



Investigating the socio-technical dynamics of rural electrification in Nepal

A case study from the Okhaldunga district

Master's thesis in Industrial Ecology

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Cover:
Three pictures taken during the case studies showing a women's group, a solar mini grid, and a rice mill. (Own photographs)

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ABSTRACT

In the past two decades, Nepal has significantly increased access to electricity for its population. The remaining efforts towards electricity access for all are focused on rural areas where electrification can have an important role in rural development. However, realizing the benefits of electrification depends on addressing socio-technical factors.

Understanding deep-rooted social dynamics and how they are connected to the technical aspects of electricity access is essential for providing the necessary complementary activities for rural development.

This master thesis aims to gain a systemic understanding of the socio-technical dynamics within rural electrification by studying the case of electrification in the Okhaldhunga district in Nepal. With the help of semi-structured qualitative interviews, drivers and barriers in this electrification process are identified, supported by literature and contextual interviews. With the help of two theoretical frameworks: Diffusion theory by Rogers and Energy Cultures by Stephenson et. al., as well as existing research on the topic, the results are placed in a fitting context.

The results, which are composed of the four themes: 1. Cooking and appliances for households; 2. Education, knowledge, and culture; 3. Government and institutions; and 4. Opportunities provide the basis for the discussion. The academic contribution of the thesis lies in the interrelationships between the subthemes which are later connected to the theory and supporting literature for context and relevance. Resulting from the discussion, the need for three complementary activities is presented, aiming to mitigate the gaps that were addressed in the discussion. The three complementary activities include: 1. Targeted education and knowledge programs; 2. Trust, communication, and collaboration improvement; and 3. Local opportunity creation. Finally, this thesis produces action recommendations to support stakeholders in their efforts to increase the rate of positive change with the ongoing rural electrification of Nepal.

Keywords: rural electrification, socio-technical dynamics, knowledge, rural development

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List of Abbreviations

AEPC	Alternative Energy Promotion Center
e.g.	exempli gratia / for example
GW	Gigawatt
ICT	Information and communications technology
i.e.	id est / that is
IEA	International Energy Agency
kW	Kilowatt
LPG	Liquid Petroleum Gas
NEA	Nepal Electricity Authority
SHS	Solar Home System
SSHS	Small Solar Home System
SMG	Solar Mini Grid

List of Definitions

Auto-coding by style (NVivo):

“If you have applied paragraph styles in your documents you can use them to automatically code the content. For example, you could make nodes for each question in an interview and code the responses.” (*NVivo 11 for Windows Help - About Coding*, 2024)

Barrier:

“Something that prevents something else from happening or makes it more difficult.” (Cambridge Dictionary, 2024a)

Base-charge:

Minimum charge, electricity users with a single-phase low voltage connection have to pay monthly. It includes up to 20 units (kWh) of electricity. (NEA, 2023)

Coding (NVivo):

The action of assigning source content to a node or case. (*NVivo 11 for Windows Help - Key Terms*, 2024)

Driver:

“Something that makes other things progress, develop, or grow stronger.” (Cambridge Dictionary, 2024b)

Electrification:

“Electrification means replacing technologies or processes that use fossil fuels, like internal combustion engines and gas boilers, with electrically powered equivalents, such as electric vehicles or heat pumps. These replacements are typically more efficient, reducing energy demand, and have a growing impact on emissions as electricity generation is decarbonized.” (IEA, 2024b)

Energy access:

“A household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average.” (IEA, 2020)

Energy transition:

“A change in the primary form of energy consumption of a given society, e.g., the historic transition from wood to coal and then to oil and gas in industrial Europe; the current shift from biomass fuels to commercial energy in some areas of the developing world.” (Cleveland & Morris, 2015)

Fuel stacking

“A phenomenon of using multiple stove-and-fuel cooking combinations within the same household.” (Zheng & Ochieng, 2020)

National Grid:

The national electricity network in Nepal run by the NEA. (NEA, 2023)

Micro hydropower plant:

Small hydropower plant with a capacity between 10 and 100 kW, depending on the setting off-grid or grid-connected (Energylopedia, 2024)

Pico hydropower plant:

Small hydropower plant with a capacity of lower than 10 kW, usually off-grid (Energylopedia, 2024)

Theme:

A theme node is a collection of references about a specific theme, topic, concept, idea or experience. (*NVivo 11 for Windows Help - About Theme Nodes*, 2024)

