy sources to meet its energy needs. Traditional practices include the use of biomass fuels such as firewood, dried dung, and agricultural residues for cooking and heating. The SHS is overwhelmingly used for lighting purpose.

This sub-chapter highlights the findings of an exhaustive investigation into the complex structure of energy practices in the study area. The study area is being inaccessible due to its rugged topographical setting and the dispersed type of settlement. Consequently, commercial energy sources, particularly the NEA grid line is not reaching to the local villages as the demand of the rural people. The cost of infrastructure development is quite expensive because of the high transportation cost. As a result, last mile people are compelled to use the traditional sources of energy which leads to unsustainable use of the local resources. Energy consumption pattern is characterized by a substantial reliance on biomass, predominantly for household purposes such as cooking, with dung cakes serving as the primary cooking energy source.

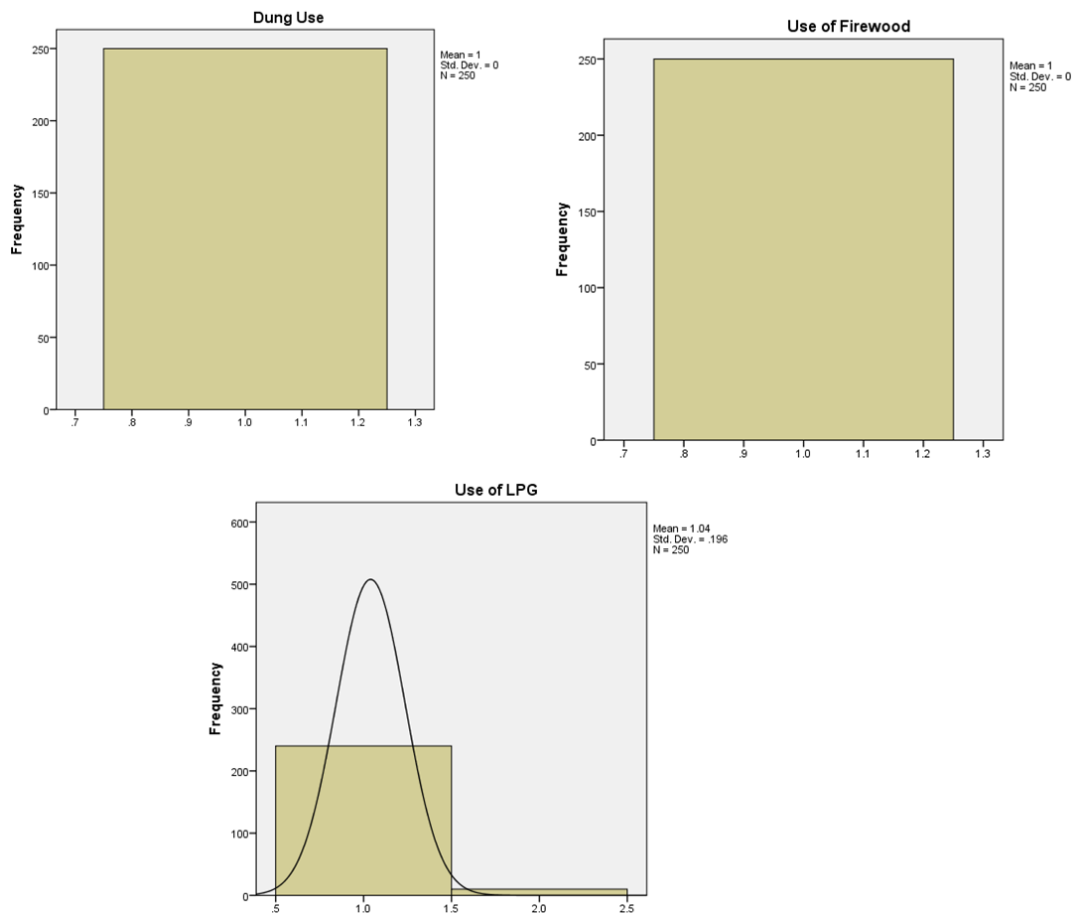
The renewable energy sources are available across various rural clusters within Dolpo Buddha RM which fulfills the basic energy requirements. Currently, Small Solar Home (SHS) systems provide lighting facilities in each household, although there exists a demand for eCooking solutions and heating solutions. Conversely, the usage of imported LPG for cooking is steadily rising, despite its exorbitant cost. The local population in Dolpo Buddha RM heavily relies either on dung cakes or imported LPG.

In contrast, the Government of Nepal (GoN) aims to have electric Cookstoves in all households by 2030 to reduce dependency on biomass and fossil fuels and expand the energy mix with a focus on renewable energy. Nepal has also commitment to the

Sustainable Development Goals (SDGs) includes reducing carbon emissions (SDG-13), promoting for clean energy adoption (SDG-7), and ensuring good health and well-being of people (SDG-3). Without clean energy development in last-mile village, the national target cannot be achieved and without enough supply of energy in those particular places, rural development and sustainable livelihood is not possible.

Cooking Energy

The rural households of Dolpo Buddha RM are profoundly dependent upon traditional energy resources for the cooking purpose. Almost all households use dung cake and fuel wood as the primary source of fuel for cooking purpose followed by LPG. The use of LPG is becoming very popular these days. Majority of households prepare dung cake from own Yak or collects from nearby pasture land (almost free of costs). Similarly, the fuel wood collection from 25 km away nearer to Sisol where GoN owned forest land is existing. In general, dung cakes and fuel wood are collected and stored by family members, especially women, during periods of less intense agricultural activity and the off-season of Yarsha collection in Dolpo Buddha RM of Dolpa District.

Figure 4*Use of Cooking Energy at Household Level*

Source: Field Survey, 2023.

Due to its accessibility, affordability, and cultural familiarity, dung cake stands out as the predominant cooking energy source at 100% usage, deeply rooted in the cultural tradition of the study area. It encourages a positive relationship between feeding demands and animal management. Fuel wood, which is obtained from distant forests but is scarce in the alpine region due to its location, continues to be widely used.

Surprisingly, the use of LPG by more than 80% of surveyed households for cooking indicates a transformative shift in cooking energy practices. Despite the high cost of LPG, the scarcity of fuel wood compels local people to adopt LPG, as there are no alternatives for heating loads. This change reflects the preferences and willingness of last-mile villages to explore alternatives to conventional biomass fuels.

Primary Cookstove in the Study Area

In Nepal, diverse ethnic groups, cooking and heating practices, and stove operations varied significantly. The primary Cookstoves used in Dolpo Buddha RM played a crucial role in shaping the daily lives and cooking practices of its residents. Factors like the location of the kitchen, stove type, kitchen function, socio-cultural and religious beliefs, and variations played a significant role in the cooking system.

The study findings revealed that for the primary Cookstoves, nearly all surveyed households used Metallic Improved Cook Stoves (MICS) in their kitchens for cooking purposes. These stoves addressed the dual need for cooking and space heating for people living in remote high hills. There were various models of MICS, each tailored to specific household needs. These models encompassed Three Pot Holes with a Water Tank, Three Pot Holes with a Grate and an Ash Tray, Two Pot Holes with a Grate and an Ash Tray, and other models.

Situated on the border, local residents had the option to acquire these MICS from the Chinese market. The cost of these stoves varied, ranging from NPR 7,000 to NPR 20,000 per system, offering households diverse options based on preferences and budget constraints. The adoption of these MICS held economic and environmental significance at the household level.

An inherent characteristic of these stoves was their ability to provide consistent warmth and efficient fire management, even when utilizing dung cake as the primary fuel ingredient. This innovative design ensured a dependable cooking experience while aligning with cooking practices, ethnic diversity, and space heating needs of the local population. By catering to the unique requirements of the residents, these MICS contributed to improved cooking efficiency and reduced environmental impact.

The Biomass Energy Strategy 2017 envisages promoting biomass energy as a reliable, affordable, and sustainable energy resource to address the growing energy demand of Nepal. It aims to promote clean cooking technologies of at least tier 3 to all households by 2030 (MoFE, 2021). For this purpose, ICS ranked tier 3 or above (ICS T3+: Factory-made portable Cookstove; uses solid biomass or pellets; efficiency above 30%; tier 3 or above) should be promoted all over the country. Local people are demanding reliable and sustainable electricity supply not only for lighting purposes but also for heating loads, especially demanding eCooking solutions. Interestingly, during the household survey and FGD, all participants were aware of eCooking solutions such as rice cookers, induction cooktops, and infrared models as well.

Purpose of Fuel Wood Use

In remote highland areas, fuelwood plays a critical and indispensable role in the daily lives and survival strategies of local residents. With limited access to modern energy sources, communities heavily rely on fuelwood for essential tasks. Despite challenges in accessing contemporary alternatives, fuelwood remains the primary source for meeting basic needs. Its importance extends beyond energy provision, encompassing cooking, space heating, cultural practices, and water boiling. Examining fuelwood usage across 250 households reveals its diverse purposes, with cooking being the most common (75.60%), followed by space heating (14.40%) and water boiling (5.20%). This highlights not only the practical necessity of fuelwood but also the resilience and adaptability of these communities in navigating their isolated mountainous environment.

Table 26*Purpose of Fuelwood Use*

Purpose of Use	Number	Percent
Cooking	189	75.60
Animal Feed Preparation	0	0.00
Alcohol Preparation	12	4.80
Space Heating	36	14.40
Boiling water	13	5.20
Others (specify)	0	0.00
Total	250	100.00

Source: Field Survey, 2023.

Source of Fuel Wood

In the alpine region and buffer zone of Shey Phoksundo National Park (SPNP), where Dolpo Buddha RM is situated, the sourcing of fuelwood presents a unique challenge due to the scarcity of vegetation in the nearby settlements. The rugged terrain and high-altitude setting contribute to the limited availability of trees and shrubs that typically serve as sources of fuelwood. As a result, local communities in this remote area must devise innovative strategies to secure this essential energy resource. Residents may need to venture far distances to gather fuelwood or rely on alternative biomass materials, such as dried agricultural residues or animal dung, to meet their cooking and heating needs. The absence of easily accessible vegetation highlights the resourcefulness and adaptability of the inhabitants in managing their energy requirements within the constraints of their environment.

Table 27*Sources of Fuel Wood*

Source of Fuel Wood	Number	Percent
Hire labour to collect from nearby forest	205	82.00
Purchase from market	31	12.40
Collect ourselves from nearby forest	14	5.60
Total	250	100.00

Source: Field Survey, 2023.

Respondents were queried to gather information regarding the sourcing of fuel wood. The study captured the primary means of acquiring fuel wood from various sources. The data revealed that hiring labor to collect wood from nearby forests accounted for 82% of the total responses. Another 12.40% of responses indicated that fuel wood was purchased from the market. Additionally, 5.60% of respondents mentioned that they personally collected wood from nearby forests. This distribution of sources reflects the collection strategies employed by the local inhabitants to ensure a steady supply for their cooking energy needs.

Responsibility of Fuel Wood Collection

In rural families, women are predominantly responsible for domestic work. They play key roles in managing and utilizing traditional energy resources, forming an intimate relationship with these resources. Women assume multifaceted roles as collector, user and manager of energy resources, bearing significant responsibilities in their household. Much of their time is spent on fuel wood collection. The scarcity of fuel wood and the use of low-grade fuel have adverse effects on health of women and their family members. The long hours spent travelling long distances to collect fuel wood and carrying heavy loads require considerable energy.

Table 28*Responsibility of Fuelwood Collection*

Responsibility of Collection	Number	Percentage (%)
Adult male	10	4.00
Adult female	138	55.20
Both	102	40.80

Source: Field Survey, 2023.

Regarding the responsibility of the fuelwood collection, it was observed that in 40.80 percent of cases, both the adult members of the family take the responsibility to collect the fuelwood. However, the survey also reveals the fact that in many households this responsibility is still taken by the women i.e., 55.20 percent. The four percent cases of this responsibility remaining within only male adult members of their family.

Table 29*Responsibility of Fuelwood Collection in Different Sources*

Responsibility	Source of Fuel Wood	Number	Percentage (%)
Adult Male	Government Forest	8	3.20
	Buy	2	0.80
Adult Female	Government Forest	111	44.40
	Buy	27	10.80
Both	Government Forest	79	31.60
	Buy	23	9.20
Total	Government Forest	198	79.20
	Buy	52	20.80

Source: Field Survey, 2023.

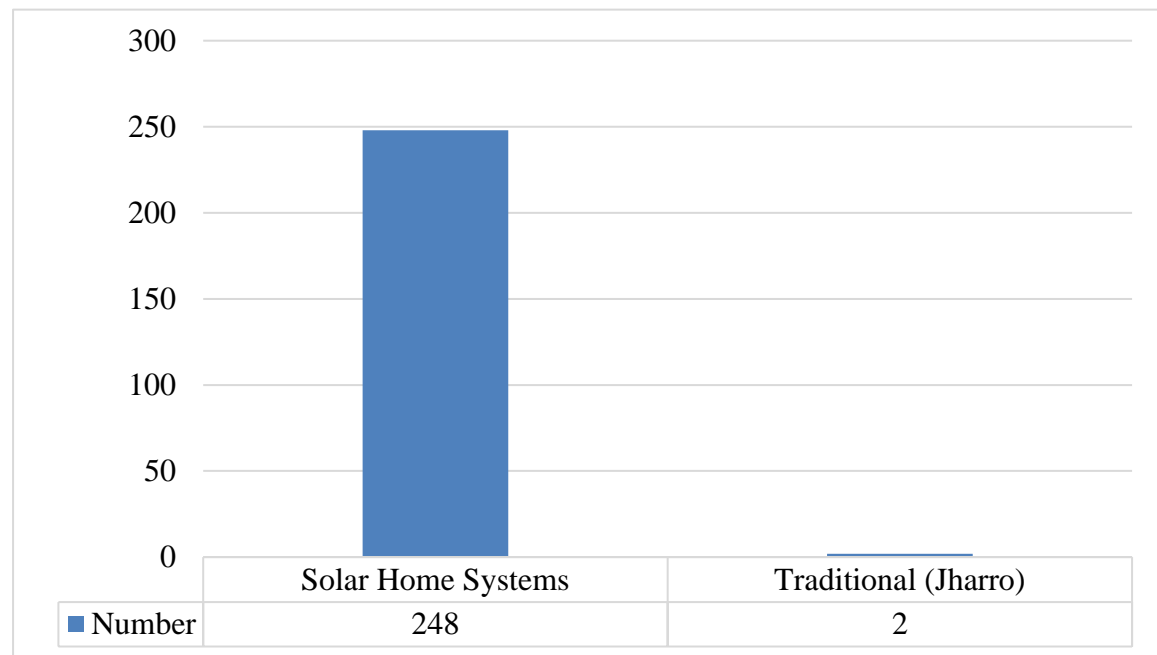
Table 29 illustrates the distribution of responsibilities for fuel wood collection across various sources. It provides insights into the division of roles based on gender and age groups. Among adult males, a mere 3.20 percent collected fuel wood from government forests, while 0.80 percent chose to purchase it. In contrast, adult females played a significant role, with 44.40 percent responsible for gathering fuel wood from

government forests and 10.80 percent opting to buy it. When considering both genders, 31.60 percent of the responsibilities involved collecting from government forests, and 9.20 percent preferred purchasing. Interestingly, children did not report any responsibilities for fuel wood collection. Overall, the data emphasizes a substantial reliance (79.20 %) on government forests for fuel wood collection, while 20.80 percent preferred to purchase it.

Access to Electricity

This segment mainly deals with the existing electrification situation in Dolpo Buddha RM, considering various options, including the national grid and RETs. Currently, there is no access to the national grid line. The solar PV system has become popular as the primary source of electrification. Tuki, Lanterns, and Jharro (firewood flame) were prevalent lighting devices used before the installation of Solar Home Systems (SHS). The use of kerosene has been completely replaced after the installation of SHS.

According to data from the RM office, almost every household has already installed SHS with capacities ranging from 50 watts to 100 watts, except for six households. These six households are still using *Jharro* for lighting purpose. Furthermore, the RM has planned to install Solar Minigrid Projects in their location with support from the AEPC, as there is no possibility of NEA grid extension for the next 5 years due to its remoteness and its location within a buffer zone of SPNP.

Figure 5*Lighting Facility in the Study Area*

Source: Field Survey, 2023.

Of the total 250 households surveyed for the study, 99.2% of households are using SHS for lighting purposes, while 0.8% still use *Jharro* (the traditional means to generate light in the home). The aging of SHS and maintenance requirements, financial burden, and other implications were the main reasons for using *Jharro* for lighting.

Status of Renewable Energy Technologies (RETs) Installed

Based on various sources and secondary information, it is evident that there is a substantial promotion of RETs. Solar technology has been installed in the majority of households. Currently, the MICS are installed in the kitchens of every household. Water mills are also providing services for agro-processing, *Uba* produced in the local area.

Table 30*Installed RETs in the Surveyed Households*

RETs Type	Number of System	Ownership Type	Status
Solar Home Systems (SHS)	248	Household level	Operational
Metallic Improved Cookstoves (MICS)	250	Household level	Operational
Agro-processing mills (IWM)	10	Community type	Operational
Institutional Solar Photovoltaic System (ISPS)	6	Institutions or organizations	Operational

Source: Field Survey, 2023.

Table 30 outlined the RETs present in the surveyed households. It revealed that 248 SHS were installed at the household level, alongside 250 MICS, both of which contributed to efficient and sustainable energy use. Additionally, there were 10 agro-processing mills (water mills) operational at the community level, likely aiding in local agricultural processing. Six Institutional Solar Photovoltaic Systems (ISPS) were also operational, serving institutions or organizations with renewable energy.

Agro-processing Mills

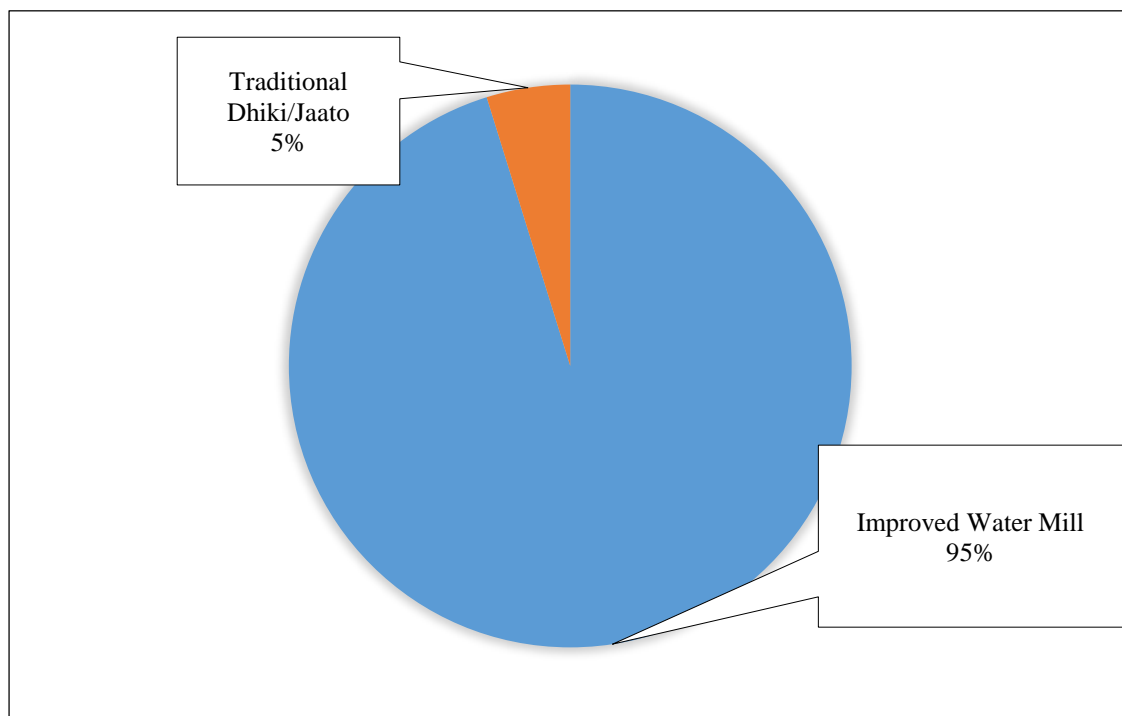
Agro-processing mills in Dolpo Buddha RM, situated in the upper Dolpa region, play a crucial role in local agricultural activities and economic development. These mills are specialized facilities designed to process agricultural products such as grains, cereals, and other crops. By utilizing mechanical processes, these mills help transform raw agricultural materials into value-added products, contributing to food security and livelihood enhancement within the community.