1. Introduction

Reaching 100% of anything is an impressive feat. Doing so in a short span of time can make it seem even more impressive. In about two decades, Nepal has gone from only serving around 20% of its population with electricity (IEA, 2024d) to plan the finale push towards establishing electricity access for all. This is certainly impressive, although numbers can provide an embellished version of reality. What these numbers tell us is how many households have distribution lines connected to them. While access is an important prerequisite for having the related benefits of electricity, it is only a technical part of the transition. Technical fixes can sometimes prove useless because of neglect of other relevant factors. There are case-specific deep-lying social factors in play that are central to transitions and not considering these can be detrimental. Understanding the impacts of electricity access requires the consideration of socio-technical aspects of the transition, especially in rural areas.

The topic of energy transitions in rural areas through electrification is an important one. Electricity access is indicated to have a role in rural development (Riva et al., 2018a) (Chaurey et al., 2004) (Bastakoti, 2003), but the dynamics are complex and multifaceted. There is a need for research that produces adequate and reliable data that works towards mapping the impacts of electricity use in the context (Riva et al., 2018a). This thesis investigates the socio-technical enablers and barriers in the rural energy transition towards electrification in Nepal.

Electricity access

Estimations from the IEA point towards 760 million people still lacking access to electricity (IEA, 2024c). It is widespread knowledge that access to electricity is of benefit to people. Without any official declarations or resolutions, there are arguments to be made that electricity access has become a basic human need. Being a key driver to socio-economic development, lacking reliable access to electricity puts a limit on people's opportunities and quality of life, especially in a rural context. In rural cases, electrification can with the support of complementary activities and infrastructural preconditions have positive feedback effects contributing to greater health service, education, and income

generation among others (Riva et al., 2018b). A transition done with clean energy resources is not only important for improving individual living conditions in a country but also for enhancing its national economic growth (Tika Ram & Rijal, 2021).

Nepal's energy transition

Nepal has been undergoing a major energy transition in recent years, aiming to reach 100% grid electrification by the end of 2024 (Pandey, 2022). The country has been heavily reliant on traditional biomass fuels such as firewood and agricultural waste for cooking and heating, which has led to deforestation, indoor air pollution, and health problems (Tika Ram & Rijal, 2021). By promoting the use of electricity and increasing its hydropower generation, Nepal has the potential to improve its economic trading position with its neighbors while increasing its energy independence (Chitrakar, 2019). Hydro generation could accommodate the increase in per capita electricity use needed for a domestic energy transition by electrification while excess electricity is exported (ADB, 2020).

This thesis

The Okhaldunga district was chosen as the case study area. Field trips were made between February, and April 2024, to three villages in the district for the collection of qualitative data. The collection was made through interviews with stakeholders of the energy transition towards rural electrification. By conducting qualitative interviews with stakeholders, the intention was to generate a deeper understanding of the complex system. Further on the results of the interviews were analyzed through diffusion theory as described by Rogers (2003) and the Energy Cultures framework (Stephenson et al., 2010). They were also compared to findings from existing research. This work process intends to generate recommendations on how to improve the situation.

1.1. Research aim

This master thesis aims to gain a deeper understanding of the social dynamics within energy transitions related to rural electrification and to contribute to research in the area. This is done by studying the case of electrification in the Okhaldunga district in Nepal.

It is important to acknowledge that projects are executed in a short time span with limited priority to follow up on the resulting impacts for the respective stakeholders. The impacts of rural electrification are multifaceted and complex. Investigating the status quo from a systems lens aims to shed light on gaps hindering development and provide an understanding of the knowledge currently missing in these kinds of transitions. Essentially this thesis seeks to bridge the technical with the often-neglected social aspects of electrification.

The research specifically targets...

...the socio-technical factors influencing how electricity access is utilized by people.

...the roles and responsibilities taken by stakeholders on different levels.

The aim is to produce recommendations for stakeholders to empower themselves and each other by strengthening the drivers and mitigating the barriers related to the utilization of rural electrification. These recommendations may be applicable to cases similar to the one studied here.

1.2. Scope and limitations

This study mainly focuses on when electricity access is already established and the pathway forward as Nepal is within reach of 100% electricity access. Other research on the implementation of electricity in rural areas is readily available, related to generation, transmission, and distribution.