The agro-processing mills serve as vital assets for the local farmers, enabling them to efficiently process their harvests and minimize post-harvest losses. These mills likely include water mills, which utilize the power of flowing water to drive machinery and facilitate various processing tasks. Given the rugged terrain and remote location of upper

Dolpa, these agro-processing mills represent a sustainable and eco-friendly means of adding value to agricultural produce without heavy reliance on external energy sources. Besides this, traditional methods of agro-processing, such as *Dhiki/Jaanto*, still exist in a few numbers.

Figure 6

Agro Processing Means among the Surveyed Households



Source: Field Survey, 2023.

The Figure 6, majority of households (95%) visit their respective Improved Water Mill (IWM) for the agro-processing of food grain specially Uba. However, some households still process the food grains using *Dhiki or Jaanto* (traditional methods). During the field study, a total of ten agro-processing mills were observed. Out of ten water mills, six are privately owned and another four were established with the support from Local Government (LG).

Individually owned IWMs are operated by the owner or their family members. In the case of community-owned mills, an operator is assigned on a rotational basis from

among the beneficiary households for their operation. The average processing capacity of IWM for *Uba* 20 kg per hour and tariffs are collected in both cash and kind. Private owners charge NPR 10 per kg processing whereas community owned water mill charge NPR 5 per kg. The flour produced from water mills is typically of better quality compared to that from diesel mills because it does not undergo heating during the grinding process.

As per the provided data during the field visit, the average cost of installation of IWM including the Ghatta (Traditional technology in rural areas, water mills, commonly known as Ghatta) house is too expensive, was found to be NPR 0.6 million. This technology has also helped in inducing positive changes in the socio-economic conditions of the local millers and the whole community. One of the participants (48) who is Ward Chairperson of Dho said

Time and effort have been saved as the significance of water mills in our village cannot be overstated. For many years, we had been eagerly anticipating the Nepal Electricity Authority's national grid for electrification, but there is no progress, leaving us without access to electricity. Although small solar home systems had been installed at the household level, there was still no possibility to operate electric mills for agro-processing. We had a few Traditional Water Mills (TWMs), but the villagers, especially women and children, faced significant difficulties due to the lengthy processing time. Now, Improved Water Mills (IWMs) in different clusters make life easier, especially benefiting women and children.

In general, previously local people used to manually process their grains at home, which required a significant amount of physical effort and time. The women in the village began advocating for the establishment of faster processing mills. Recognizing the local issues, the Ward office provided financial assistance to improve the water mills, which

subsequently alleviated the burdens on women and children. The participant (43) who is local resident of the study area said

With the installation of the grinding mill, the processing of cereal crops has become much easier, saving both time and physical effort, I observed as a local resident of Dho Tarap valley. As a result, women are now able to allocate their time to enhance their livelihoods, attend to their children, and manage household activities. All the villagers are very pleased, and their lives have become more convenient, reflecting on the positive impact. Processing of *Uba* used to take hours with a lot of effort, but now it is completed in a short time. A significant time is saved after installation of IWM.

Source of Information

The significance of information sources in promoting and adopting RETs is paramount. Various individuals and channels, such as neighbors, relatives, dealers, and family members, have played pivotal roles in facilitating the installation of RETs. Their encouragement and advocacy have greatly influenced potential users to embrace these technologies. These sources initiated the dissemination of information about RETs, actively engaged in conversations and recommendations regarding RE systems.

Neighbours and relatives, being part of the immediate social circle, wield considerable influence on decision-making, sharing experiences and success stories that inspire others. Dealers and distributors of RE systems offer expertise and guidance, addressing technical queries and fostering confidence in adopting RETs. Family members, integral to daily life and decision-making, also contribute significantly by understanding and advocating the benefits of RETs. To evaluate the effectiveness of these information sources, the study collects data on individuals' sources of information for

installing clean energy solutions, offering valuable insights into decision-making channels for RET adoption.

Table 31

Source of Information

Source of Information	Number	Percentage (%)
Promoters and Local Organizations	49	19.60
Rural Municipality Office	72	28.80
Promotional materials	29	11.60
Neighbours/Friends/Relatives	71	28.40
Social Media	29	11.60
Total	250	100.00

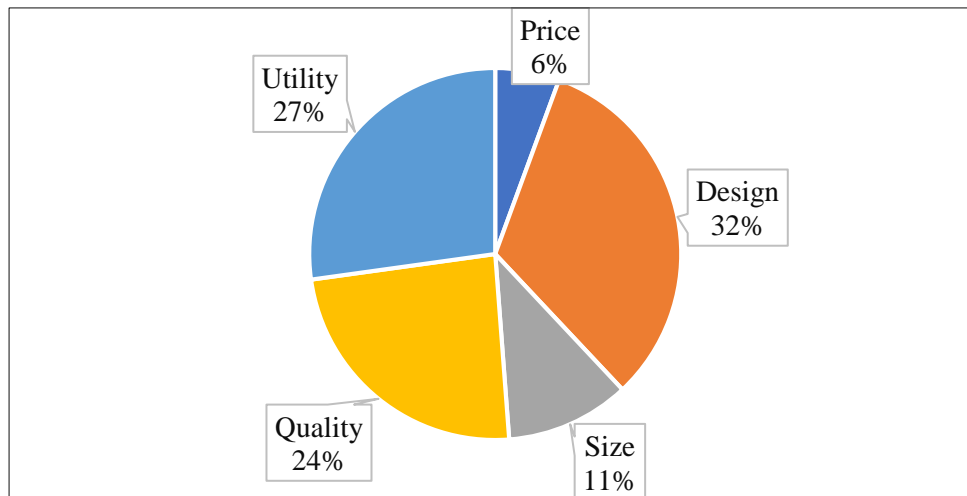
Source: Field Survey, 2023.

Promoters and local organizations contributed 19.60 percent of the data, while the Dolpo Buddha RM Office provided 28.80 percent. Promotional materials were another source, accounting for 11.60 percent. Neighbors, friends, and relatives played a significant role, contributing 28.40 percent. Social media platforms were also a prime source of information for 11.60 percent of households.

The survey reveals that neighbors, friends, relatives, and the RM office are instrumental in motivating local people, as these sources cover two-thirds of the respondents.

Reason for Installation

Assessment was conducted regarding the reasons for installing SHS, ICS, IWM, and other RE technologies with the owners in the study area. The envisaged reasons encompass better quality, utility of the installed system, system size, design, and price attributes. These reasons are presented based on their preferences. Figure 5 provides details about the product attributes that influenced the purchase decision.

Figure 7*Product Attributes that Influenced in Purchase Decision*

Source: Field Survey, 2023.

The installation of the RE system can be attributed to several key reasons, as outlined by respondents. A total of 14 respondents (6 %) cited price as a motivating factor. The design aspect played a significant role, with 81 respondents (32 %) emphasizing its importance. Size considerations were noted by 27 participants (11 %), while 60 respondents (24 %) highlighted the factor of quality. The utility of the RE system emerged as a major driver, with 68 individuals (27 %) indicating its significance in their decision-making process.

Energy Consumption Patterns

In the remote and challenging landscape of the Dolpo Buddha RM, nestled within the last mile villages, distinct energy practices influence the daily lives of its inhabitants. Cooking practices in rural households predominantly involve the use of traditional solid fuels, including dung cakes and fuel wood, which have been deeply ingrained in local traditions. This is followed by a noticeable yet somewhat limited adoption of LPG for cooking. SHS are popular for lighting purposes, and people are seeking better electricity services. The monthly average of surveyed households' energy consumption patterns particularly for cooking purpose is given below.

Table 32*Monthly Average of Surveyed Households' Energy Consumption*

Energy Type	Unit	Minimum	Maximum	Mean	Std. Deviation
Dung Cake	Kg	200	900	479.20	195.85
Firewood	Kg	300	550	419.00	70.06
LPG	Number	1	2	1.05	0.21
Crop Residue	Kg	20	20	20.00	0.00

Source: Field Survey, 2023.

According to the survey findings, dung cake consumption ranks highest, with an average of 479.20 kg (range: 200-900 kg), followed by firewood at 419.00 kg (range: 300-550 kg). LPG utilization averages 1.05 units (range: 1-2 units), while crop residue is used at an average of 20 kg per month. A local technical person (29) from Takshi village stated

After the installation of MICS, it directly contributed to saving the consumption of dung cake and firewood by an estimated 0.5 kg per day. The direct and indirect benefits of MICS include increased thermal efficiency, reduced cooking fuel consumption due to faster processing and efficiency, reduced women's labor, decreased indoor air pollution and related smoke-induced health disorders, prevention of fire hazards, and reduced cooking time. Thus, the use of MICS not only saves dung cake and fuelwood but also reduces the time required for cooking and cleaning utensils in a smokeless environment.

Analysis of Changes in Daily Life after RE System Implementation

Within this section, the focus shifts towards an investigation of the significant changes in the daily lives of rural inhabitants subsequent to the installation of RE systems. Clearly discernible is the categorization of SHS end uses into two distinct categories: consumptive and productive end uses. Furthermore, a comprehensive analysis

delves into the changes in daily life that have arisen following the operation of ICS and IWM technologies in last-mile villages.

Awareness on RET Type

An inquiry was conducted to assess the current state of awareness regarding available RE systems, along with their utility and effectiveness. This inquiry served as the foundation for evaluating the advantages and disadvantages during interactions with the survey respondents and participants in the FGD. They believe that public awareness is of utmost importance, and the RM office has a crucial role in promoting RETs within the local area. Their expectations during the meeting included regular awareness campaigns and capacity-building activities.

Table 33

Awareness Level of Respondents on RETs

Awareness Level	Yes	Percentage (%)
Solar Home System (SHS)	250	100.00
Improved Cookstove (ICS)	250	100.00
Improved Water Mill (IWM)	246	98.40
Solar Minigrid (SMG)	250	100.00
Metallic Improved Cookstove (MICS)	250	100.00
Institutional Solar Photovoltaic System (ISPS)	150	60.00
Solar Pumping Systems	25	10.00
Parabolic Solar Cooker	5	2.00
Solar Dryers	35	14.00
Micro Hydropower/Peltric Set	75	30.00
Gasifier	1	0.40
Bio-briquettes	3	1.20
Wind energy	35	14.00
Biogas (gobargas)	102	40.80
RE Programs	5	2.00
Provision of RE Subsidy Policy	3	1.20

Source: Field Survey, 2023.

The awareness levels of local inhabitants on RETs in the Dho Tarap Valley indicate a high level of familiarity with certain technologies. Solar Home Systems (SHS), Solar Mini Grid (SMG), Improved Cookstoves (ICS), and Metallic Improved Cookstoves (MICS) each have a 100% awareness rate among the surveyed population (N=250). Similarly, the Improved Water Mill (IWM) has a high awareness level at 98.4%. However, awareness of other RE technologies varies significantly. Institutional Solar Photovoltaic Systems (ISPS) are known to 60% of respondents, while Solar Pumping Systems and Parabolic Solar Cookers have much lower awareness levels at 10% and 2%, respectively. Awareness of Solar Dryers and Wind Energy stands at 14%, and Micro Hydropower/Peltric Sets are known to 30% of the population. Biogas (gobargas) has a 40.8% awareness rate, whereas Gasifiers and Bio-briquettes are known to only 0.4% and 1.2% of respondents, respectively. Awareness of RE Programs and the Provision of RE Subsidy Policy is also low, at 2% and 1.2%, respectively.

The majority of respondents were fully aware of SHS, ICS, IWM, Solar Minigrid, and other pertinent RE systems. However, it was noted that local residents displayed a lack of familiarity with the existing RE policies and the provision of subsidies for specific RE technologies.

Energy Access and Gender Perspective

In Dolpo Buddha RM, over 95% of the energy consumed for cooking purposes is derived from biomass, as indicated in the Municipal Profile of 2074. The adoption of clean cooking solutions in rural areas is characterized by limited access. Dung cakes and fuelwood account for nearly all of the cooking energy requirements, although the use of LPG is also on an increasing trend. The extended time required for fuelwood collection due to scarcity in their area, along with the use of low-grade dung cakes and agro-residues, has significantly impacted the health status of women.

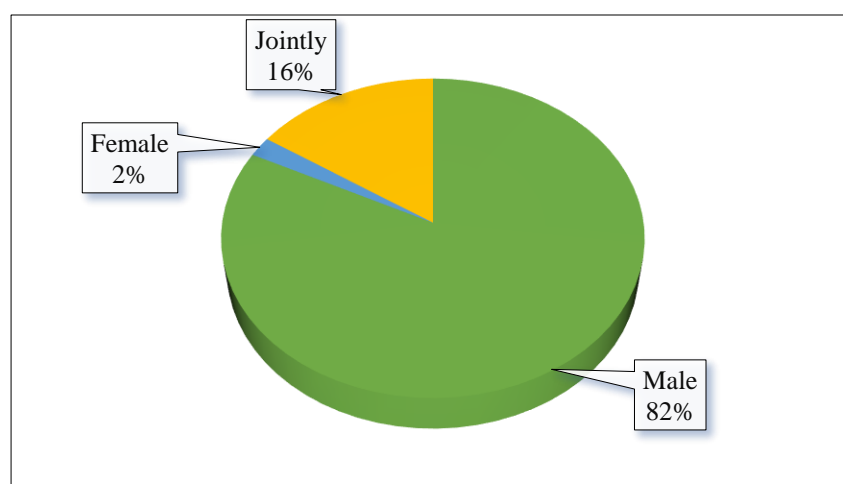
Access to clean energy services plays a crucial role in achieving the targets of SDG-7, with a specific focus on women and energy linkages. Increasing women's involvement in the new energy mix approach can ensure that women's groups benefit. In this context, several inquiries were made to female members to assess whether the installation of RE systems has made any difference in the women's empowerment process. This is further supplemented by asking questions about women's participation in household decision-making, income-generating activities, and control over resources. All the questions were tried to probe whether the installation of RE systems at the household level has any effect on their regular activities.

Decision Making Role at Household Level

In the process of adopting new technology in households, decision making plays a crucial role. In Nepali society, male members traditionally hold greater influence in decision making when it comes to purchasing household amenities. However, when it comes to the purchase decision of cooking solutions, female members emerge as the key decision makers within the family.

Figure 8

Decision Making Role at Household Level



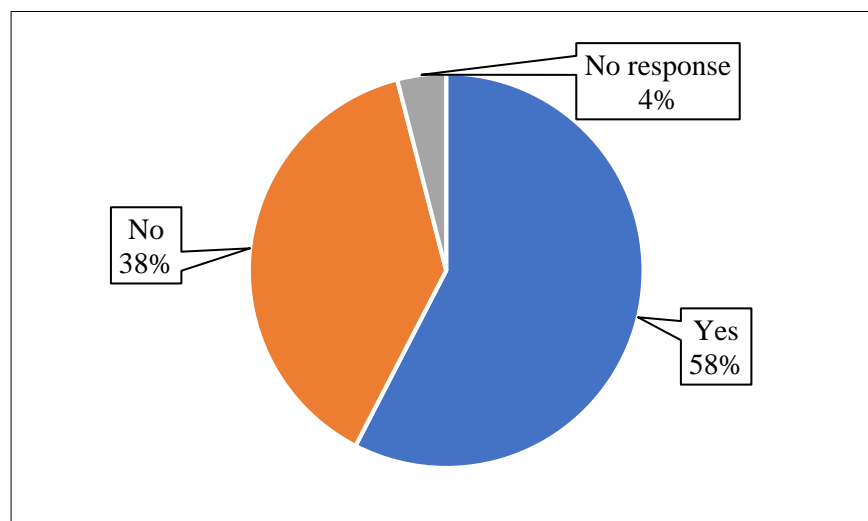
Source: Field Survey, 2023.

In terms of decision-making responsibilities at the household level, the majority (82%) of cases observed male adult members assuming the role of financial decisions, including purchasing household amenities. However, the survey also reveals that in 16 percent of households, this responsibility was shared jointly, while only two percent of households had women taking on the decision-making role.

A follow-up question was asked to the respondents regarding the role of women in decision-making at the household level. It was found that their main role was in purchasing kitchen utensils and managing daily household activities.

Figure 9

Control Over their Income at Household Level



Source: Field Survey, 2023.

One of the indicators of women empowerment is whether they have control over the income of their earnings. Fifty-eight percent of the respondents have expressed that they have control over their income and thirty-eight percent have negative answer while about four percent of the women remain silent in this regard. The high percentage of response towards income control is the hesitance of true reporting about income, decision-making and control over resources. In general, women have less control over household (HH) cash transaction and decision making.

Table 34*Female Participation in Community Activities*

Role of Female Members	Number	Percentage (%)
Yes	228	91.20
No	22	8.80
Total	250	100.00

Source: Field Survey, 2023.

Table 34 illustrates the level of female participation in community activities. Out of a total of 250 respondents, a significant majority of 91.20% indicated that female members actively engage in community activities. A smaller proportion, constituting 8.80% of respondents, indicated that female members do not participate in community activities. This data reflects a positive trend of female involvement in various community activities, emphasizing a high level of engagement and contribution within their society.

Sources of Investment

The investment and financing aspects of the RE system were explored through the survey. Sources of investment plays a crucial role in acquiring RETs, which include SHS and MICS at the household level. Family savings, Yarsha collection and selling, livestock selling, loans, and others were the main sources of initial investment. The participants of the FGD shared similar views on the sources of investment as those reported in the household interviews. Family savings were the predominant source of investment followed by borrowing from village moneylenders and banks. The majority of participants have responded that they installed the RE system on a down payment basis. The amount of investment for both SHS and MICS varies according to size and brand. The cost of SHS varies from NPR 30,000 to NPR 100,000, whereas the cost of MICS varies from NPR 7,000 to NPR 20,000.

Under the prevailing Renewable Energy Subsidy Policy 2022, households in remote last-mile areas like Dolpa receive subsidy support for SHS based on their

capacity. SHS with a capacity ranging from 10 to 20 Wp are granted a subsidy of NPR 5,000, while systems with a size of 50 Wp or above receive a subsidy of NPR 10,000 per household. Similarly, there is a subsidy provision for MICS within the range of NPR 4,000 to NPR 5,000 per system per household. However, survey respondents expressed diverse views on the subsidy amounts and the entities providing them. A significant majority of respondents lacked clear and precise information regarding the specifics of the subsidy provision.

Major Benefits of RETs

This section addresses the effects on various household activities following the implementation of RETs. It encompasses alterations in household routines, information accessibility, health and environmental aspects, social and family interactions, and occurrences of accidents. The study attempted to collect information on households' perceptions of sustainable development indicators. For the purpose of this study, questions pertaining to indoor smoke, better lighting facilities, time saving and its utilization, and other relevant information were inquired with the respondents. Nevertheless, the study findings rely on the households' perceptions of whether such differences have been noticed by the users or not.

Changes in Household Activities

Due to the improved quality of lighting within the household and the extension of daily working hours, various changes are being observed in both social and family aspects of life. Most of the respondents felt that after installation of RETs at the household level has led to noticeable shifts in domestic activities. They observed significant changes in various household tasks such as improved lighting, education, cooking, washing, and cleaning among family members.