Rural development is connected to electricity access and therefore this study is done in rural areas. Three villages are studied in the same region and therefore the patterns and insights are most relevant to the area. The villages are in their respective unique circumstances, widening the scope of the research conducted. Comparing the three villages gives insights into the differences and similarities of their circumstances. Meanwhile, their differences are also a limitation as the findings from each village cannot be fully validated until a similar village is studied to strengthen the conclusions. From a time perspective, this study gives current accounts of each village's circumstances. The

accounts given by people interviewed determine the results and therefore conclusions drawn, making it subjective.

This study requires that people in these villages have access to electricity that could be used by them to their benefit. Therefore, to be within the chosen scope the cases need to follow three requirements:

- The supply of electricity needs to be enough for it to at least enable the use of household electrical appliances.
- The same requirement applies to the reliability and stability of the supply.
- Enough time needs to have passed since access to electricity has been established.

Learnings from this region can be transferred to other cases but need to be done with context, which is not covered here. This study can highlight insights that could be of interest when studying other cases. The main transferable elements are regarding energy transitions towards electrification with an emphasis on rural development.

1.3. Outline of this thesis

This thesis has the following structure: the following subchapter gives a brief background of Nepal relevant to this topic. It is followed by a literature review that consists of a theory and a conceptual framework which are later used to analyze the result of the study.

The literature review also includes an account of existing research which is used to identify research gaps and research questions. Chapter 3 describes the method used to conduct the field work and process it, including data gathering and data analysis. Afterward, in chapter 4, the results are presented in the form of themes identified. For the discussion, connections are drawn between the themes, and they are analyzed with the help of the theory and conceptual framework, while complemented by the findings from existing research. The following chapter gives recommendations on how to mitigate the identified gaps during the discussion. Finally, suggestions are given on how to expand on this study.

1.4. Case study country

Nepal has an estimated population of 31 million (Central Intelligence Agency, 2024). It is currently considered to be a least developing country (UN, 2024a) but is moving towards graduating to be a middle-income country by the end of 2026 (UN, 2024b). Despite developments in the economy, the country remains behind compared to other countries in the region in metrics such as annual per capita income. Many in rural Nepal seek opportunities outside of their communities. This can be in more urbanized areas of Nepal such as Kathmandu, although going abroad is often favored. A significant number of Nepalis migrate as foreign labor workers (Gautam, 2008). Remittance is a part of the majority of the household's income and made as of the fiscal year 2020/21, 22.5% of Nepal's gross national product. This showcases how substantial foreign labor migration is for the country's economy. Although the remittance has more than monetary gains. Social remittance refers to bringing back knowledge, skills, and ideas which combined with monetary remittance is used to invest in the community and promote development. Foreign labor migration also has negative aspects such as ill-treatment and exploitation of the workers in the countries they migrate to. Positive or negative, this is a major part of the reality of Nepal today. Be it for job opportunities or education opportunities, the keyword is opportunities, which youths feel they need to seek outside of their rural communities (Aryal, 2022).

Landlocked between India and China, Nepal can be defined by three regions: mountain, hill, and terai. As the country lacks gas and oil reserves, it relies on its neighbors for imports to meet the country's energy needs (Paudel et al., 2023). In the fiscal year 2020/21 approximately 32% of Nepal's total energy available had been imported from India, showcasing this reliance (NEA, 2021). One of the major energy imports includes LPG cylinders used for cooking (Chitrakar, 2019). These cylinders are seen everywhere in Kathmandu and the smallest villages in the hills of the Okhaldunga District. The other more prominent alternative for cooking is the age-old practice of using firewood, especially in rural areas (Paudel et al., 2023). Fuel mixing for cooking has become a more common practice with time as socio-economic development has taken place. These households use both firewood and mainly LPG as the alternative fuel for cooking where

the former is still used more predominantly seemingly because of socio-economic and cultural reasons (Pokharel & Rijal, 2021).

The main organization responsible for the generation, transmission, and distribution of electricity is the NEA working on behalf of the state (NEA, 2024). They work with the Independent Power Producers Association to link the private and governmental sectors. In addition to what the NEA generates themselves, they purchase electricity from Independent Power Producers (IPPAN, 2024). Besides the NEA, there is another organization, the Alternative Energy Promotion Centre working on behalf of the state. Their purpose is more specific and includes promoting renewable energy technologies, improved cooking stoves, and supporting electrification among others (AEPC, 2024). The rough terrain makes it challenging to provide some rural and remote areas with electricity through a robust national grid. Local installations have also proved effective alternatives in providing rural communities with electricity (Koirala et al., 2013). One way the NEA and AEPC fit together is by having the AEPC establish off-grid solutions in villages and areas that are not going to be reached by the national grid through the NEA for the foreseeable future. The AEPC uses mainly solar PVs together with batteries and mini or micro hydro as sources to provide electricity (AEPC, 2024). Although the mountainous country houses approximately 6,000 rivers, with a potential of 42 GW of economically viable hydropower (ADB, 2020). This number is often brought up when talking about the electricity potential of Nepal and has been so for several years now.