Table 35*Study Hours/Working Hours during Night Time after Installation of SHS*

Increased Hours During Night Time	Number	Percentage (%)
1 hour	13	5.20
2 hours	184	73.60
3 and more	35	14.00

Source: Field Survey, 2023.

Table 35 illustrates the increase in study and working hours during night time following the installation of SHS. The majority of respondents (73.6%) reported an increase of 2 hours per night. Additionally, 14% of respondents experienced an increase of 3 or more hours, while 5.2% reported an increase of 1 hour. These findings suggest that the installation of SHS has significantly extended the productive hours available during the night.

More than 50 percent of the respondents noted that the impact of enhanced lighting on male activities is limited, as most domestic chores are predominantly carried out by female members. Nonetheless, male engagement in activities like social work, chatting, and providing coaching for child education has shown an increase. This is largely attributed to the newfound ability to conduct these tasks into the late hours of the night. Likewise, the installation of MICS in the kitchen has resulted in a cleaner environment and faster cooking processes, as reported by female members. Additionally, the improved facilities have enabled female members to continue working into the late hours of the night. A significant portion of the respondents asserted that the study hours of children have extended following the installation of SHS. The participant (59), Immediate Past Chairperson of Dolpo Buddha RM, said

I reflect on the remarkable transformation of our community has experienced due to the introduction of SHS for the lighting purpose. Before SHS, the community

faced significant energy challenges, relying heavily on fuelwood for cooking and lighting. Kerosene, an expensive alternative, was difficult to transport locally, created further hardships. The scarcity of energy hindered various aspects of daily life. The installation of SHS has brought profound changes. Previously absent formal schools in the area now allow all children to attend locally, easing the burden on families and ensuring access to quality education. Like many others, my family has seen a significant improvement in our quality of life such as the ability to prepare food late at night, enhancing household efficiency. Bright lighting has enabled the identification and removal of contaminants from food, even during nighttime hours. My wife expressed her satisfaction, stating, “Now I can easily clean raw rice and vegetables at night”. Proper lighting also benefits the younger generation, allowing our grandchildren to study during the night, thereby improving their educational opportunities and eye health. The journey from darkness to lighting in Dho Tarap Valley, driven by SHS, has brought about numerous positive changes. Access to electricity has empowered women, improved education, and enhanced overall quality of life. As local demand grows, there is increasing interest in developing SMG subprojects. Local people need more power for eCooking and thermal power, crucial for space heating during the winter season.

Health Benefits and Environment

Upon installation of RE system, it is anticipated that the household environment will improve due to the better quality, smoke free lighting and cooking provision. The anticipated improvements in health primarily encompass respiratory and consumption related issues. The shift to cleaner and more efficient energy sources is expected to have a

positive impact on the overall well-being of household members, leading to reduced respiratory problems and a decrease in consumptive diseases.

Table 36

Reduction in Indoor Air Pollution

Users' Perception	Number	Percentage (%)
Drastically reduced	170	68.00
Reduced	72	28.80
Not reduced	1	0.40
Do not know	7	2.80
Total	250	100.00

Source: Field Survey, 2023.

In the course of the field survey, surveyed households were queried about their perception regarding the decrease in indoor air pollution as a result of adopting MICS. A substantial majority (68 %) of the households reported a significant reduction in indoor smoke, with an additional 28.80 percent acknowledging a perceptible reduction. This signifies that a total of 96.80 percent of respondents have observed a decrease in indoor air pollution due to the implementation and utilization of MICS.

Table 37

User's Perception of Reduction in Health Problems

Users' Perception	Number	Percentage (%)
Eye Infection	212	84.80
Respiratory Diseases	54	21.60
Cough	23	9.20

Source: Field Survey, 2023.

Furthermore, the study aimed to assess the extent of the influence exerted by the adoption of domestic RETs on the health of all family members of the users. All participants were requested to express their opinions regarding the decrease in the occurrence of particular health issues subsequent to the installation and utilization of SHS

and MICS. The majority of respondents indicated that these technologies have notably or simply diminished instances of fire or smoke-related ailments. A significant majority of respondents (84.80%) reported a reduction in eye infections. Additionally, 21.60% of respondents perceived a decrease in respiratory diseases, while 9.20% noted a reduction in cough. During the KII one of the official of Dho Tarap Health Post said

In 2005, the Dho Tarap Health Post embarked on a mission to provide basic healthcare and raise health awareness among students and villagers in the Dolpo region. Over the years, it has evolved into a vital healthcare institution, with a remarkable journey of progress and expansion. The pivotal moment came in 2009, marking the transformation of the health post into a birthing center. The commitment of a nurse and a health assistant, who returned to work after completing their studies in Kathmandu in 2011, further strengthened its services. By 2012, the birthing center was fully equipped with attached toilet bathrooms, indoor wash basins, and a small solar electrification system. In 2015, a significant shift occurred as the health post transitioned to a government-built facility. Today, it operates with dedication under the management of Crystal Mountain Secondary School (CMS) alumni, offering a range of health-related programs to the community. The year 2019 brought a major milestone when the Government of Nepal approved the upgrade of the health post to a 15-bedded hospital, with construction plans underway. This upgrade aims to enhance healthcare services for the people of Dho Tarap and ensure better accessibility to healthcare facilities. Local government support plays a crucial role, providing essential medicines, budget allocations for medical equipment, and hiring local medical staff on a contract basis. This support enables the health post to deliver vital healthcare services effectively. With improved power supply, the hospital will be able to

provide continuous 24-hour oxygen supply to patients and operate essential equipment, including Wi-Fi. Reliable and continuous electricity supply through the SMG project to the hospital will significantly contribute to providing better health facilities to the local community. Furthermore, the presence of the vaccine storage facility at the Dho Tarap Health Post, made possible by the ISPS of 1.5 kWp has ensured the smooth and uninterrupted continuation of vaccination programs for the rural municipality upon receiving vaccines.

Advantage of IWM

Prior to the installation of IWM, the agro-processing technologies used in the area were either home based traditional agro-processing or traditional water mills as revealed by the study. Interestingly, none of households surveyed in the study area used diesel mills as their most prioritized for the agro-processing needs before IWM. The respondents feel that IWM is very beneficial in terms of saving time, faster agro processing and providing better quality products.

Table 38

Major Benefits of IWM

Benefits	Number	Percentage (%)
Save in Time	247	98.80
Increase in Income	25	10.00
Fast Processing	240	96.00
Quality Products	145	58.00

Source: Field Survey, 2023.

A substantial 98.80% (247 respondents) noted that IWM saves time. Additionally, 96.00% (240 respondents) highlighted fast processing as a major advantage. Quality products were identified as a key benefit by 58.00% (145 respondents). Furthermore, 10.00% (25 respondents) indicated an increase in income due to IWM.

Regarding the reduction in drudgery after IWM installation, the field study shows almost all users believe that there is actual reduction in drudgery after IWM.

The time saved as a result of faster agro-processing is being utilized by the beneficiaries in different ways. The responses received from the FGD participants suggest that majority would devote more time to agricultural works, household activities, income generating activities, studies and social works.

Utilization of Saved Time

The installation of MICS has the potential to decrease the workload and drudgery experienced by women and children. This is attributed to the primary responsibility of women and children for gathering dung cakes or fuelwood. With MICS reducing the need for these materials in the kitchen, the burden of collecting them is typically reduced upon the installation and utilization of MICS. The study aimed to capture households' perceptions regarding time savings resulting from the use of MICS. An endeavor was made to gather information across all age groups within the family, focusing on adult male and female members as well as children residing in the households.

Table 39

Time Saved After the Installation of MICS

Cooking Fuel Collection Time	in Minutes			Std. Deviation
	Minimum	Maximum	Mean	
	30	75	59.4	11.866

Source: Field Survey, 2023.

Table 39 depicts the daily time savings attained through the collection of fuelwood or dung cakes, encompassing values spanning from a minimum of 30 minutes to a maximum of 75 minutes. The average time saved per day is computed at 59.4 minutes, accompanied by a standard deviation of 11.866, which signifies the extent of

fluctuation around the mean time savings. Consequently, nearly one hour per day is saved as a result of the installation of the RE system within their households.

Table 40

Use of Saved Time

Particulars	Number	Percentage (%)
Working in the Farmland	101	40.40
Helping Children with their Studies	41	16.40
Cleaning House	42	16.80
Income Generating Activities	35	14.00
Recreational Activities	16	6.40
Social Activities	15	6.00
Total	250	100.00

Source: Field Survey, 2023.

A follow-up question was asked with the households regarding the utilization of the saved time towards useful purpose. As data shows, the saved time is mostly used for income generation, including animal husbandry, handicraft production, small-scale greenhouse vegetable cultivation and agricultural works. Of the total 250 households administered with this question, 40.40 percent reported that they use the saved time on agricultural activities. Similarly, the households also reported that they help their children with their studies (16.40 %), clean their house periphery (16.80%) and involve in social activities (6 %). During the KII one of the male teacher (29) of Crystal Mountain Secondary School, Takshi village said

The SHS has facilitated extended study hours and encouraged parents to provide nighttime coaching for their school-going children. Such systems have contributed to the extension of the daily average working time by two hours for both male and female members. Another significant impact of SHS is improved access to information, with activities such as listening to the radio, watching TV, and using mobile phones becoming common within households equipped with SHS.

Likewise, the installation of MICS has led to a reduction in indoor air pollution and a noticeable enhancement of the household environment. The introduction of a smoke-free kitchen, even when using low-grade biomass like dung cakes, has yielded improved health conditions, particularly in reducing respiratory and eye diseases. However, concerning SHS, the improper disposal of expired batteries could emerge as an environmental concern, given that a majority of locals are unaware of the proper recycling or disposal procedures.

Users' Satisfaction Level

The users' satisfaction with the performance of the installed RE systems was assessed, revealing a range of responses.

Table 41

User's Satisfaction with the Performance of RE System

RE system performance	Number	Percentage (%)
Highly Satisfied	35	14.00
Satisfied	54	21.60
Neither Satisfied or Dissatisfied (neutral)	143	57.20
Dissatisfied	13	5.20
Highly Dissatisfied	5	2.00

Source: Field Survey, 2023.

The study data reveals that the majority of households are neither satisfied nor dissatisfied with the performance of their system. Among the respondents, 14 percent expressed a high level of satisfaction, while 21.60 percent indicated being satisfied with the performance. A significant proportion, comprising 57.20 percent, maintained a neutral standpoint, reporting neither satisfaction nor dissatisfaction. The main reason for neutrality is that they received electricity for lighting but not surplus power for heating energy. On the contrary, a smaller percentage, 5.20 percent, conveyed dissatisfaction, and

a mere 2.00 percent voiced a high level of dissatisfaction with the performance of installed RE system. The main reason of dissatisfaction was due to maintenance requirements and associated costs.

Table 42

Level of Satisfaction with Service the Providers (Rank by Households)

Reasons	Number	Percentage (%)
Highly Satisfied	13	5.20
Satisfied	26	10.40
Neither Satisfied or Dissatisfied (neutral)	206	82.40
Dissatisfied	5	2.00

Source: Field Survey, 2023.

The level of satisfaction with service providers, as ranked by households, reveals a distribution of perceptions. Among the respondents, 5.20 percent expressed a high level of satisfaction, while 10.40 percent indicated being satisfied with the service providers. A significant majority, comprising 82.40 percent, maintained a neutral stance, reporting neither satisfaction nor dissatisfaction. Their neutrality in satisfaction with service providers mostly arises from the lack of visits after the installation. Although the systems are operational and continue to provide facilities to rural people since their installation, routine visits by service providers are irregular. On the contrary, a smaller portion, two percent, conveyed dissatisfaction, with no respondents expressing a highly unsatisfied sentiment. This indicates that the routine visit by the installer or supplier company is desired to be more.

Social, Economic, and Environmental Impacts

This section encompasses an in-depth investigation of the multi-layered effects that installed RE systems have on various aspects of society, the economy, and the environment. By scrutinizing these impacts, the study aims to explore the broader

implications of RE system adoption, including how it influences social dynamics, drives economic activities, and contributes to environmental sustainability.

Social Impacts of Energy Practices

The World Bank identifies six dimensions of social capital: groups and networks, trust and solidarity, information and communication, collective action and cooperation, social cohesion and inclusion, and empowerment and political action (Grootaert et al., 2004). Among these six categories, the SHS is anticipated to have a tangible impact on the information and communication component. Access to quality electricity in the village has made lives a lot easier with better lighting facilities especially during the night time while also powering small but widely essential electronic devices such as television, radio and mobile phones.

Similarly, in the context of fuelwood collection and dung cake preparation, the collective action and cooperation among the rural households in the study area was observed. Cooking energy in extremely remote hill areas can have a profound impact on social life. The availability and accessibility of cooking energy sources directly influence daily routines, meal preparation, and communal interactions within these communities. Family members are gathered in the Kitchen due to space heating effect of MICS and actively involved in chitchats. One of the male participant (38) from Kalang village said

In Dolpo Buddha RM, LPG represents a transformative shift in energy practices and socioeconomic dynamics. Its introduction symbolizes modernization, progress, and an improved quality of life. LPG not only reflects a tangible shift towards sustainable energy but also carries the potential to enhance social standing, promote health and well-being, and create opportunities for economic growth through improved living conditions, education, and local entrepreneurship.

Improved Access to Affordable Services

Before having access to solar electricity, local residents were required to travel to Dunai, the headquarters of Dolpa District, for printing and photographs. Presently, these facilities are conveniently accessible within the village itself. Likewise, the distance needed for agro-processing has been notably shortened due to the presence of agro-mills within the village, considerably reducing the time required for such tasks. The absence of reliable electricity access previously hindered service delivery in local hotels. However, the electricity supply from SHS has significantly improved the provision of services for travelers and local residents, offering better lighting facilities and mobile phone charging services.

Community Health Facility

The Institutional Solar PV System (ISPS) of 1.5 kWp capacity has already been installed on the premises of Dho Tarap Health Post. Access to electricity has also contributed to the health sector, especially in maternity and child care. Previously, childbirth, especially during the night was very difficult and risky. However, now the situation is much easier. The regular vaccination program is ongoing. The vaccine storage facility became possible after the installation of ISPS on the health post premises, and the vaccination program has been smooth and uninterrupted, ensuring vaccines are available for the local people.

SHS lighting has improved the safety and security of the area. The area is also highly at risk of snow leopards and wildlife, and the risk is significantly reduced with lighting facilities at night when walking outdoors and using outdoor toilets. The male participant (59) during KII who is local traditional healer mentioned

In the Dolpo Buddha RM, traditional healing practices hold a special place in the lives of local inhabitants. Local people in this region prefer to consult Amchis for

their healthcare needs. These practices have deep historical roots in Dho Tarap, where access to modern medical facilities remains limited. Most locals primarily seek treatment at the Amchi hospital, locally known as “Dolpo Menchi Khang Centre School,” with only a minority visiting health posts. Interestingly, even those who use modern health centers often consult traditional healers alongside. The school has also benefited from a solar home system, which provides lighting and power supply for nighttime consultations. The improved lighting facility and power supply will support the grinding of herbal products in the near future.

Economic Impacts of RE Uses

Energy is a fundamental component of economic growth. The interaction between energy supply and demand has a substantial impact on whether a sustainable energy framework is feasible. Not only do historical consumption patterns influence the energy landscape, but also changing economic systems. To assess the possible consequences of altering economic dynamics on the energy sector, it is crucial to understand the relationship between various economic indicators and historical consumption patterns.

With the installation of RE systems in rural areas brings about significant positive economic impacts. The adoption of such systems leads to improvements in fundamental livelihood indicators and contributes to the overall economic development of rural communities. In contrast to traditional energy practices like burning dung cakes, which have dual negative consequences: extreme air pollution and loss of compost/fertilizer. By transitioning to renewable energy sources, these adverse effects are diminished. The reduction in air pollution improves the health and well-being of local residents, leading to decreased healthcare costs and enhanced labor productivity. A participant (46) from Dhoru village said

The installation of metallic ICS in the study area has resulted in substantial dung savings (approximately 0.5 kg of dung cake per day). The saved dung can be used as fertilizer, promoting sustainable agricultural practices. Moreover, the installation of different RE systems generates employment opportunities, as well as skills development, in the maintenance and operation of these technologies. The supplier company provided basic knowledge regarding the operation and maintenance of installed RE systems. Additionally, three to five persons in the local area have gained employment opportunities through RE promotional activities. As a result, rural economic development is stimulated, creating a more sustainable and prosperous future for entrepreneurship development.

Rural residents invest significant time and effort in fuel gathering due to the high biomass consumption of conventional cooking methods. This burden of fuel collection prevents women and children from engaging in educational, social, and income-generating activities.

Table 43

Economic Assessment of Energy Uses at Household Level

Energy Source	Unit	Market Price (NPR)	Existing Use	Economic Impact Analysis
Fuelwood	Bhari	1000	Yes	High transportation costs per yak; scarcity increases overall cost.
Kerosene	Litre	400	No	Completely replaced; significant savings due to non-use.
Candles	Number	50-100	No	Completely replaced; significant savings due to non-use.
Dry Cell Batteries	Pair	250	No	Completely replaced; cost savings from alternative energy sources.
LPG	Cylinder	8000-10000	Yes	Increasing use due to fuelwood scarcity;

Energy Source	Unit	Market Price (NPR)	Existing Use	Economic Impact Analysis
				high cost impacts household budgets.
Dung Cake	Kg	0	Yes	Freely available; cost-effective but labor-intensive.
<i>Jharro</i>	Number	0	Yes	Minimal use, freely available, labor-intensive.

Source: Field Survey, 2023.

Fuelwood, priced at NPR 1,000 per bhari, incurs high transportation costs and scarcity issues. Kerosene, candles, and dry cell batteries, previously used, have been completely replaced, resulting in substantial savings. LPG, costing NPR 8,000-10,000 per cylinder, is increasingly used due to fuelwood scarcity, though it strains household budgets. The cost of transporting LPG cylinders to distant settlements is high-priced. Dung cakes and *Jharro*, both freely available, are cost-effective but labor-intensive.

RE Costs and Affordability

The cost of energy, whether it be electricity, cooking fuel, or heating sources, has a big impact on how much it will cost to live generally and run a business. For marginalized communities in particular, affordable energy is crucial to ensure fair access to necessities like heating, cooking, and lighting. High energy costs may put a burden on household finances and force trade-offs between those costs and those of other necessary products and services. Energy affordability also affects the competitiveness of enterprises and the expansion of the entire economy. To promote energy security, reduce social inequality, and support successful economies, it is essential to strike a balance between sustainable energy sources, effective technologies, and affordable pricing structures.

Table 44*RE System and Accessories Cost*

Rating of RE costs	Number	Percentage (%)
Very High	7	2.80
High	92	36.80
Average	132	52.80
Cannot Say	19	7.60
Total	250	100.00

Source: Field Survey, 2023.

The cost of the installed RE system and its accessories was measured using a rating scale of RE costs ranging from 1 to 4, indicating levels of 'cannot say,' 'average,' 'high,' and 'very high.'

Table 44 presents a rating of costs associated with RE systems and their accessories from the users' perspective. In terms of price, 7 users reported it as 'very high,' 92 users claimed it as 'high,' while the majority of users (132) described it as 'average.' Additionally, 19 users were not able to provide this information, potentially indicating uncertain or unreported costs.