In 2021 the annual electricity consumption per capita was around 300 kWh which is double that in 2015 (IEA, 2024e). Being a country with a low per-capita electricity use, one of the key strategies for promoting sustainable energy transition in Nepal has been rural electrification with 79% (The World Bank, 2022) of its population living in rural areas. Electricity generation has also seen a positive trend and tripled between 2015 and 2021 (The World Bank, 2022). The work toward rural electrification is being done through a combination of public and private investments, as well as international aid and support (Paudel et al., 2023). Electrification is accommodated by the expansion of electricity generation and rural access to electricity. By promoting the use of electrical appliances in rural areas, the NEA is hoping to increase the domestic consumption of

electricity. This rural household electrification is stated by the NEA to be given top priority for the socio-economic development of Nepal (NEA, 2021). As access to clean energy improves and rural incomes rise, residents in rural areas seem to be progressively shifting from traditional energy sources to cleaner alternatives. The evolving energy transition towards electrification not only alters the structure of energy demand and consumption in Nepal but also carries significant policy implications for the country's sustainable governance of energy resources (Pokharel & Rijal, 2021).

2. Literature review

The process of finding relevant literature was guided by and changed with the research aim and findings from the field. As the study took form and new directions there was a need for iterative work which meant the need for more or different literature relevant to that new direction. In this chapter literature from the latest and final iteration is presented, meaning only literature that is deemed the most relevant. To find relevant literature the academic search engine Consensus was used. By searching for keywords and full sentences several papers would be suggested and the relevant ones were picked out. The papers were first screened by looking at the full title, abstract, published year, and citations and later used if the content of the full paper was relevant to the topic of this study. As the literature review and research questions are connected, the relevancy of the literature is in addressing the research questions. This chapter consists of a theory, a conceptual framework, and existing research.

2.1. Theory

The theory part of the literature review will introduce Diffusion theory by Rogers (2003) and the Energy Cultures framework by Stephenson et al. (2010).

2.1.1. Diffusion theory

A concern for Nepal is to increase the electricity consumption of the country and its people. As electricity access is being established for more and more people the question is in what ways it can be utilized, especially in the rural areas. If electricity usage remains low, then the expectations stakeholders have of this technology are not met. Barriers to low usage need to be overcome. To be able to assess the situation, insights are drawn from the diffusion theory of Rogers (2003) which explains the diffusion of innovations comprehensively. More specifically these insights are related to technology adoption, social change, and communication aimed towards influencing behavior. In this thesis, the main purpose of understanding and employing the foundations of diffusion theory is to

be able to identify what is needed for higher electricity usage to be spread in rural Nepal. The theory can be applied to multiple disciplines which makes it applicable to this thesis. Rogers (2003) gives the following definition of diffusion, 'Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system'. The key elements here are innovation, communication channels, time, and the social system.

Innovation

Innovation is described as an idea, practice, or object which is perceived as new by individuals. Rogers (2003) puts forward five characteristics of innovation. How these characteristics of innovations are perceived by the individuals plays a part in their rates of adoption. The first characteristic is the degree of relative advantage (1) an innovation offers compared to its predecessor. It may be measured in economic terms with social prestige, convenience, and satisfaction as influencing factors. Compatibility (2) with the values and norms of the social system accelerates the adoption rate, while incompatibility drags it out while requiring changes in the value system first. An innovation can entail complexity (3) if it is difficult to understand and use. Trialability (4) of an innovation is the degree to which it can be tried out by the individual who is considering adopting it. By experimenting with the innovation on a smaller scale, the potential adopter can learn by doing and decrease preliminary uncertainties before choosing to fully adopt it. Lastly, there is the observability (5) of the results of an innovation. This refers to how easy it is for others to observe what an innovation gives. More visibility leads to peer discussion of the innovation which makes it more likely to be adopted. These are the five characteristics that determine the rate of adoption of an innovation. Simply put, the more of each innovation is perceived by individuals to possess the faster the rate of adoption of it may be. Relative advantage (1) and compatibility (2) are of particular importance.