Environmental Impacts of RE Uses

Nepal may not be a major contributor to greenhouse gas emissions, but due to its location and topography, it is highly vulnerable with the impacts of climate change. The study area is rich in ecological diversity, with slightly over 80 percent of the land covered by rugged topography. In rural areas, environmental problems are largely related to the depletion of forest resources, loss of topsoil, watershed disruption, landslides, declines in farm production, flooding, indoor pollution, and misuse of pesticides and insecticides. All of these factors have cumulative effects on the physio-biological and socioeconomic environment, as well as on the quality of life. A 42-year-old male climate change activist, during his site visit to the Upper Dolpa region in July 2023, stated

In the present scenario, most households installed 50Wp to 100Wp SHS for lighting. Local people are aware of SHS benefits like lighting, powering TVs and radios, charging batteries and mobiles, and operating grinders. SHS generated no pollution, waste, or noise, and didn't require portable fuels. Environmental impacts of PV technology are mainly from manufacturing solar cells and batteries. SHS used lead-acid or advanced batteries, needing replacement every 5 to 10 years. Proper maintenance and recycling are crucial. SHS reduced kerosene use, cutting CO₂ emissions and improving indoor air quality. It also reduced reliance on disposable dry-cell batteries, which often ended up in the environment.

The study area heavily depends on traditional fuels, which have a critical impact on the fragile environment of the Himalayas and its surroundings. The impact of fuelwood collection on deforestation is a much-disputed question. The biological process itself is complex; the demand for and supply of fuelwood vary considerably over ecologically sensitive areas like Dho Tarap. Difficult accessibility to forest land, tradition and culture, and climatic factors are possible reasons for these variations. The fuelwood deficit is largest in the study area, making the dependence on forests for cooking energy needs unsustainable.

As mentioned earlier, dung cakes constitute a significant portion of cooking fuel, which, in the long term, leads to various serious environmental problems, some of which are already visible. The burning of animal dung further reduces the nutrient content of farmlands. Due to increased use of dung cakes, decreased agricultural land productivity forces farmers to cultivate new land or switch to non-agricultural work, as local villagers added during the FGD. In order to improve the situation, various measures need to be taken. Promoting sustainable and reliable eCooking system is desirable. Additionally, the

availability of MICS that enhance fuel efficiency can help reduce the amount of dung cakes or fuelwood needed.

Physical and Biological Environment of the Study Area

The area experiences pronounced variations in its seasonal climate, with wet monsoon observed from June through September, followed by dry conditions prevailing from October to May. According to SPNP officials, the area has a maximum summer temperature of 15°C and can reach as low as -20°C in the winter season, with an average of 0.8°C. The average monsoon occurs during the months of June and July. The weather is characterized by snow, cold winters, and dry winds. The massive barrier created by the Dhaulagiri and Kanjirowa mountains prevents most of the rain from reaching the Trans-Himalayan area of Upper Dolpa. As a result, places like Takshi, Dho, and Kalang within Upper Dolpa receive less than 500 mm of rainfall annually. Rainfall patterns throughout the year display significant fluctuations (DHM, 2023). These villages are situated in a high hill physiographic region at an altitude of 4100 to 4300 meters.

The area enjoys approximately 300 days of sunlight annually. The average daily duration of sunshine at the site varies, ranging from a minimum of 2.5 to 3 hours in July to a maximum of 7.5 to 8 hours in April. This compares to the national average of 6.8 hours of sunshine per day. The daily average solar radiation fluctuates between 4.15 and 6.76 kWh/m²/day, with an annual average of approximately 5.707 kWh/m²/day (Solargis, 2023). According to local villagers, snowfall occurs intermittently during the three-month period from December to February, accumulating up to 300 mm in depth. The snowfall patterns have been altered, which might be due to climatic variations. During a field visit in June 2023, the researcher also experienced snowfall in the local villages, which had not been seen before, as stated by the villagers.

The geological composition of the site primarily consists of the Higher Himalayan Crystalline, predominantly comprising Precambrian high-grade metamorphic rocks, which include gneisses, quartzites, and marbles. The upper portion is characterized by the prevalence of migmatites and granite gneisses. The principal soil types include Dystrochrepts, Haplumbrepts, and Haplustalfs (SPNP, 2023).

The local mountains are mostly surrounded by rocky hills without dense forest coverage. Grazing occurs in grasslands adjoining the open lands of the village for goats, horses, and yaks. In these remotely located high mountain villages, agriculture and animal husbandry are the main occupations, with goats and yaks being the primary livestock. Many local inhabitants rely on the trade of various medicinal plants, with a specific emphasis on the Caterpillar Fungus *Senensis* (Yarsha Gumba). Unfortunately, the yield of this species is declining due to over-harvesting, premature collection, and potential environmental impact.

The buffer zone of the Shey Phoksundo National Park (SPNP) was declared in 1998. The Buffer Zone Regulation of 1996 envisions community participation in conserving the buffer zone areas of national parks. According to this regulation, 30-50% of the total revenue earned by national parks is allocated to the buffer zone management committee for natural resource conservation and community development.

The SPNP park provides prime habitat for globally threatened species such as the Snow leopard (*Panthera uncia*), Tibetan wolf (*Canis lupus*), Musk deer (*Moschus chrysogaster*), and Red Panda (*Ailurus fulgens*). Additionally, Pallas cats, Himalayan brown bears, Blue Sheep, and Himalayan Tahr are also found in the study area. The northern regions contain barren areas in the upper Himalayas and Trans-Himalayan slope lands, characterized by some Rhododendron, Caragana shrubs, and dominant species like Salix, Juniper, White Himalayan Birch, and occasional Silver Fir in the high meadows of

the Himalayas (SPNP, 2023). The Trans-Himalayan ecosystem and cultural richness of SPNP hold significant potential to contribute to the rural economy of its residents, including the buffer zone like Dolpo Buddha RM, through the concept of ecotourism. A male participant age of 62 from Sipcho village said

In the high Himalayan region of Nepal, particularly in Dolpo, Yarshagumba is crucial for local economic survival. This endoparasitic fungus, resembling a caterpillar-fungus hybrid, holds significant economic and cultural value.

Thousands collect it annually, making it a primary income source. Portable solar home systems enhance safety during collection by providing reliable lighting.

The market value of Yarshagumba supports rural livelihoods, but climate change and market volatility pose challenges. Sustainable management is essential for preserving this resource and the well-being of local communities.

Vulnerable Population and Climate Justice

The remote location of Dolpo Buddha RM magnifies the impact of climate shifts, rendering the inhabitants disproportionately susceptible to their consequences. The livelihoods of these rural communities are deeply rooted in traditional practices such as agriculture, animal husbandry, and the sustainable use of natural resources. However, the changing climate disrupts these age-old rhythms. Unpredictable weather patterns have become the new norm, leading to unreliable growing seasons, reduced crop yields, and more frequent livestock losses. The delicate balance between nature and human sustenance is now imbalanced, ultimately threatening the cultural and economic foundations of the Dolpa inhabitants.

Climate justice demands that the global community recognizes the role of these vulnerable populations play in the climate crisis. The carbon emissions of these local communities are negligible compared to global emissions, yet they bear the brunt of the

consequences. As climate-induced hardships deepen, an urgent need for equitable solutions arises. The principles of climate justice call for comprehensive support systems that empower these communities to adapt and thrive.

Localized strategies must be prepared and implemented, incorporating traditional knowledge with modern technologies to build resilience. Access to clean and renewable energy, diversified livelihood opportunities, and education on climate-smart practices are essential to secure the future of local inhabitants in Dolpo Buddha RM. Collaboration among local stakeholders, governmental bodies, and international organizations is crucial to create sustainable pathways out of vulnerability. In the pursuit of climate justice for the people of Dolpo Buddha RM, the concerned stakeholders have a responsibility not only to address the immediate challenges but also to challenge the systemic inequalities that perpetuate their vulnerability. The promotion and development of clean energy, such as renewable energy technologies (RETs) on a large scale, is just one solution to minimize the adverse effects of climate change at the local level. The Chief Conservation Officer of Shey Phoksundo National Park, Suligad Dolpa, stated:

As a Chief Conservation Officer, I emphasize the critical link between RE uses and rural livelihoods. Our remote community relies heavily on traditional fuels like fuelwood and dung cakes, which harm both the environment and our quality of life. RE systems, particularly Solar Minigrid (SMG) projects, offer a sustainable solution that aligns with our conservation goals. They provide clean energy while preserving the fragile ecosystem of the buffer zone. By adopting SMG and ISPS systems, we improve living standards and create local employment opportunities in installation, maintenance, and operation. This decentralized energy access reduces reliance on harmful fuels, enhancing community health and safety. Moreover, reliable energy supports local businesses

and agriculture, fostering economic growth and resilience against climate change impacts. Achieving this vision sustainably requires careful planning, investment, and community engagement. Collaborations with governmental agencies, NGOs, and the private sector are crucial for successful implementation. Our goal is to transform Dolpo Buddha RM into a sustainable and economically vibrant region while safeguarding its natural beauty and biodiversity.

Chapter V

Enablers and Barriers to Wider Uptake of RE Systems

The broader adoption of RE systems is influenced by a complex interplay of enablers and barriers that shape their integration into various sectors. These factors significantly impact on the pace and scale of RE technology implementation. Enablers act as catalysts that facilitate the uptake of RE systems, while barriers present challenges that hinder their widespread adoption. A thorough analysis of these enablers and barriers is essential for understanding the dynamics of RE system implementation and formulating effective strategies for promoting sustainable energy practices. This section explores the key enablers and barriers that contribute to the wider uptake of RE systems in the energy landscape of Dolpo Buddha RM.

Enabling Factors for RE System Implementation

The successful implementation of RETs relies on a range of enabling factors that collectively facilitate a transition to sustainable energy. A robust policy framework forms the cornerstone, while technological advancements continuously enhance the feasibility and efficiency of RE systems. Financial support mechanisms, such as grants and subsidies, alleviate financial barriers and bolster the economic viability of RE investments. Moreover, educating stakeholders about the environmental and economic benefits of RE fosters support and dispels misconceptions, creating a receptive mindset among consumers. Adequate infrastructure, including road connectivity and smart grid, ensures efficient energy distribution and utilization, while community participation enhances acceptance and aligns projects with local needs.

The following section discusses major enabling factors, focusing on their relevance to the study area.

Table 45*Enablers for RE Use in the Study Area*

Enablers for RE Use	Percentage (%)
Community Participation	100.00
Innovating Technology	58.00
Capacity Building	82.00
Social Factors	42.00
Strong Local Government	96.00
Local Partnership	92.00
Market Opportunities	99.20
RE Subsidy Policy	36.00

Source: Field Survey, 2023.

The enablers for RE use in the Dho Tarap Valley are diverse. Community participation is universal at 100%. Innovating technology is adopted by 58%, whereas capacity building reaches 82%. Social factors influence 42%, and strong local government support is evident at 96%. Local partnerships are robust at 92%. Market opportunities are nearly universal at 99.2%. However, the RE subsidy policy impacts only 36%. These enablers collectively highlight critical areas for enhancing RETs implementation in the region.

Table 46*Enabling Factors for RETs Implementation*

Enabler	Description	Impact Level (Low/Medium/High)	Remarks
Government incentives	Subsidies, tax rebates, grants	High	Subsidy provision for all RETs
Technological advancements	Improvements in efficiency and cost reduction	High	Cheaper and more efficient system
Public awareness	Increased awareness and	Medium	Information

Enabler	Description	Impact Level (Low/Medium/High)	Remarks
	education about RE benefits		dissemination on RETs
Policy support	Strong regulatory framework and policies	High	Different programs and policies
Access to finance	Availability of soft loan	Medium	Soft loans for RE projects
Infrastructure development	Road access, communication	High	Ease transportation
Market demand	Enterprises and growing demand	Medium	Energy mix, provide surplus power
Environmental Concerns	Rising awareness of climate change impacts	High	Preference for low-carbon solutions

Source: Field Study, 2023.

Government incentives, such as subsidies, tax rebates, and grants, have a high impact on the adoption of RE sources by providing financial support for all RETs. Technological advancements, which improve efficiency and reduce costs, also have a high impact, resulting in cheaper and more efficient systems. Public awareness, through increased education about the benefits of renewable energy, has a medium impact, facilitated by information dissemination on RETs. Policy support, characterized by a strong regulatory framework and various programs, has a high impact on the promotion of renewable energy.

Access to finance, particularly through the availability of soft loans, has a medium impact by enabling funding for renewable energy projects. Infrastructure development, including road access and communication, has a high impact by easing transportation and connectivity. Market demand, driven by enterprises and growing energy needs, has a medium impact by contributing to an energy mix and providing surplus power. Lastly,

environmental concerns, with rising awareness of climate change impacts, have a high impact by fostering a preference for low-carbon solutions.

Community Participation

Access to cleaner energy, especially for household lighting and cooking, serves as one of the indicators used to determine the economic status of a particular family. During the field survey, it was observed that almost all families in the surveyed households continue to rely on biomass-based energy for cooking and household heating. The Ward chairperson of Kalang village said

Over the past three decades, the term "participation" has been incorporated into the vocabulary of Development Partners (DPs), Government Agencies, and local NGOs' programs and projects, at both the study and implementation levels. In Dolpo Buddha RM, indigenous people have been using dung cakes as a primary source of cooking fuel, significantly replacing fuelwood. They gather the required dung cakes from the pasturelands according to their needs. Local people have a cultural tradition of collaborative efforts for fuelwood collection, dung cake preparation, *Uba* plantation, harvesting, and other tasks as well. Even household-level energy systems are purchased only after consulting with their neighbors. If a community leader suggests or introduces any new technology, the local villagers will follow the instructions they received.

Community participation is a fundamental and indispensable aspect of RE development, particularly evident in the context of Upper Dolpa, Nepal. The successful implementation of various RE initiatives, such as Solar Home Systems, Solar Parabolic Cookers, Improved Metallic Cookstoves, and Improved Water Mills, has demonstrated the significant role that engaged and empowered communities play in driving sustainable energy transitions.

Table 47*Role of Community Participation on RE Projects*

Impact area	Percentage (%)
Social acceptance	99.20
Sustainability	83.20
Operation and maintenance	100.00
Cost efficiency	47.20
Social equity	42.00
Knowledge and capacity	90.00

Source: Field Survey, 2023.

Table 47 highlights the crucial role of community participation in RE projects. Social acceptance is exceptionally high at 99.20%, indicating strong community support. Sustainability is also significant at 83.20%, reflecting the projects' long-term viability. Operation and maintenance score a perfect 100.00%, showing the community's dedication. However, cost efficiency is lower at 47.20%, indicating financial challenges. Social equity is at 42.00%, suggesting issues in fair benefit distribution. Knowledge and capacity are strong at 90.00%, indicating substantial community understanding and skill development.

Community participation positively impacts project acceptance, sustainability, cost efficiency, social equity, and knowledge and capacity, though it may also lead to potential delays, reliance on volunteer efforts, initial engagement costs, exclusion risks, and the need for additional training.

Recently, the Dolpo Buddha RM initiated activities to develop community scale Solar Minigrid Projects (SMGs) in Dho Tarap Valley. Local participation creates an enabling environment that fosters a sense of ownership, empowerment, and shared responsibility. By involving local residents in the planning, decision-making, and execution phases of these proposed projects, the initiatives will be tailored to the unique

needs and preferences of the community. This bottom-up approach will ensure that the solutions put forth are contextually relevant, effectively addressing the specific energy requirements and socio-economic conditions of the area. The provision of better electricity could lead to the establishment of various types of electricity-based enterprises. The potential enterprises include agro-processing mills, printing and photocopy services, communication towers, metal workshops, poultry farms, and more. A male participant of 39 in Sipcho village clearly stated that

The community consultation will act as a catalyst for knowledge dissemination and skills development. The collective efforts of local people, working hand in hand with technical experts and relevant stakeholders, will not only ensure the successful deployment of the SMGs but also instill a sense of unity and shared ideas. This unity will be crucial for gathering support, addressing potential challenges, and maintaining the system over time. Additionally, when rural people actively participate in the construction and development of SMGs, they will not only enhance their livelihoods through improved energy access but also create opportunities for local employment and entrepreneurship. By engaging local residents in decision-making, implementation, and ongoing management, such type RE projects will become more relevant, sustainable, and impactful.

Innovative Technology

The study area can be accessed within a two-day walk from the district headquarter Dunai. However, due to its remote geographic location and its position within the buffer zone of Shey Phoksundo National Park, the extension of the national grid electricity to this area presents significant difficulties (NEA, 2023). The local population relies heavily on biomass resources, particularly dung cakes, for their cooking energy needs. One of the key challenges in this alpine, high-altitude region is the perennial

scarcity of fuelwood. Additionally, the availability of LPG is also a major concern due to its high cost (Dolpo Buddha RM, 2023).

Despite these challenges, Nepal has established its national targets aimed at achieving the Sustainable Development Goals (SDGs). In this context, the implementation of portable small-scale RE Systems such as SHS, MICS, and Solar Parabolic Cookers emerges as a practical solution for domestic energy requirements. Furthermore, the potential of SMGs and existing water mills at the community level holds significant capacity. These innovative technologies offer a pathway towards promoting RE adoption within the local community. One of the officials, aged 32, in Dolpo Buddha RM highlighted that

Innovative technologies play a key role in enabling the broader acceptance and adoption of RE solutions in the region. These initiatives not only address the immediate energy requirements but also align with Nepal's sustainable development aspirations. By leveraging these advanced systems, Dolpo Buddha RM can make substantial progress towards achieving its Sustainable Development Goals (SDG) and its targets, improving energy access, and fostering rural development.

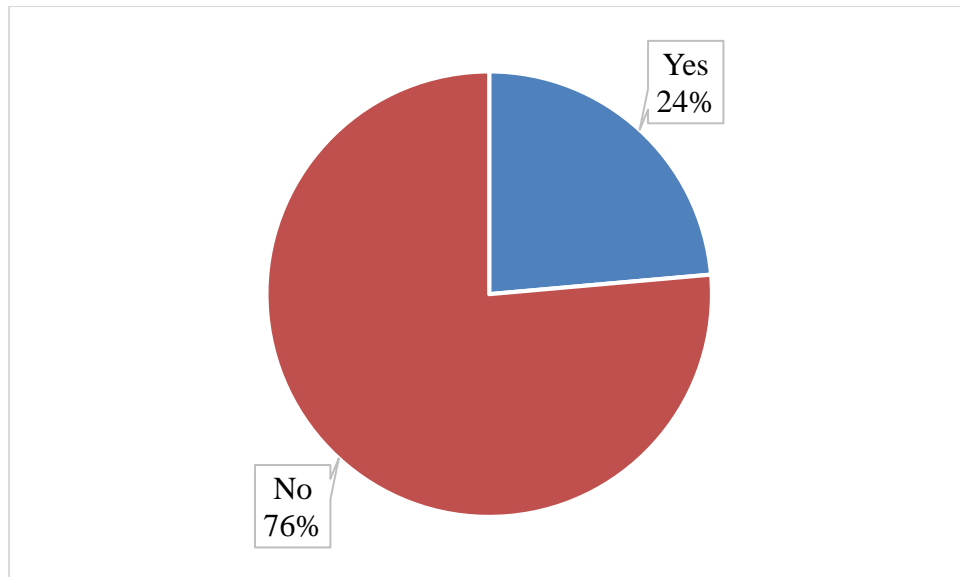
Capacity Building

Energy plays an indispensable role in driving economic and social progress, as well as enhancing the overall quality of life. A dependable and affordable energy supply stands as a pivotal factor in fostering socio-economic growth. The difficult topography and dispersed rural settlements prevalent in the region necessitate substantial investments in the development of rural infrastructure, particularly in the realm of energy services. Thus, it is widely recognized that achieving electrification in rural areas, whether through grid connectivity or off-grid solutions, lacks commercial viability. Consequently, this

undertaking demands supplementary financial contributions from diverse Development Partners (DPs) or governmental entities. The Government of Nepal has duly acknowledged the significance of energy in the comprehensive advancement of the nation, particularly in its pursuit of sustainable development targets and as a crucial component in its poverty alleviation endeavors. A female participant (54) from Dho village said

Local people are well-informed about the benefits provided by existing RE systems in our area. For instance, the savings on kerosene and battery expenses, improved indoor air quality due to smoke-free kitchens, enhanced lighting conditions, and the ability to access television and radio broadcasts. She also voiced the notion that cheaper RE systems tend to be less durable, whereas more expensive options often remain financially out of reach. Moreover, training programs focused on enhancing awareness about the utilization of RE systems are also needed to both households and school children.

A few training sessions supported by the RM were centered on technical know-how, income generation, accounting and finance, organizational management, safety awareness, and leadership, among other topics. Ten individuals with prior experience in local radio and mobile repair attended the training facilitated by the RM for RE maintenance and repair activities, specifically focusing on Solar PV systems.

Figure 10*Orientation on Basic Repair and Maintenance of Installed Systems*

Source: Field Survey, 2023.

During the household survey, 59 out of 250 respondents reported receiving orientation on basic maintenance for the SHS. This maintenance includes tasks such as checking and topping up the battery water level, periodically cleaning the solar panel, cleaning the bulbs, and replacing blown fuses. Additionally, majority of respondents indicated having basic knowledge to operate Cookstoves and IWMs.

Some evident outcomes of the capacity-building efforts, such as improved decision-making, institutional development, and the establishment and operationalization of repair and maintenance activities, were observed within the study area. However, it is noteworthy that a considerable gap still exists in terms of capacity building requirements, particularly with regards to the existing and potential entrepreneurs working within the study area. The need for comprehensive capacity building training remains substantial, with a focus on empowering these individuals to effectively navigate the challenges and opportunities presented by the RE landscape.

Social Parameters

The adoption of RE systems in Dolpa is greatly influenced by social factors besides technical and economic ones. In this isolated region with limited traditional energy sources, RE offers significant socio-economic benefits. For rural Nepal, specific enabling factors might differ based on local conditions, infrastructure, and socio-economic factors.

Table 48

Socio-economic Factors as an Enabling Factor for RE Use

Enabling factor	Existing value	Impact on RE
Road connectivity	Within Dho Tarap, not connected outside (2 days foot trails)	Better roads facilitate the ease transport of RE equipment and maintenance
Mobile network	Moderate (Ncell and NTC)	Enhances communication for RE management
Income level	Average household income NPR 53762/month	Higher incomes increase the ability to invest in RE solutions
Education level	Literacy rate below 50%	Higher literacy rates can lead to better understanding of RETs
Employment rate	Low (10%)	Employment opportunities in RE can boost local economies

Source: Field Study, 2023.

Switching from open biomass to RE solution based cooking improves indoor air quality, particularly benefiting women, who often handle household cooking. During the FGD, the majority of participants stated that reliable electricity from RE enables extended study hours for children and broader access to educational content through electronic devices such as radios and lights. This access to information, along with income opportunities from electricity, aids poverty reduction and economic growth. Additionally,

RE fosters community empowerment by providing households with control over their energy supply, promoting self-reliance and resilience. Overall, the social advantages of RE, including improved health, education, income, and empowerment, are key drivers of its widespread acceptance in Dho Tarap village, Dolpa.

Strong Local Government

The prevailing Constitution mandates 22 exclusive powers to the Local Governments (LGs), encompassing the planning and execution of local-level development (as outlined in Schedule 8), together with 15 concurrent powers for local-level functioning (as outlined in Schedule 9). The Local Government Operations Act, 2017 (LGOA), has been enacted to facilitate and empower the local governments that have been established and to define their powers, duties, responsibilities, and relationships with other levels of government.

The LG authorities are preparing annual and five yearly plans. The annual plans help local government to identify bottleneck of development and distribute local resources equally by keeping in mind the goals and targets set by provincial and federal government with regards to different national and global agenda. Furthermore, the LGOA, 2074 has clearly provided mandates to promote RE related policies, technologies and other functions related to small RE projects (upto 1 MW).

In May 2022, the Government of Nepal (GoN) conducted the second election for all 753 local levels throughout the country, followed by Federal and Provincial level elections in November 2022. The elected officials are actively engaged in addressing the needs and concerns of their constituents, implementing development projects, and promoting good governance practices. When queried with Dolpo Buddha RM representatives, they expressed readiness to contribute the necessary matching funds for the financial closure of approved SMG subprojects in the near future.

Local Partnership

Stakeholders in the RE sector engage through various approaches and levels of involvement, with the AEPC leading at the central level. This includes DPs, LGs, Civil Service Organizations (CSOs), private sectors, and financial institutions. A male participant (aged 43) as a local political leader in Dho Tarap said

Local partnerships are crucial for facilitating RE system implementation, involving collaboration between communities, government bodies, NGOs, and private entities. While full subsidies are not provided, beneficiaries contribute cash or kind. LGs show interest in promoting RE systems and monitor system functionality. Persistent local partnerships are essential for long-term viability and improvement. They ensure ongoing sustainability and enhancement of RE systems, reflecting a shared commitment to clean energy. Local participation in planning, construction, installation, operation, and post-installation management is key factor for reliability and sustainability of proposed SMG subproject in Dho Tarap Valley.

Market Opportunities

The substantial renewable resources, particularly its high altitude and sunlight and wind potential due to its rugged environment, provide a strong foundation for the development of RE. There is a sizable market for off-grid and decentralized RE solutions because of increased demand for energy and gaps in access to electricity, particularly in rural areas. Government incentives, subsidies, and supportive policies all serve to encourage investment in RE projects. Opportunities for grid integration and public-private partnerships are presented by the continuing national grid expansion and the private sector's involvement in RE development. Additionally, due to reducing technology costs, RE systems are economically viable and support the SDGs.

Nepal necessitates substantial infrastructure advancement. The accessibility of cost-effective and environmentally sound energy services remains a notable concern within the nation. Since the 1990s, the GoN and DPs have provided support to the RE sector (AEPC, 2023). The viability of RE projects relies on multiple factors, encompassing manufacturing capacity, available resources, infrastructure availability, and geographical location.

Following discussions with a selected group of energy experts, it becomes evident that the concept of subsidies is not favored due to its potential to disrupt market dynamics. One of the participants (48) from AEPC said

The presence of market competition facilitates the punctual execution and advancement of projects. A visible difference of 3 to 4 years in implementation timelines between public sector and private sector projects highlights a prevalent challenge in Nepal. A substantial number of approximately 4 million households and numerous enterprises are reaping the benefits of RE systems, which have been endorsed and strengthened through the collaborative endeavors of the AEPC and its associated partners.

The Constitution has also highlighted the significance of RE as a crucial developmental focus. Considering the globally endorsed goals, notably Sustainable Energy for All (SEforALL), Sustainable Development Goals (SDGs), and Nationally Determined Contributions (NDCs) connected to the Paris Climate Change Agreement, along with the domestic targets outlined in national Periodic Plans, with the aim of achieving universal energy access by 2030, a distinct prospect emerges for the advancement of RE sector.

In spite of robust policies and notable achievements in delivery, approximately 5% of total households in Nepal still lack access to reliable electricity (NEA, 2022).

Additionally, more than 3 million households continue to rely on traditional cook stoves, which pose significant health risks, particularly for women and children (AEPC, 2022). Awareness about energy and financing options still remains inadequate, and there are limited coordinated efforts being made to generate demand. For instance, the study area is equipped with SHS, MICS, IWM, ISPS and only a few parabolic solar cookers. Nevertheless, there remains untapped demand potential for SMGs and other RE infrastructures. In off-grid areas, there exists significant potential for promoting RE systems, which could substantially improve the rural livelihoods of the community.

RE Subsidy Policy

Since the establishment of AEPC in 1996, there has been a consistent provision of subsidies for the promotion of RE in Nepal. The role of subsidies as an enabling factor for RE promotion in Nepal is significant and multi-faceted, contributing to several key aspects of the country's sustainable energy development.

Subsidies make RETs more affordable for individuals and communities, particularly in rural and remote areas with limited financial resources. By reducing the upfront costs, subsidies encourage wider adoption of RE solutions among households and businesses. By making clean energy solutions such as SHS, ICS, IWM, and other RETs more affordable, subsidies help bridge the energy access gap. They directly contribute to rural development by promoting the use of RE technologies that empower local communities. Furthermore, subsidies accelerate the adoption of new and innovative RE technologies, driving technology transfer and knowledge dissemination. During the KII with AEPC personnel, he further highlighted that

The prevailing subsidy policy, the Renewable Energy Subsidy Policy 2022, outlines specific criteria for identifying eligible beneficiaries for subsidies. This ensures that the subsidies are directed towards those who genuinely require

support, such as low-income rural households. The policy identifies and prioritizes specific renewable energy (RE) systems that are eligible for subsidies, helping to channel resources towards technologies that align with the country's energy goals and sustainability objectives. Moreover, clear guidelines in the Renewable Energy Subsidy Delivery Mechanism 2023 are provided regarding the amount of subsidy that eligible beneficiaries can receive for adopting RE solutions. This transparency helps potential beneficiaries plan and make informed decisions. The prevailing policy also defines a streamlined application process for accessing subsidies, ensuring that beneficiaries can easily apply for and receive the financial support they are entitled to.

The existing policy also outlines subsidies for RETs in Remote Hill Category 'A'.

Table 49

RE Subsidy Provision for Remote Hill

S.N.	Subsidy for Remote Hill Category A	Technology Type
1	90%	Micro Hydro, Mini Hydro
2	18000	IWM-Short Shaft
3	38000	IWM-Long Shaft
4	5000	SHS 10-20 Wp
5	10000	SHS 50 Wp and above
6	90%	Solar Minigrid (upto 250 kWp)- LG Owned
7	Upto 65% (not exceeding NPR 500000)	ISPS
8	Upto 90%	Solar PV Pumping System for drinking water
9	Upto 60% (not exceeding NPR 2 million)	Solar PV Pumping system for irrigation purpose
10	Upto 70% (not exceeding NPR 4 million)	Solar street light

S.N.	Subsidy for Remote Hill Category A	Technology Type
11	Upto 80% (not exceeding NPR 9000)	Upto 20 Wp (Solar PV system for religious places)
12	Upto 70% (not exceeding NPR 20000)	50 Wp and above (Solar PV system for religious places)
13	NPR 20000	200 Wp and above (Solar PV to charge batteries/inverters at household level)
14	50% interest subsidy on bank loan for 5 years	For commercial purpose: 1500 Wp
15	75% interest subsidy on bank loan for 5 years	For household purpose: 500 Wp
16	60% of total cost or NPR 15000 (lowest value)	Domestic Solar Cooker
17	75% of total cost or NPR 1 million (lowest value)	Institutional Solar Cooker
18	60% of total cost or NPR 22500 (lowest value)	Solar dryer (3-20 sq. ft.)
19	75% of total cost or NPR 150000 (lowest value)	Solar dryer (21-85 sq. ft.)
20	75% of total cost or NPR 150000 (lowest value)	Solar dryer (85 sq. ft. above)
21	NPR 32500 for 2 m ³ NPR 39000 for 4 m ³ NPR 45500 for 6 m ³ or above	Domestic Biogas System *Additional 10% for targeted group.
22	NPR 4000 for Single or Two pot holes with grate & ash tray NPR 5000 for Three pot holes with water tank NPR 5000 for Three pot holes with grate & ash tray	Metallic Cookstove
23	NPR 495,000 per kW	Wind energy or Wind-Solar hybrid system

Source: RE Subsidy Policy, 2022.

Household's respondents were queried about the availability of subsidies. As previously noted, many beneficiaries/users are unaware of subsidy availability. They often assume that the amount paid to the agent or Installer Company covers the total system cost. Findings indicate that most users (90%) are unaware of the subsidy provider and the exact amount they received. The study further suggests that the subsidy amount should be clearly stated in the price list, and the subsidy provider should widely advertise it through appropriate channels.

The policy emphasizes the importance of monitoring the outcomes and impacts of the subsidy program. Regular evaluation helps in assessing the effectiveness of the subsidies in achieving their intended goals. Additionally, the policy outlines the roles and responsibilities of concerned stakeholders. It could also address the coordination among different stakeholders, such as government bodies, development partners, financial institutions, and technology providers. Effective coordination ensures a unified approach to channeling subsidies to the beneficiaries. However, a critical observation is that the policy still lacks information on how the subsidy program fits into the broader national energy strategy and long-term sustainability goals. It should be ensured that subsidies contribute to a sustainable energy transition.

Analysis of Barriers and Challenges in the Study Area

Development hurdles are primarily caused by political, governance, and socioeconomic dimensions, demanding the nation's utmost attention. Promoting RE systems in Nepal also faces several significant barriers. Limited financial resources pose a challenge, as the upfront costs of establishing RE systems can be high. This financial constraint is exacerbated by the absence of favorable financing mechanisms, making it difficult for individuals and remote rural communities to invest in RE technologies.

Additionally, a lack of awareness and understanding about the benefits of RE systems hinders their adoption. Insufficient technical capacity and expertise, particularly in rural areas, pose obstacles to proper installation and maintenance. Regulatory and policy uncertainties, along with bureaucratic processes, can slow down the implementation process. The expansion of the national grid also impacts the feasibility of integrating RE systems into the existing energy infrastructure. Addressing these barriers requires a collaborative approach that involves financial incentives, awareness campaigns, capacity building, streamlined regulations, and improved infrastructure planning.

Table 50

Barriers for the Market Development of RETs in Dho Tarap Valley, Dolpa

Barrier Type	Description
Institutional	Institutional capacity, limited research and design, demonstration, implementation
Market	Small size of the market, limited access to markets for modern RETs
Awareness	Lack of awareness/ access to information on RETS
Financial	Inadequate financing arrangement (both local & national perspective)
Economic	Unfavorable cost, low subsidies and high energy prices
Technical	Lack of access to the technology, inadequate maintenance facility
Capacity	Lack of skilled human resource and training facilities
Social	Lack of social acceptance and local participation
Environment	No proper valuation of both social and environmental benefits
Policy	Lack of proper co-ordination in between RE sector and market regulatory mechanism

Source: Field Study, 2023.

Table 50 also identifies several barriers to the market development of RETs in Dho Tarap Valley, Dolpa. These include institutional limitations, small market size, lack of awareness, inadequate financing, high costs, technical issues, insufficient skilled labor,

low social acceptance, undervaluation of environmental benefits, and poor policy coordination.

Based on the FGD and KII the following section highlights the major barriers to promoting RE systems in the study area.

Infrastructure Challenges

Developing RETs in remote rural areas of Nepal poses significant infrastructure challenges. These regions, often characterized by their geographical isolation and limited connectivity, require specialized attention to establish robust and sustainable energy solutions. The rugged terrain and lack of proper roads make transporting equipment and materials a daunting task. Additionally, establishing power transmission and distribution networks in these areas demands careful planning due to the challenging topography.

Overcoming these infrastructure hurdles necessitates innovative solutions, such as utilizing off-grid systems that can operate independently. Adequate infrastructure is not only crucial for the successful implementation of RETs but also plays a pivotal role in enhancing the overall socio-economic development of these remote rural communities, providing them with access to essential services and improving their quality of life.

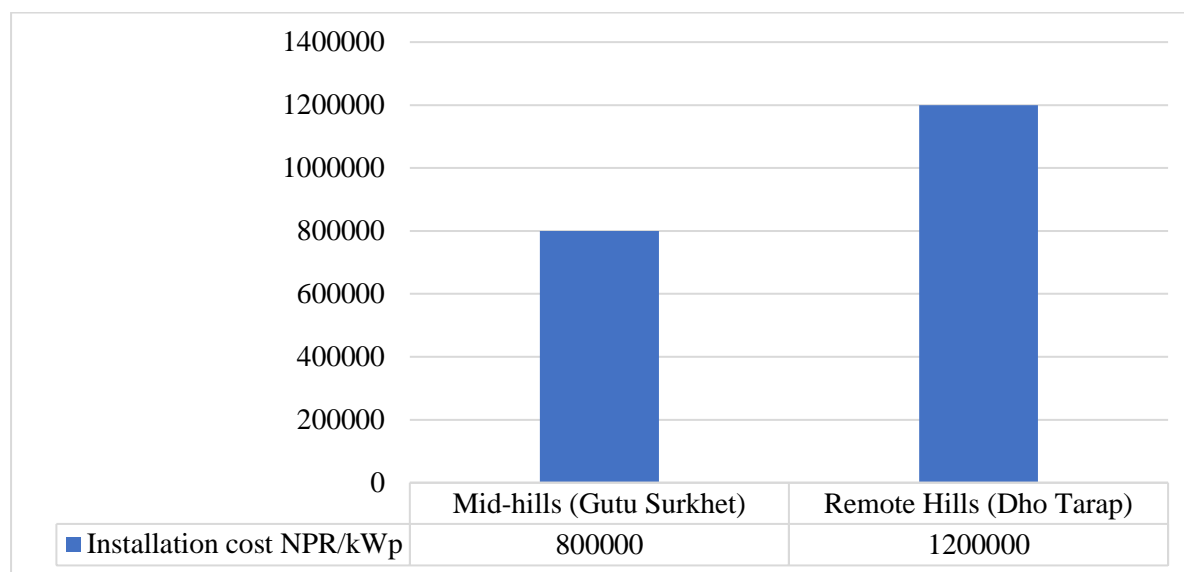
High Capital Costs

The high capital costs associated with RETs implementation in remote rural areas present a formidable challenge to sustainable energy development. The study area, often characterized by limited financial resources and inadequate infrastructure, faces substantial barriers when attempting to promote RE solutions. The initial investment required for the installation and setup of RETs, such as solar PV modules and improved metallic Cookstoves, can be significantly higher than that of traditional fossil fuel-based alternatives.

Moreover, transporting equipment, materials, and skilled labor to these remote locations increases logistical difficulties and costs. As a result, the communities that would benefit the most from clean and reliable energy sources often find it challenging to access and afford RETs due to these financial barriers.

Figure 11

Comparison of Installation Cost Per Kilowatt (Tentative) for SMG Projects



Source: Field Study, 2023 and AEPC, 2023.

When examining the upfront investment required for RE Projects, particularly for SMG subprojects, a comparison of installation costs in two distinct hill regions of Nepal reveals significant cost disparities. According to personnel from the AEPC, the tentative installation cost per kilowatt-peak (kWp) in the mid-hills region (Gutu, Surkhet) is approximately NPR 800,000. In contrast, the estimated installation cost per kWp in the remote hills (Dho Tarap, Dolpa) is notably higher, at NPR 1,200,000. This disparity highlights the increased financial burden associated with implementing SMGs in more remote and challenging terrains. During a KII, one of the energy experts aged 47, from the AEPC stated

The higher costs in remote areas can be attributed to several factors. First, the logistical challenges of transporting materials and equipment to these inaccessible

regions contribute to increased expenses. Second, the lack of economies of scale in remote rural areas further exacerbates the issue of high capital costs. The relatively small energy demand and dispersed population make it difficult to justify the substantial upfront expenditures required for RE projects. As a result, these financial barriers significantly hinder the adoption and development of renewable energy solutions.

Addressing the high capital costs of RETs in remote rural areas requires a multi-faceted approach. The GoN is providing subsidies to offset the initial investment burden. Collaboration with private sector entities can also facilitate innovative financing models that distribute costs over time or involve revenue-sharing arrangements. Furthermore, technological advancements and research can lead to cost reductions over time, making RETs more affordable and accessible. Ultimately, finding the right balance between financial viability, environmental benefits, and social equity is essential to overcoming the high capital costs and unlocking the potential of RE systems in these remote rural areas.

Low Population Density

The Upper Dolpa region of Nepal, renowned for its pristine natural beauty and remote landscapes, presents a distinct set of challenges in energy development due to its low population density. Situated in the northwestern part of the country and bordered by Tibet, China to the north, this region is characterized by rugged terrain, high mountain ranges, and limited accessibility. These geographical features, combined with a sparse population, significantly hinder the establishment of conventional energy infrastructure and create substantial barriers to energy development.