Communication channels

Diffusion is described as a type of communication that revolves around a new idea. Rogers (2003) defines communication as 'the process by which participants create and share information to reach a mutual understanding'. A communication channel is then the method of transferring information. Two main communication channels are described by

Rogers (2003), mass media channels and interpersonal channels. Communication through mass media channels addresses an audience through mediums such as radio, television, and so on. Interpersonal channels are exchanges between two or more individuals that take place face-to-face. An additional channel is mentioned as becoming more important with time, the interactive communication held online.

As the evaluation of innovations by individuals is suggested to be more subjective rather than objective, the conveyed experiences of peers become important for the adoption of said innovations. Therefore 'Diffusion is a very social process that involves interpersonal communication relationships' Rogers (2003). Ideas are more easily transferred between individuals who share similarities in certain attributes such as beliefs, education, and socio-economic status. Usually, a problem that occurs in the diffusion of innovations is that the individuals have differences in attributes that make it harder to communicate effectively. Diffusion demands that its participants are different at least regarding their understanding of the innovation, but ideally share similarities in other attributes.

Time

As the third element of diffusion according to Rogers (2003), time is involved in (1) the innovation-decision process, (2) innovativeness, and (3) rate of adoption. During the innovation-decision process, an individual goes through five steps before it is decided if the innovation is adopted or rejected. The five steps are (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. This process is about seeking and processing information to decrease uncertainties about an innovation. The decision period varies depending on the people and the innovation. Innovativeness refers to how early an individual will adopt an innovation. Individuals who adopt innovations at a later stage with the majority are usually of relatively lower socioeconomic backgrounds and get their information mainly from interpersonal channels. Individuals who can adopt an innovation at an earlier stage usually have greater access to information and can take risks that come with an uncertain innovation. The speed at which members of a social system adopt an innovation is the rate of adoption. This system can be a community, an organization, or something similar such as a village.

Social system

Rogers (2003) gives the following definition of a social system, "...a set of interrelated units that are engaged in joint problem solving to accomplish a common goal". Units refer to individuals, groups, and organizations. These are distinguishable from each other but share a common objective that binds the system together. There is a structure in social systems defined by the patterned arrangements of the units giving a degree of predictability to the behavior of that system's units. Norms are such patterns. A social system's structure influences the diffusion of innovations in the system. Another way diffusion is influenced is through the changes it introduces to the individuals or the social system through the adoption or rejection of an innovation. The decision to adopt an innovation can be made optionally by units of the system, collectively by the system or come as an order from authority.

2.1.2. Energy Cultures Framework

Energy Cultures is a conceptual framework developed to explain the energy decisions of consumers and the factors that influence them. It also identifies opportunities to change these. Stephenson et al. (2010) build on prior models trying to deliver a framework that is more comprehensive and bridges '...research traditions centered on the individual (economics, behavioral, technology diffusion) and those centered on wider social and technological constructs.'. To do this energy consumption behavior is studied with cultural context at the core of the framework as well as drawing from lifestyles, systems, and Science and Technology Studies thinking. Cultural norms are seen as key drivers of shaping individuals' actions and interactions. Furthermore, an interpretation of behavior is given which points to the interactions between cognitive norms, energy practices, and material culture. Cognitive norms refer to the values and beliefs that influence individuals' or groups' perceptions and attitudes toward energy. Energy practices are activities and routines people engage in. Material culture encompasses the physical such as technologies and infrastructures. These three factors are dynamic and change-oriented, influenced by wider social and technological structures. The Energy Cultures framework is 'designed to identify clusters of 'energy cultures' – similar patterns of norms, practices and/or material culture – as a tool for understanding the potentials and possibilities for

sites of action to achieve behavior change, whether these are at a general policy level, or targeted at a specific group or a household characteristic.’ (Stephenson et al., 2010). In this thesis, this conceptual framework acts as a tool used to better understand the context of the rural Nepali electricity user and explain their behavior related to electricity. This is important when producing recommendations for how to better utilize the ongoing rural electrification for the highest benefit of stakeholders.

2.2. Existing research

The literature review of previously done research explains how electricity access has previously in different contexts been connected to rural development. Additionally, a specific study based on a case from Nepal is presented.