Table 51*Total Area and Existing Population in Dolpo Buddha RM, Dolpa*

Area of Dolpo Buddha RM	377.38 km ² (145.71 sq. m.)
Total Population	2420 (male: 47.4%, female: 52.6%)
Total Population in Dho Tarap valley	1502 (male:701 and female: 801)
Total households	543
Density	6 km ²

Source: Dolpo Buddha RM, 2023.

The low population density in the study area critically impedes energy development efforts. With fewer residents dispersed across scattered settlements, the demand for energy sources remains limited. This limited demand renders large-scale energy projects. The remote location and limited transport infrastructure make the transportation of construction materials, equipment, and skilled labor to the region difficult and costly. This isolation inflates energy development project costs and leads to delays in their completion. The absence of readily available technical skills in the region further complicates matters, as importing experts from distant areas increases expenses and introduces logistical challenges. One of the participants, aged 52, described the problems associated with low population density:

RE sources, such as solar and wind power, might seem like viable alternatives in these circumstances. However, even these options face constraints due to the low population density. The installation and maintenance costs of RE systems, while lower than those of large-scale infrastructure, can still be prohibitively expensive when distributed across a small population. Additionally, the extreme climatic conditions and harsh winters prevalent in the Upper Dolpa region can impact the efficiency and reliability of these RE systems, further diminishing their feasibility.

Lack of Repair Centers

According to the local villagers during a focus group discussion (FGD) conducted at the premises of Dolpo Buddha RM, the lack of repair centers constitutes a notable barrier to the successful implementation and sustainability of RE systems in the study area. This issue significantly impacts the feasibility and long-term viability of implementing RETs in the region. One of the key challenges arising from the absence of repair centers is the vulnerability of RE systems to breakdowns and malfunctions. Without nearby repair centers, residents and communities relying on RE systems for their energy needs experience extended downtime when these systems break down.

During the field observations, few systems (2.4% of installed SHS) were found to be nonoperational due to the lack of repair and maintenance facilities. This disruption not only affects daily life activities but can also result in economic losses, particularly for activities that rely on energy sources like agriculture or tourism (such as homestay businesses). An entrepreneur, aged 45, at Dho village highlighted the challenges faced due to the lack of repair and maintenance centers:

The time and resources required to transport equipment for repair can outweigh the benefits of using RE systems in the first place. Moreover, the absence of repair centers hampers the development of local expertise and technical knowledge. In regions where RE systems are widely used and repair centers are available, a culture of skill development and knowledge sharing often emerges. In the absence of repair centers, the opportunity for local capacity building is limited, and communities remain dependent on external technicians.

To address this challenge, efforts should be directed towards establishing local repair and maintenance facilities equipped with the necessary tools, spare parts, and skilled personnel. Additionally, action should be taken regarding the need for skill

training for the regular and immediate repair and maintenance of equipment, along with the provision of necessary spare parts in the RM.

Socio-Cultural Barriers

The development of RE systems in the last-mile villages of Nepal faced several socio-cultural barriers that needed to be understood and addressed for successful implementation. The unique cultural heritage, traditional practices, and social dynamics interacted with the introduction of RE technologies, often shaping the way these technologies were perceived and accepted by local communities. The Upper Dolpa region is home to indigenous communities with deep-rooted traditional beliefs and practices. The introduction of modern technologies, including RE systems, is sometimes met with skepticism or resistance due to concerns about disrupting traditional ways of life. A proprietor of local hotel aged 48, at Takshi village stated:

The cultural practices in the region are more likely to be accepted when they align with the local community's needs and preferences. For instance, local people are increasingly demanding more power and have expressed a desire to operate electric cooking (eCooking) appliances. However, when selecting eCooking options in the near future, we would prefer infra-red Cookstoves over induction cooktops. The primary reason for this preference is our requirement for space heating. Infra-red Cookstoves not only provide efficient cooking solutions but also contribute to heating the living spaces, which is essential in the cold climate of the region.

Addressing these socio-cultural barriers required a holistic and context-sensitive approach. It should involve active engagement with the community, respecting their traditions, and tailoring the introduction of RE technologies to align with their values and needs. Collaborative efforts that involve local leaders, educational initiatives, and

communication strategies are keys to successfully navigating these challenges and fostering the integration of RE uses in the Upper Dolpa region of Nepal.

Policy and Governing Barriers

During the site visit, interactions were held with key positions within the Dolpo Buddha RM to discuss policy and governance barriers affecting the development of large-scale RE projects particularly proposed SMG subprojects. Promoting RE systems in the last-mile villages of Nepal encounters several policy and governance barriers that must be addressed to facilitate their successful implementation. These barriers are often linked to regulatory frameworks, institutional capacities, and governance structures that impact the feasibility and effectiveness of RE initiatives in the region.

Tables 52 provide a comprehensive overview of policy and governing barriers that can affect the promotion and adoption of renewable energy technologies in Dolpo Buddha RM. It outlines key metrics for evaluating these barriers and their impacts, helping to identify areas for improvement and policy intervention.

Table 52

Policy and Governing Barriers Identified

Barrier type	Description
Lack of clear policy	No clear provision for eCooking from RE source
Regulatory hurdles	Long approval times can delay projects and increase costs.
Inadequate subsidy	Limited subsidy amount creates RE projects financially unfeasible
Poor coordination	It can lead to fragmented efforts and inefficiencies
Permitting challenges	As the area is located in buffer zone, difficult permitting processes can delay project timelines and increase costs.

Source: Field Study, 2023.

A lack of clear policy provisions for eCooking from RE sources creates uncertainty and hinders implementation. Regulatory hurdles, such as long approval times, delay projects and increase costs. Inadequate subsidies make RE projects financially

unfeasible, while poor coordination leads to fragmented efforts and inefficiencies.

Additionally, permitting challenges, especially in SPNP buffer zone, complicate and prolong project timelines, further escalating costs. These barriers collectively impede the effective deployment of RE solutions in rural regions.

Table 53

Local Demand for Electric Power versus Policy Barrier

Locally Preferred Cooking Solution	eCooking system
Power Rating (kW)	1.8
Operating Start Power (W)	1800
Available Power per HH after SMG (kW) as per the Subsidy Policy	0.33

Source: Field Study, 2023 and Desk Study 2023.

Table 53 illustrates a significant policy barrier in meeting local demand for electric power. The locally preferred cooking solution, an eCooking system, generally requires a minimum power rating of 1.8 kW and an operating start power of 1800 W. However, the available power per household after the implementation of the SMG, as directed by the current subsidy policy, will be only 0.33 kW. This discrepancy highlights a critical gap between the energy needs of households and the power provision allowed under existing policy, clearly indicating the need for policy revisions to support the adoption of high-demand electric appliances in rural areas where other alternatives are not viable.

Environmental Challenges

In the context of promoting solar energy in the Upper Dolpa region of Nepal, battery management emerges as a critical environmental challenge and a significant barrier that affects the sustainability of these systems. Battery management is pivotal for the effective functioning and longevity of RE systems, especially in areas with intermittent energy sources like solar or wind.

The harsh climatic conditions of the Upper Dolpa region present a formidable challenge to battery performance and durability. Extreme temperatures, ranging from freezing cold in winters to warm summers, can lead to rapid battery degradation. Batteries are sensitive to temperature fluctuations, and their efficiency can decline significantly under such conditions. As a result, the batteries' lifespan might be shortened, necessitating frequent replacements and thereby contributing to waste generation. Improper disposal can lead to soil and water contamination, releasing hazardous materials into the environment. Given the ecological sensitivity and reliance on traditional agriculture, such contamination can have far-reaching negative consequences for both the environment and local communities.

Policy and Institutional Implications

A range of initiatives intended for the development of environmentally friendly energy sources have been included in current policy and institutional implications for RE promotion in Nepal. The GoN highlights the necessity of expanding RE sources while also diversifying its energy mix. By offering financial incentives for RE projects, the Renewable Energy Subsidy Policy promotes involvement from the private sector. Through subsidy support, capacity building, and technical assistance, AEPC promotes RE projects in Nepal.

Government Initiatives and Regulations

Nepal has implemented various government initiatives and regulations to promote renewable energy within the country. These initiatives are aimed at increasing energy access, reducing reliance on fossil fuels, and mitigating the impacts of climate change. Article 51 (f) 3 of the Constitution of Nepal states, “ensuring a reliable and affordable energy supply and proper utilization of energy by generating and developing renewable energy for the fulfilment of citizens' basic needs”.

Public Participation and Decision-Making

In the RE sector development of Nepal, public participation and decision-making stand as pivotal pillars, ensuring not only the technical viability of projects but also their social and environmental sustainability. Participating in the decision-making process with the general public and local communities encourages ownership, transparency, and accountability, which ultimately improves outcomes for all parties involved.

Prior to initiating RE projects, the government and project developers shall be actively involved in collaborating with local communities, civil society organizations, and other relevant stakeholders to gather input and feedback. This consultation process is helpful in identifying problems, preferences, and potential implications that would be difficult to notice from a purely technical standpoint. It is common practice to hold public hearings so that the community may voice their concerns and ideas with regard to intended developments. Most of the participants during FDG said

Local people need information dissemination, including the users' manual, to be provided in formats that are user-friendly for the community and in local languages. A robust feedback process can help foster community trust and ensure the ongoing success of any development projects. Public participation encourages the alignment of transitioning to RE with local needs, values, and objectives within a broader context. By addressing both environmental and energy security goals, this alignment reinforces objectives at all levels, including federal, provincial, and local.

Future Pathways for Sustainable Energy Practices in the Study Area

The chairperson of Dolpo Buddha RM, during the key informant interview, highlighted the need for solar mini-grids:

In pursuit of sustainable energy practices in Dolpo Buddha RM, significant advancements are expected. We put forth is the local government is planning to launch 4-5 SMG subprojects in the next year. This deliberate action not only improves access to electricity but also lowers carbon emissions. In addition to this effort, an in-depth plan has been demonstrated through the emphasis on improvements in traditional water mills, the adoption of MICS, and other RETs in the area known as the buffer zone. These endeavours align with the priorities of harnessing local resources, empowering local groups, and advancing a sustainable energy transition. The commitment of RM to holistic energy development which promises a more sustainable and resilient future for Dolpo Buddha RM.

During field visit, I met a Swiss Citizen who is a frequent traveller and who returned to the Dho Tarap valley after 30 years said

I noted significant changes in the Dho Tarap area during my visit. Previously, transportation relied solely on mules and foot trails, but now motorbikes are noticeably present throughout the valley. Traditional attire like Radi Pakhi has become rare as locals adopt fancier clothing from Tibet or Nepalgunj, reflecting the valley's modernization and external influences. Mobile phones are now ubiquitous, serving as lifelines for communication and the need for charging batteries a daily ritual. The introduction of greenhouses has signalled a shift in agricultural practices, diversifying diets beyond the staple Tsampa. Since the flour has already been roasted, Tsampa is straightforward to prepare and doesn't require cooking. In fact, it is considered a convenient food and is frequently used by the local villagers, locally known as 'Satu of Uba'. My journey and observations highlight the difficulties of development and preservation in remote areas. A delicate balance is necessary to preserve the valley's natural beauty, respect its

traditions, and encourage sustainable expansion. Locals relied on kerosene and Jharro for lighting prior to the introduction of modest solar home systems. It is particularly difficult to manage batteries in the high-altitude circumstances. LPG use also increased in popularity. The history of Dho Tarap Valley is more than just a record of change; it also serves as a sobering warning about the need for careful development that respects the area's rich mosaic of traditions.

Chapter VI

Demand of RE Systems in the Study Area

In recent years, the pursuit of sustainable energy solutions has gained paramount importance across the globe. Within this context, the challenge of last-mile electrification in Nepal has come to the forefront. As the nation seeks to provide reliable and accessible energy to even its most remote corners, the role of RE sources has emerged as a crucial pathway. This section deals with the demands, potentiality, opportunities, and challenges associated with utilizing RE for achieving last-mile electrification in Nepal.

Energy Demands in the Study Area

Energy demands in the Upper Dolpa region of Nepal are influenced by a range of factors, including socio-economic activities, climatic conditions, infrastructure availability, accessibility, affordability, and the local population's lifestyle. Given its remote and rugged terrain, the energy demands in Upper Dolpa stands apart from more urbanized areas.

Household Energy Needs: The primary energy demand in Upper Dolpa revolves around household lighting, cooking, and heating. Traditional biomass sources like firewood and animal dung are frequently used, leading to indoor air pollution and environmental degradation. Solar Home Systems (SHS) with capacities ranging from 50-100 Wp are being used for lighting and mobile charging purposes. Surveyed households expressed a need for surplus power to operate eCooking solutions such as Kettles, Induction Cooktops, and infrared Cookstoves. Based on field consultations with the surveyed respondents and FGD participants, the daily energy demand was estimated.

Table 54*Household Energy Demand of Surveyed Household*

Required Load	Power (W)	Quantity	Demand factor	Average hours/day	Days/ week	Average Wh/day
LED Lights (3 nos)	5	3	90%	5	7	67.5
LED Lights (3 nos)	7	3	90%	5	7	94.5
Radio and/or Mobile	5	1	90%	2	7	9
Television and/or Wi-Fi	60	1	90%	4	7	216
Electric kettle	1000	1	90%	2	7	1800
eCooking (Induction/Infra)	2000	1	90%	2	7	3600
Total of single household (kWh/day)						3.6

Source: Field Study, 2023.

The Table 54 illustrates the household energy demand for a single surveyed household in Dho Tarap Valley, Dolpa. Given the high deficit of fuelwood in the area, it is assumed that all households follow a similar energy demand pattern. The table details the required load, power consumption, quantity, demand factor (90% assumed), average use hours per day, days per week, and average watt-hours per day for various household appliances. The appliances include LED lights, radio and/or mobile chargers, televisions, electric kettles, and eCooking devices. The total daily energy demand for a single household is calculated to be 3.6 kWh per day. This data is crucial for understanding the energy needs and planning for RE solutions in rural areas.

Livelihood Activities: Agriculture and animal husbandry are pivotal to Upper Dolpo's livelihoods. Energy is crucial for various activities like milling and processing agricultural products, as well as for dairy production, herding, and livestock management.

Tourism: Dho Tarap, one of the highest settlements globally and route to Shey Phoksundo National Park, boasts a buffer zone with cultural and natural attractions,

making it a popular trekking and tourism destination. Energy is needed for cooking, lighting, and heating in guesthouses and lodges, particularly during the tourist season.

Education and Healthcare: Energy plays a vital role in providing lighting and powering computers in schools, as well as refrigeration and other equipment in healthcare centers. The introduction of an X-Ray machine in the local hospital could revolutionize healthcare capabilities. Reliable energy access supports education, health services, and overall community development.

Communication and Connectivity: In an increasingly interconnected world, energy is crucial for operating communication devices and maintaining connectivity, facilitating information exchange and access to services. Regular power supply is required for mobile charging, television, and radio usage.

Religious and Cultural Practices: Dolpo Budda RM is renowned for its monasteries and cultural heritage. Energy is essential for lighting and heating during religious ceremonies and practices.

Public Services and Energy-Based Enterprise: The energy demand in Dho Tarap Valley, Dolpa, is substantial for existing public service institutions, including schools, health posts, monasteries, rural municipality offices; ward offices, women's houses, banks, and police offices. Additionally, there is a significant energy requirement for existing small industries and potential enterprises. Promoting these enterprises aims to develop local entrepreneurs and create employment opportunities, thereby improving rural livelihoods. Furthermore, end-use enterprises will enhance the sustainability of intended SMG subprojects by maximizing electricity use in productive sectors. While the promotion of end-use enterprises greatly impacts livelihoods through job creation, economic activity enhancement, market expansion, and increased awareness, this study also probes the possible enterprises in local context.

Table 55*Potential Demand of Productive Enduses at Dho Tarap Valley*

Potential electricity based enterprises	Number
IME center	1
Photocopy and printing centers	2
Mobile repair centers	3
Hotels and homestay	20
Computer institute	1
Grocery shops	5
Small furniture	2
Poultry farm	2
Cold store	1
Stone cutting	1

Source: Field Study, 2023.

The potential for electricity-based enterprises in Dolpo Budda RM is substantial and diverse. Agro-processing activities can benefit greatly from reliable electricity, improving production and efficiency. The establishment of IME center, photocopy centers, and mobile phone repair centers can enhance local connectivity and accessibility powered by electricity. Electrification of small hotels and drinking water lifting facilities can significantly enhance community services. Furniture shops, cold storage units, computer institutes, grocery shops, and computer repair centers would all thrive with consistent power supply, enriching both business operations and community services.

Localized energy solutions that align with the unique characteristics of the study area will play a crucial role in ensuring that energy needs are met while minimizing negative impacts on the environment. During the KII, the owner of Mountain Star Hotel highlighted the transformative impact of RETs on the local tourism and he said

I have witnessed first-hand the profound impact of RETs on our tourism sector.

Dho Tarap, nestled within the breath-taking Shey Phoksundo National Park, has

become a sought-after destination for its stunning natural beauty and rich cultural heritage at an altitude of 4200 meters above sea level. Despite its allure, the region faced significant challenges with electricity access, which hindered the growth of our tourism industry. Before the installation of SHS, Dho Tarap struggled with sporadic power availability, posing challenges for businesses like the Mountain Star Hotel. Tourists increasingly demanded modern amenities such as Wi-Fi connectivity, reliable heating during cold winters, and operational equipment like grinding machines. Access to stable electricity significantly improved the overall guest experience, allowing tourists to stay connected and share their experiences online, thereby enhancing their satisfaction. Our investment in RE sources particularly solar energy not only elevated service standards but also fostered economic growth and sustainability in the region.

Potential Energy Source in RM

The Dolpo Buddha RM exhibits significant potential for the development of both Solar Energy and Small Wind Energy Projects. However, the feasibility of Biogas installations is rendered irrelevant by the prevailing cold climatic conditions. In addition, the limited water courses deter the implementation of micro or mini hydro projects. The RM further faces challenges due to the scarcity of available biomass resources. Considering the various circumstances, extending the national grid poses difficulties. As a researcher, the following possible options were identified.

In light of this, two plausible alternatives emerge: the implementation of solar-powered energy projects or the establishment of a cross-border grid extension from China. Both options present more viable avenues for addressing the energy needs of the Dolpo Buddha RM. It could provide a reliable and consistent source of energy, mitigating the difficulties associated with extending the national grid across challenging

terrain. This method can enhance energy security for the RM and also strengthen economic and diplomatic connections between the two areas.

Wind-Solar Resource Assessments

The Dolpo Buddha RM holds significant potential for solar energy, as evidenced by various previous studies. Solar home systems have been the primary means of electrifying rural households in the RM until now, and this trend is expected to continue in the near future. This is especially true if the extension of the NEA grid proves difficult due to the challenging buffer zone and rugged topography. A contributing factor to the successful adoption of solar-based technologies is that over 95% of the settlements in the RM face either south or east, a favourable orientation for solar technology installation in Nepal.

Table 56

Solar Resource Potential at Dho Tarap Valley

Location	Dho Tarap, Karnali Province, Nepal
Geographical Coordinates	29.128408°N, 083.186792°E
Global Horizontal Irradiation (GHI)	5.262 kWh/m ² per day
Direct Normal Irradiation (DNI)	5.583 kWh/m ² per day
Global Tilted Irradiation at Optimum Angle	6.007 kWh/m ² per day
Optimum Tilt Angle	33°
Air Temperature	0.8°C
Terrain Elevation	4,119 m

Data Source: Solargis and Global Solar Atlas, 2023

According to Solargis and Global Solar Atlas, the Global Horizontal Irradiation (GHI) is 5.262 kWh/m² per day, while the Direct Normal Irradiation (DNI) is 5.583 kWh/m² per day. The Global Tilted Irradiation at the optimum angle is 6.007 kWh/m² per day, with an optimum tilt angle of 33°. The air temperature in the region is 0.8°C, and the terrain elevation is 4,119 meters.

It is clear that thorough investigations to assess possible wind sites inside the RM have not been done based on findings from field discussions with local inhabitants and information acquired from desk studies. However, considering Dho Tarap's altitude range of 3900 to 4300 meters above sea level, the possibility of finding suitable spots for wind turbine installation is realistic. Thorough site assessments are essential to determine if wind energy is feasible in the RM.

Through this study, the potential of SMG subprojects development is found to be extremely high and important too in Dolpo Buddha RM. It could be a good alternative for isolated places where the national grid is not provided or costly too. Table 57 shows the identified potential sites for SMG subprojects in the study area.

Table 57

Potential Sites Identified for SMG Subprojects

S.N.	Location Name	Ward	Potential Beneficiaries
1	Dho village	1	Households/Entrepreneurs/Monasteries/Hospital/RM Office/Ward Office/Police office
2	Dhoro village	1	Households/Entrepreneurs/Monastery
3	Sipcho village	1	Households/Entrepreneurs/Monasteries/
4	Kalang village	2	Households/Entrepreneurs/Monasteries/Health post/Ward Office
5	Takshi village	3	Households/Entrepreneurs/Monasteries/Health post/RM Office/Ward Office/Police office

Source: Field visit, 2023 and Dolpo Buddha RM office.

* There might be additional similar sites within the study area. Thus, conducting a feasibility study is necessary to determine the genuine potential of SMG subprojects and their suitability for both lighting and cooking purposes. These sites were identified through a discussion with the RM office.

During the Focus Group Discussion (FGD), it was found that the complete energy package, including cooking, thermal, and electricity solutions, is the local demand. However, the subsidy policy restricts the provision of sufficient power for cooking needs. Currently, local residents in places like Dolpo Budda RM continue to rely on traditional cooking fuels, hindering the potential benefits of eCooking solutions in these areas.

The main finding emphasizes that RETs, particularly SMGs, are the best options for rural areas, especially in remote locations like Dolpo Budda RM. However, the sustainability of SMGs is questioned when they do not adequately address the power supply requirements for cooking solutions. The field consultations suggest that an isolated system of larger-sized solar PV systems for individual households could be more cost-effective and beneficial in meeting the diverse energy needs of the rural households. This analytical overview highlights the need for a more comprehensive and flexible subsidy policy that considers the varied energy demands of rural households, particularly in remote high hills areas.

Planning for Improved Cookstoves including eCooking Solutions

The promotion of clean cooking solutions should always be encouraged, as it offers multiple benefits such as forest conservation and positive impacts on people's health and safety. Awareness should be raised among local communities about the advantages and applications of clean cooking solutions. Information about the government's prevailing plans, policy and programs should be provided to the locals.

Planning for Solar Dryers, Solar Street Lights, Religious Solar Home System

As stated in the preceding section, the deployment of various RETs like Solar Dryers, Solar Street Lights, and Religious Solar Home Systems should be facilitated based on the specific demands of the community members. Additionally, conducting feasibility studies for promoting these RETs is crucial prior to implementation.

Nevertheless, despite this consideration, these technologies should be given priority to meet the local needs.

Livelihood Outcomes: The Role of RE Systems

Remote and isolated communities often face significant challenges in accessing electricity due to their distance from the national grid networks, difficult terrain, and lack of infrastructure as mentioned earlier. Advances in RE technology, such as more efficient solar panels, improved battery storage, and innovative mini-grid solutions, have made last-mile electrification more feasible and cost-effective. RE systems empower local communities by giving them control over their energy supply. LG can actively participate in the planning, installation, and management of these systems, fostering a sense of ownership and sustainability.

Last-mile electrification aligns with global goals such as the United Nations Sustainable Development Goals (SDGs), particularly Goal 7 (affordable and clean energy) and Goal 13 (climate action). International partnerships and initiatives can also provide funding and expertise to accelerate last-mile electrification efforts. The last-mile electrification powered by RE systems is a transformative solution that bridges the energy gap for remote and underserved communities. It empowers communities, drives development, and contributes to environmental preservation, making it a key strategy for achieving universal energy access and the SDGs.

Increased Access to Energy

The implementation of RETs in Dolpo Buddha RM has led to enhanced energy accessibility. Prior to the adoption of these technologies, the RM faced challenges in accessing consistent and reliable electricity due to its remote location. As a result, households, schools, healthcare centers, and other community facilities now have access to electricity, enabling various activities that were previously hindered by the lack of

power. However, there remains a notable demand for increased electricity supply to rural households, enterprises, public institutions, and other pertinent stakeholders.

Reduced Energy Costs

In Dolpo Buddha RM, the utilization of kerosene has been entirely replaced by SHS in the surveyed households. Kerosene costs approximately NPR 400 per liter at the study site. On average, each household in the area previously consumed about three and a half liters of kerosene per month. However, with the introduction of solar electricity in the locality, kerosene use has been entirely replaced. Consequently, the monthly savings per household amount to an average of NPR 1400.

Likewise, it is estimated that each household saves around 4 pairs of dry cell batteries per month due to the availability of electricity. Given that the cost of a pair of dry cells is NPR 250 in the local market, the calculated savings resulting from the replacement of dry cells total NPR 1000 per month per household. Although additional power is not currently available for eCooking technology, residents are using LPG for cooking purposes. LPG cylinder prices range from NPR 7000 to NPR 10000. Despite this, there remains a substantial demand for electricity not only for lighting but also for cooking and supporting entrepreneurial ventures.

Income Generation

Small-scale RETs have been promoted in the Dolpo Buddha RM. Some noteworthy instances are SHS for lighting, water mills used as agro-processing units, and MICS meant to reduce indoor air pollution while providing an efficient heat supply for cooking. Furthermore, only two solar parabolic cookers were identified within the study area. The forthcoming establishment of community-based SMG subprojects is planned to improve energy access. These efforts, crucially, will facilitate the ultimate development of commercial enterprises and promote micro-level economic activities. However, the

majority of respondents stated that they saved time after installing RETs in their homes. The time saved was put toward household income activities. In addition to the reductions in energy costs, it is difficult to quantify the equivalent amount of income generated because of the time savings after RETs installation.

Improved Health Conditions

Better health makes people more active and as a result people will be economically productive. High income will make possible to afford improved technologies in energy transformation and thereby to improve living condition. In this context, the improved cooking stove has an important role for efficient utilization and reduction in consumption of fuel wood. Likewise, improvement in indoor environment, health and the reduction of workload for firewood collection, saving time etc. are benefits that are obtained from promotion/dissemination of MICS in Dolpo Buddha RM. In high hill/mountain areas of Nepal, metallic stoves should be promoted. The dual purpose of such stoves: cooking food as well as space heating is the main concern for the people residing in high hill areas.

Reduced Drudgery

RE systems substantially reduced dependency on traditional energy sources such as biomass, lowering the time and effort necessary for firewood or animal dung collection. This result provided individuals with more hours that could be allocated toward more productive activities, which benefited women and children in particular. The substitution of kerosene and dry cell batteries with RE solutions saved time for the rural population.

Better Education Opportunities

Extended study hours, e-learning, and skill development are made possible by reliable power, considerably contributing to human capital advancement and economic

possibilities. Children now have the ability to study not only during the day but also in the evenings and at night, because of the widespread acceptance of solar lighting. This improved availability of energy enabled people to watch Television, listen Radio as well as operate electrical equipment.

FGD participants highlighted that after the installation of RETs, the availability of information raised effective awareness among children about the potential risks of cigarettes, alcohol, and drugs, as well as the value of adopting healthy habits like washing hands before meals. Beyond the benefits of prolonged study hours in the home, the implementation of solar PV technology eased the way for computer education and internet connectivity in school. As a result, one of the most transformative impacts of solar-powered electricity within the study site was education. During the Key Informant Interview (KII) one of the School Coordinator, highlighted that

Crystal Mountain Secondary School (CMS) plays a crucial role in Dolpo Buddha RM as the only secondary-level educational institution. Situated in the remote Dolpo region, CMS serves as a beacon of hope and progress, standing as the first formal school in Upper Dolpa. Since its inception in 1994, CMS has received steadfast support from NGOs like Action Dolpo and Vision Dolpo, along with various development partners, earning the prestigious title of "A school on the roof of the world." As our electricity needs continue to grow, we are expanding our infrastructure to include multimedia projectors, laptops, desktops, printers, and enhanced cooking facilities in the hostel.

Reduced Carbon Emission

To reduce carbon emissions in residential areas, it is essential to decrease LPG usage and promote electric appliances like eCooking. The ambition of Nepal for net-zero emissions by 2045 aligns with achieving SDGs by 2030 and is tied to implementing

Nepal's Climate Change Policy (2019), REDD+ strategy, and National Adaptation Plan (NAP) for 2030 and 2050 (GoN, 2021).

Small-scale RETs installed in Dolpo Buddha RM have also contributed in reduction in carbon emissions in some extent. Collectively, these RE uses have led to a more environmentally friendly energy landscape by effectively reducing the emission of harmful greenhouse gases into the surrounding environment. Solar PV systems harness clean solar energy, minimizing reliance on fossil fuels and, as a result, carbon emissions. Similarly, the use of improved Cookstoves has resulted in a more efficient combustion process, lowering pollutant emissions associated with traditional cooking methods. Furthermore, the improvement of water mills, which are frequently used in agro-processing, has streamlined energy utilization, resulting in less carbon-intensive practices. One of the participants, from Samye Siddhi Dungdrupling Gumba, expressed that

As the esteemed Lama Guru of the monastery, we face distinct energy challenges critical to our religious ceremonies and daily spiritual practices. A primary challenge we encounter is the reliability and stability of our current energy supply. Traditional sources like firewood and dung cakes are scarce in our remote location, complicating tasks such as cooking and water boiling. Moreover, the high cost of LPG cylinders further exacerbates our energy predicament, impacting both our quality of life and the performance of sacred rituals.

Implications of RETs for Sustainable Rural Livelihoods

The adoption of RETs holds significant potential to transform rural communities by addressing energy challenges and contributing to overall sustainable development. RE systems will have profound influences on sustainable rural livelihoods that are far-reaching, encompassing economic, social, environmental, and developmental dimensions.

RETs will provide opportunities for economic diversification and growth in rural areas. The installation, maintenance, and operation of solar Minigrid projects will create employment opportunities for local residents, ranging from technicians and engineers to entrepreneurs engaged in energy-related businesses. This can stimulate local economies, reduce unemployment, and enhance income generation, thereby improving the economic well-being of rural populations. During the KII, the Chairperson of Dolpo Buddha RM said

Our community faces daunting challenges, notably the lack of electricity and sustainable economic opportunities. Recognizing these issues, I have set forth an ambitious vision to improve our residents' quality of life. Dolpo Buddha RM boasts breathtaking landscapes, yet our geographical isolation means many lack access to basic amenities like electricity and affordable cooking fuels. Fuelwood is rare and costly, and LPG remains unaffordable for most. Since taking office, I have prioritized a comprehensive four-year plan that allocates a significant portion of our budget to an electrification project. This commitment highlights our dedication to enhancing the well-being of our community members. I have actively collaborated with government agencies. For us, success lies in electrification, robust economic development, and empowering our community through inclusive decision-making. These pillars offer hope and promise improved livelihoods for the resilient people of Dolpo Buddha RM. By harnessing the power of RE source, rural areas can build more inclusive and prosperous societies while safeguarding their natural resources for future generations.

Chapter VII

Summary, Conclusion and Recommendations

Summary of Findings

The study aimed to assess current energy practices in rural areas and their benefits on rural life, along with socio-economic characteristics, settlement patterns, and household surveys within the study area. Output indicators include data on demographic characteristics, household income and expenditure, literacy rates, occupation distribution, land use, communication facilities, food sufficiency, and household amenities. The study utilized household surveys, interactions with local government, field observations, and checklists, along with insights from key informants.

Findings reveal that the majority of houses have mud-bonded stone walls and mud roofs. Settlement patterns indicate dispersed households with varied land use, including agricultural land, forests, settlements, and roads. Communication facilities, food sufficiency, and amenities are available but show disparities. The population consists of 47.4% males and 52.6% females, with a literacy rate of 43%. The study area comprises a population with low literacy rates, primarily engaged in agriculture (72%). The study area is predominantly inhabited by Gurung, Bhote, and Magar ethnic groups, sharing common customs and languages. Access to communication facilities and food sufficiency is documented, alongside agricultural practices and household amenities. Household income and expenditure patterns vary, with a majority owning between 0.5 to 1 hectare of land. Women are primarily engaged in household chores and child care.

Households predominantly use cow dung and fuelwood for cooking, supplemented by LPG. Despite the area being accessible only after a two-day foot journey and lacking road access outside the valley, the high scarcity of biomass-based fuel, particularly firewood, is making LPG more popular. It is likely to become the

predominant cooking energy source in the near future. The RETs such as Metallic Improved Cookstove (MICS) in all households, Solar Home Systems (SHS) in 99.2% of surveyed households, 10 nos of Improved Water Mills (IWM), and few Solar Parabolic Cookers are available in local area which makes household activities more easy and contributing on rural livelihood positively. Enablers for RE system implementation include community participation, innovative and portable systems, capacity building, and market opportunities. However, barriers such as infrastructure challenges, high capital costs, and socio-cultural factors hinder widespread adoption.

Energy demands in the study area encompass cooking, livelihood activities, tourism, education, healthcare, and connectivity. Proposed solutions include Solar Mini-Grid Projects, Improved Cookstoves, Solar Dryers, and Street Lights, aiming to enhance livelihood outcomes and reduce carbon emissions. Energy practices impact access to services, community health, and environmental conservation positively. However, energy costs remain a concern, and environmental challenges persist.

The study findings suggest to prioritize SMGs integrated with eCooking Solutions for sustainable development and improved quality of life. Isolated Solar Home Systems of capacity 1 kWp or more having surplus energy is also local demand. Sustainable implementation of RE systems with durable technology is advocated, especially in buffer zones. Policy recommendations emphasize government initiatives, public participation, and international agreements to promote sustainable energy solutions and community development.

Conclusion

The study exploring the linkage between RE uses and rural livelihoods in the Upper Dolpa region presents a comprehensive understanding of the transformative potential of clean energy in shaping sustainable development. The unique socio-economic

and environmental context of Dolpa, characterized by remote locations, challenging terrains, and cultural richness, underscores the significance of RE systems in catalyzing positive change. The findings highlight that RE systems offer a multifaceted pathway to uplift rural livelihoods. Access to reliable and clean energy unlocks a spectrum of opportunities across diverse sectors. It empowers local communities by fostering economic growth, creating jobs, and enabling income-generating activities. Furthermore, RE systems are instrumental in agro-processing, and rural enterprises, thereby amplifying productivity and income while minimizing environmental impact. The study illuminates how RE systems act as a catalyst for education and skill development, improved healthcare services, and fostering gender empowerment. By replacing traditional energy sources with sustainable alternatives, RE systems helping to reduce drudgery, especially for women, and contribute to the overall well-being of rural people in remote area. Beyond basic needs, energy plays a vital role in various aspects of rural life.

The study also emphasizes that realizing the full potential of RE systems for rural livelihood enhancement necessitates a holistic approach. Collaborative efforts involving local communities, government agencies, development organizations, and private stakeholders are crucial for effective implementation, maintenance, and scalability of RE projects. Furthermore, addressing technical, financial, and institutional challenges is vital to ensure the sustainability of these systems. In essence, the study reveals that the linkage between RE uses and rural livelihoods in Dho Tarap valley transcends mere energy access; it is a transformative journey towards socio-economic empowerment, environmental stewardship, and cultural preservation. By embracing renewable energy, local community can stride confidently towards a future that blends tradition with innovation, prosperity with sustainability, and resilience with progress. The insights

gleaned from this study stand as a roadmap for similar regions worldwide seeking to harness the power of renewable energy for the holistic betterment of their societies.

Recommendations

Based on the findings of the study on the linkage between RE uses and rural livelihoods in Dho Tarap Valley, several recommendations emerge to maximize their positive impacts on the community, economy, and environment. General recommendations include involving local communities in planning and implementation to tailor solutions to their specific needs, providing training for managing RE systems to foster sustainability and ownership, and implementing gender-sensitive strategies to ensure women's active participation and benefit. Designing versatile RE systems, exploring microfinance models, and fostering local enterprises are also crucial. Integrating RE into broader development plans, supported by awareness campaigns and a robust monitoring framework, is essential for sustained impact. Policy recommendations emphasize targeted subsidies, training programs, awareness campaigns, partnerships, and specific electrification plans. Promoting local production, integrating eCooking solutions, and developing supportive policy frameworks are critical for advancing sustainable rural electrification in Dolpa, ensuring long-term benefits for its communities while safeguarding cultural heritage and the environment.

Research for Further Study

Following this study, various avenues for further research and exploration have emerged. These include conducting longitudinal studies to assess the enduring impact of RE uses on rural livelihoods in Dolpa, comparing experiences with other similar regions globally, and investigating emerging RE technologies' suitability for Dolpa's context. Additionally, exploring community-based RE projects, analyzing cost-benefit dynamics, evaluating gender dynamics, and assessing policy effectiveness are crucial. Moreover, the

examining resilience against climate change and disasters, and studying local governance and cultural dimensions of RE adoption are essential research directions.

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ANNEXES

Consent Form:

Research: Linkage between Renewable Energy Uses and Rural Livelihood in Dho Tarap Valley, Dolpa

Hello, my name is Bibek Kanta Neupane, and I am a member of the research team at the Central Department of Rural Development, Tribhuvan University in Kritipur, Kathmandu, Nepal. Our team is currently conducting a survey on Linkage between Renewable Energy uses and Rural Livelihood in your area. The purpose of this survey is to gather accurate and truthful information, which will form the foundation for my research.

Your participation in this survey is completely voluntary, and any information you provide will be treated as confidential. The interview is expected to take approximately 50-60 minutes. If there are any questions you prefer not to answer, please let me know, and we can move on to the next question. You are also free to stop the interview at any time without having to provide a reason. There is no right or wrong answers in this discussion; we are genuinely interested in your thoughts and experiences. Your honest opinion is of utmost importance to us.

The records from this study will be kept as confidential as possible. Only I and my supervisor Prof. Dr. Chandra Lal Shrestha will have access to the files and any audio tapes. Your data will be anonymized – your name will not be used in any reports or publications resulting from the study. All digital files, transcripts and summaries will be given codes and stored separately from any names or other direct identification of participants. Any hard copies of research information will be kept in locked files at all times.

Consent for audio video recording, photographs taken	<input type="checkbox"/> YES <input type="checkbox"/> NO
The information you provide will be used for M.Phil. dissertation and that the information will be anonymised.	<input type="checkbox"/> YES <input type="checkbox"/> NO
You agree that anonymised information can be quoted in research outputs.	<input type="checkbox"/> YES <input type="checkbox"/> NO

If you have any questions regarding this study please contact the researcher, Bibek Kanta Neupane on bkanta.neupane@gmail.com or 9851131273. If you have any concerns or complaints regarding the conduct of this study, please contact the Central Department of Rural Development on contact@cdrd.edu.np .

Please retain a copy of this consent form.

Participant name:

Signature: _____ Date _____

Interviewer name:

A. Questionnaire for Household Survey

1. Background Information

Province	Karnali
District	Dolpa
Rural Municipality	Dolpo Buddha Rural Municipality
Ward No.	
Village/ Tole	
Full Name of the Respondent	Mr./Mrs.-
Contact Number	
Full Name of the Household Head	Mr./Mrs.-
Sex of the Household Head	<input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Others <input type="checkbox"/> Prefer not to disclose
Age of the household head (in years)	<input type="checkbox"/> 18-25 <input type="checkbox"/> 26-40 <input type="checkbox"/> 41-55 <input type="checkbox"/> 56-70 <input type="checkbox"/> 71 and above

2. Socio-demographic Characteristics of Sample HH

1.	What is your education level? (Respondent)	<input type="checkbox"/> Can't read or write <input type="checkbox"/> Can read or write <input type="checkbox"/> School level <input type="checkbox"/> High school (10+2) or Intermediate <input type="checkbox"/> Bachelors <input type="checkbox"/> Master or higher <input type="checkbox"/> Prefer not to disclose
2.	What is the highest level of education earned by your family members? (Choose one)	<input type="checkbox"/> Can't read or write <input type="checkbox"/> Can read or write <input type="checkbox"/> School level <input type="checkbox"/> High school (10+2) or Intermediate <input type="checkbox"/> Bachelors <input type="checkbox"/> Master or higher <input type="checkbox"/> Prefer not to disclose
3.	What is your main occupation? (Respondent)	<input type="checkbox"/> Farming <input type="checkbox"/> Business <input type="checkbox"/> Industry <input type="checkbox"/> Government job <input type="checkbox"/> Private Service <input type="checkbox"/> Others
4.	Household income per month	<input type="checkbox"/> <28,000

		<input type="checkbox"/> 28,000-50,000 <input type="checkbox"/> >50,000			
5.	Household Size	Total	Male	Female	Others
6.	Livestock Ownership	Mules	Sheep/Goat	Yak	Others
7.	How is the food sufficiency status in your household?	<input type="checkbox"/> Up to 3 months <input type="checkbox"/> 3 to 6 months <input type="checkbox"/> 6 to 12 months <input type="checkbox"/> Surplus			
8.	Yearly Income NPR:		Yearly Expenditure NPR:		
	Source	Income	Area	Expenditure	
	Agriculture		Food		
	Wage people		Cloth		
	Remittance		Education		
	Pension		Medicine		
	Business		People		
	Service		Festival		
	Other		Other		
9.	Type of roof used at house	<input type="checkbox"/> Thatched <input type="checkbox"/> Concrete <input type="checkbox"/> Tile roof <input type="checkbox"/> Corrugated Sheet			

		<input type="checkbox"/> Other (Specify)
10.	Type of wall of the house	<input type="checkbox"/> Concrete wall <input type="checkbox"/> Stone wall <input type="checkbox"/> Mud wall <input type="checkbox"/> Thatched wall <input type="checkbox"/> Wooden wall
11.	Connection of drinking water pipeline	<input type="checkbox"/> Yes <input type="checkbox"/> No
12.	Toilet Facility	<input type="checkbox"/> Yes <input type="checkbox"/> No
13.	Telephone/Mobile	<input type="checkbox"/> Yes <input type="checkbox"/> No
14.	Electricity (National Grid)	<input type="checkbox"/> Yes <input type="checkbox"/> No
15.	Radio/Television	<input type="checkbox"/> Yes <input type="checkbox"/> No
	Remarks:	

3. Household Energy Sources and available electrical appliances

16.	Sources of Cooking Energy	<input type="checkbox"/> Firewood <input type="checkbox"/> Crop Residue <input type="checkbox"/> Dung
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		<input type="checkbox"/> Coal <input type="checkbox"/> Kerosene <input type="checkbox"/> LPG <input type="checkbox"/> Saw Dust <input type="checkbox"/> Others (Specify)
17.	Which Cookstove is used as the primary/main stove? (Choose one)	<input type="checkbox"/> Traditional Cookstove <input type="checkbox"/> Improved Cookstove (ICS) with chimney <input type="checkbox"/> Natural draft stove (metal) <input type="checkbox"/> Forced draft stove (metal) <input type="checkbox"/> Biogas stove <input type="checkbox"/> LPG stove <input type="checkbox"/> Electric Cookstove – Induction <input type="checkbox"/> Electric Cookstove – Infrared <input type="checkbox"/> Electric Cookstove – ceramic coil heater <input type="checkbox"/> Charcoal stove <input type="checkbox"/> Rice husk stove <input type="checkbox"/> Other (specify)
18.	For what purpose firewood is used? (Multiple response is possible)	<input type="checkbox"/> Cooking <input type="checkbox"/> Animal Feed Preparation <input type="checkbox"/> Alcohol Preparation <input type="checkbox"/> Space Heating

		<input type="checkbox"/> Boiling water <input type="checkbox"/> Others (Specify)	
19.	Source of firewood	<input type="checkbox"/> Hire labour to collect from community forest <input type="checkbox"/> Purchase from market <input type="checkbox"/> Collect ourselves from community forest <input type="checkbox"/> Collect ourselves from own farm <input type="checkbox"/> None	
20.	Where do you usually collect firewood from?	<input type="checkbox"/> Government Forest <input type="checkbox"/> Private Forest <input type="checkbox"/> Community Forest <input type="checkbox"/> Buy <input type="checkbox"/> Others (specify)	
21.	Who mostly collects the firewood in your family?	<input type="checkbox"/> Adult Male <input type="checkbox"/> Adult Female <input type="checkbox"/> Both <input type="checkbox"/> Children	
22.	Sources of cooking fuel	Quantity of usage per month	Price per unit
	Firewood		
	Charcoal		
	LPG		

	Kerosene		
	Crop Residue		
	Electricity		
	Others (specify)		
23.	Lighting Facility	<input type="checkbox"/> Micro Hydro or Mini Grid Electricity <input type="checkbox"/> Solar Home System <input type="checkbox"/> Kerosene <input type="checkbox"/> Solar Tuki or Lantern <input type="checkbox"/> Others (specify).....	
24.	Agro processing	<input type="checkbox"/> Improved Water Mill <input type="checkbox"/> Traditional Dhiki/Jaanto <input type="checkbox"/> Diesel based mill <input type="checkbox"/> Electric Mill <input type="checkbox"/> Other (if any)	
25.	What electronic appliances do you have in your home? (Multiple Choice)	<input type="checkbox"/> TV <input type="checkbox"/> Radio <input type="checkbox"/> Handy Grinder <input type="checkbox"/> Refrigerator <input type="checkbox"/> Rice cooker <input type="checkbox"/> Water boiler <input type="checkbox"/> Microwave/ Electric oven	

		<input type="checkbox"/> Electric pressure cooker <input type="checkbox"/> Mixer/ Blender <input type="checkbox"/> Fan <input type="checkbox"/> Heater <input type="checkbox"/> Iron <input type="checkbox"/> Computer/Laptop <input type="checkbox"/> Water pump <input type="checkbox"/> None <input type="checkbox"/> Other (specify)
26.	Please provide the energy price mechanism at local level	<input type="checkbox"/> Petrol per litre <input type="checkbox"/> Diesel per litre <input type="checkbox"/> Other (specify)

4. Benefits of installed RE systems

27.	What type of RE technology do you have?	
28.	Who motivated you to install the system at your home?	<input type="checkbox"/> Promoters and Local Organizations <input type="checkbox"/> Rural Municipality office <input type="checkbox"/> Promotional Materials <input type="checkbox"/> Neighbors/ Friends/ Relatives <input type="checkbox"/> Others (specify).....
29.	What were the product's	<input type="checkbox"/> Price

	attributes that influenced you to purchase?	<input type="checkbox"/> Design <input type="checkbox"/> Size <input type="checkbox"/> Quality <input type="checkbox"/> Utility
30.	How would you rate the cost of RE system and accessories? Specify	<input type="checkbox"/> Very high <input type="checkbox"/> High <input type="checkbox"/> Average <input type="checkbox"/> Can't say
31.	Do you think the smoke in your kitchen has reduced after the installation of improved Cookstove?	<input type="checkbox"/> Drastically reduced <input type="checkbox"/> Reduced <input type="checkbox"/> Not reduced <input type="checkbox"/> Do not know
32.	How have you perceived the incidence of following diseases?	<input type="checkbox"/> Eye infection <input type="checkbox"/> Respiratory diseases <input type="checkbox"/> Cough <input type="checkbox"/> Fire related injury <input type="checkbox"/> Others (specify)
33.	Do you think due to RE system installed, the time required to collect fuelwood has been saved?	<input type="checkbox"/> Men <input type="checkbox"/> Women <input type="checkbox"/> Children
34.	How do you or your family	<input type="checkbox"/> Working in the farmland

	members utilize saved time?	<input type="checkbox"/> Helping children with their studies <input type="checkbox"/> Cleaning house <input type="checkbox"/> Income generating activities <input type="checkbox"/> Recreational activities <input type="checkbox"/> Social activities <input type="checkbox"/> Others (specify)
35.	How satisfied are you with the performance of your RE system?	<input type="checkbox"/> Highly satisfied <input type="checkbox"/> Satisfied <input type="checkbox"/> Neither satisfied or dissatisfied (neutral) <input type="checkbox"/> Unsatisfied <input type="checkbox"/> Highly unsatisfied
36.	Rate your satisfaction with the after sales services by the service provider/installer company.	<input type="checkbox"/> Highly satisfied <input type="checkbox"/> Satisfied <input type="checkbox"/> Neither satisfied or dissatisfied (neutral) <input type="checkbox"/> Unsatisfied <input type="checkbox"/> Highly unsatisfied
37.	Education facilities including study hours during night time	
38.	Available health facilities (before and now)	
39.	Remarks	

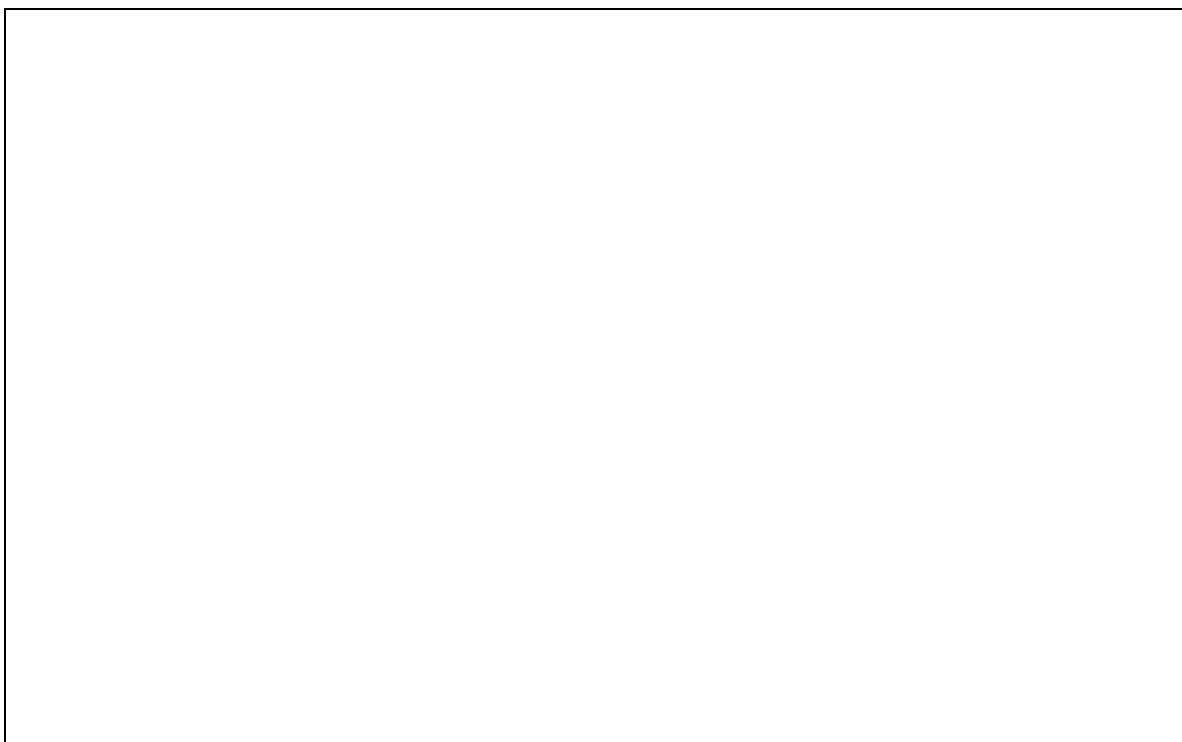
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5. Women Empowerment after RE System

40.	Does women's workload decrease after RE installation?	<input type="checkbox"/> Yes <input type="checkbox"/> No
41.	Possible reasons	
42.	Who is playing decision making role in your household?	<input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Jointly
43.	If women members involve in the decision-making process; in which activities, they are participating?	<input type="checkbox"/> Daily Activities <input type="checkbox"/> Community Activities <input type="checkbox"/> Income/Expenses <input type="checkbox"/> Others
44.	Do women have control over their income?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> No response
45.	Does girl child's education increase after RE installation?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> No response
46.	Does female member participate in community activities increase	<input type="checkbox"/> Yes <input type="checkbox"/> No

	after RE installation?	<input type="checkbox"/> No response
47.	Awareness Level	<input type="checkbox"/> Solar Home System (SHS) <input type="checkbox"/> Improved Cookstove (ICS) <input type="checkbox"/> Improved Water Mill (IWM) <input type="checkbox"/> Metallic Improved Cookstove (MICS) <input type="checkbox"/> Institutional Solar Photovoltaic System (ISPS) <input type="checkbox"/> Solar Pumping Systems <input type="checkbox"/> Parabolic Solar Cooker <input type="checkbox"/> Solar Dryers <input type="checkbox"/> Micro Hydropower/Peltric Set <input type="checkbox"/> Gasifier <input type="checkbox"/> Bio-briquettes <input type="checkbox"/> Wind energy <input type="checkbox"/> Biogas (gobargas) <input type="checkbox"/> RE Programs <input type="checkbox"/> Provision of RE Subsidy Policy
48.	Enablers for RE uses	<input type="checkbox"/> Community Participation <input type="checkbox"/> Innovating Technology <input type="checkbox"/> Capacity Building <input type="checkbox"/> Social Factors <input type="checkbox"/> Strong Local Government <input type="checkbox"/> Local Partnership <input type="checkbox"/> Market Opportunities <input type="checkbox"/> RE Subsidy Policy
49.	Impact Area	<input type="checkbox"/> Social acceptance <input type="checkbox"/> Sustainability <input type="checkbox"/> Operation and maintenance <input type="checkbox"/> Cost efficiency <input type="checkbox"/> Social equity <input type="checkbox"/> Knowledge and capacity

50. Observation

A large, empty rectangular box with a thin black border, intended for recording observations. It occupies the majority of the page below the section header.

B. Rural Municipality Level Information

1. Ethnic Composition

S.N.	Ethnicity	Female	Male	Total
1	Brahmin			
2	Chhetri			
3	Gurung			
4	Tamang			
5	Magar			
6	Bhote			
7	Other (specify)			

2. Occupation

S.N.	Occupation	Female	Male	Total
1	Farming			
2	Business			
3	Industry			
4	Government job			
5	Private Service			
6	Foreign Employment			
7	Other (specify)			

3. Income Level

S.N.	Income Level NPR/Year	Female	Male	Total
1	< 100,000			

2	100,000-500,000			
3	>500,000			

4. Literacy Status

S.N.	Literacy	Proportion
1	Illiterate	
2	Literate	
3	Primary Education	
4	Secondary Education	
5	SLC and above	

5. Organization Number

S.N.	Organization	Number	Remarks
1			
2			
3			
4			
5			

6. Community Access to Different Facilities

Facilities	Available or Not Available within the community (Yes=1, No =2)	If not, then distance from the Community to the Center (Km)
Hospital		

Health Center		
Pharmacy		
Primary School		
High School		
Secondary School		
College/ University Campus		
Post Office		
Milk Booth		
Provision/ Grocery Shop		
Market		
Bus Station		
Bank		
NGO		
Agriculture Extension Office		
Agro processing Mills		
Paved Road		
Unpaved Road		
Financial Institutions		

7. Prevalent livelihood

S.N.	Livelihood sources	Priority order*
1		
2		
3		

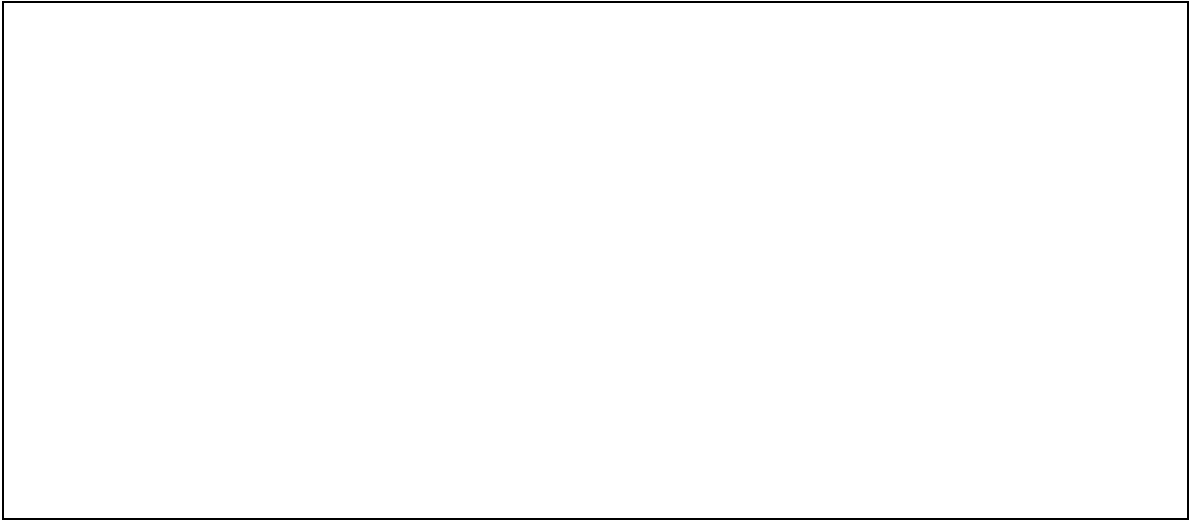
4		
5		

*Major, secondary, tertiary, etc.

8. Major changes after RE system:

S.N.	Changes in	Remarks
1	Irrigation	
2	Agriculture	
3	Forest Cover	
4	Reduced use of fossil fuel	
5	Medical / Health Post Services	
6	Health status	
7	Enterprises	
8	Education (Study habits/trends)	
9	Awareness	
10	Gender roles	
11	Sanitation/Hygiene	
12	Access to road	
13	Market center (e.g., Vegetable depot)	
14	Access to information	
15	Communication channels	T.V.
		Radio
		Telephone
		Internet

9. Overall Observation



C. Open Ended Questionnaire/Checklist for KII and Guideline for FGD

1. Has the introduction of renewable energy systems improved educational activities or communication in the community? If yes, how?
2. Are there any challenges or barriers faced by the rural people in maintaining or operating renewable energy systems?
3. Have the cost savings from using renewable energy systems had any significant impact on the households' financial situation? If yes, in what ways?
4. Are there any specific technical or infrastructure challenges that hinder the wider adoption of RE systems in the study area?
5. What are the main financial barriers faced by individuals or communities when considering the adoption of RE systems?
6. Based on your observations and interactions, what are the key recommendations or actions that can be taken to overcome barriers and promote the wider adoption of RE systems in the study area?
7. Have there been any efforts to assess the energy demands and consumption patterns of the rural people in the study area?

D. Field Photographs

Photo 1

Researcher Conducting Field Assessment at Dolpo Buddha RM Office



Photo 2

Storage of Dung-cakes for Use as Cooking Fuel



Photo 3

Researcher Documenting Field Observations



Photo 4

LPG Cylinder Imported from China



Photo 5*Settlement Patterns in Dho Tarap Valley***Photo 6***Topographical Landscape of the Study Area*

Photo 7

A Typical Kitchen in Rural Upper Dolpa



Photo 8

Happy User in IWM House for Food Processing



Photo 9

RE Systems for Household Use in the Study Area