2.2.1. Electricity access and rural development

The share of people with electricity access has steadily increased since the turn of the century and so has research investigating the impacts of it (IEA, 2024a). The speed of this transition is slowing down and there is a long way to go to provide the last 10% of the world’s population with electricity (IEA, 2023). Vulnerable rural populations of South Asia and Sub-Saharan Africa make up a significant part of people awaiting electricity access (Chaurey et al., 2004). With many of the people being reached with electricity living in rural areas its impacts on rural life and specifically development need to be investigated (IEA, 2023). In this section, we draw learnings from research already conducted on what electricity access gives and could give to rural areas.

The burden of work and its time consumption has been shown to decrease by having access to electricity (Riva et al., 2018). Cecelski (2000) suggests that when daily mundane activities become electrified, women see reduced labor hours. Benefits from electricity can be seen in timesaving for cooking activities and extension of the time household work can be done into the night. These are activities often allocated to the women of the households (Riva et al., 2018). The time gained can, in turn, be used for income-

generating activities, aided by electricity (Gurung et al., 2011a). To fully realize this opportunity, complementary activities should be implemented that intend to increase education and knowledge. Furthermore, the freed time could also be used for leisure activities such as TV watching and other forms of entertainment (Riva et al., 2018).

Chaurey et al. (2004) highlights literature that indicates the first kilowatt-hours of electricity positively affect the Human Development Index. This means that even minimal electricity inputs have positive benefits for the users. This amount of electricity covers usages such as lights and mobile charging. Electric lights allow for a pollution-free light source compared to the formerly used kerosene and extend work and study hours into the dark hours of the day (Gurung et al., 2011b). Consequently, extended work hours can have positive impacts on income generation. As for mobile charging and use, it eases communication within the local community and connects it with the outside world. This has positive feedback on electricity demand. As knowledge of appliances and uses of electricity increases through communication, so does the number of adopters (Riva et al., 2018). These results of electricity access highlight the influential role local authorities can play in rural development (Urmee & Md, 2016). In addition to lobbying for bringing electricity to their communities, they can facilitate the spread of information and knowledge needed as a part of enhancing the diffusion of electric appliances (Riva et al., 2018).

In rural cases, utilizing electrification can be done with the support of complementary activities. Infrastructural preconditions have a positive feedback effect contributing to greater health service and education, among others. A reliable electricity infrastructure is a prerequisite and a key driver for socio-economic development in the rural context. Low-quality electricity supply can negatively impact productivity, cause economic losses, and create low satisfaction among the users. This hurts the activities of entrepreneurs in rural areas. Furthermore, it can create the need for backup systems such as expensive and polluting diesel generators or low-capacity solar home systems. Improving the quality and reliability of the electricity supply may be complementary to establishing access if electricity-related activities in rural areas are to improve. For entrepreneurial activities to see more of the benefit of electricity access, favorable credit terms can enable the

purchase of electrical appliances. Although it is important to realize that there is more than capital and electricity needed for such activities to be supported. Capacity building is a complementary necessity to see more benefits of electricity. Other complementary activities to implement alongside electricity access could be educational programs, support for ownership of appliances alongside organizing reliable and competent customer service. These serve the function of increasing electricity demand and being a part of creating positive feedback effects that lead to further development (Riva et al., 2018).

Local social habits, traditions, gender relations and culture can negatively affect people's electricity usage. Within the households themselves, gender relations can entail women have limited say in how money is spent (Riva et al., 2018).

Households with stronger purchase power may see more electricity usage since they can afford to buy and use appliances. This can initiate feelings of exclusion and inequality between households with different socio-economic backgrounds in the same village. Meanwhile, in some communities, it initiates the sharing of the use of appliances between households. The indication is that observations of the right cases show that electricity usage can also positively impact social connectivity (Riva et al., 2018).

If rural electrification is followed up by proper complementary activities that positively affect the education quality and bolsters the local economy, it can reduce the outmigration from rural areas (Riva et al., 2018).

2.2.2. A case study from Nepal

Already 20 years ago Bastakoti (2003) studied how access to electricity can be more beneficial through small-scale industries, enabling rural development. The research is based on the idea that technical sides of rural electrification, meaning generation and distribution, are not enough for what the author calls effective use of power. If left alone, rural electrification does not automatically lead to more than basic usage such as lighting and basic home appliances. Usage is enhanced by entrepreneurial activities, which can

create employment opportunities and add value to the local resources. For this to happen there is a need for complementary activities such as promotion of usage, availability of credit, offering training, and spreading information related to entrepreneurial activities. The main argument Bastakoti (2003) provided is that rather than having the end goal of establishing electricity access, rural electrification programs should be working as rural development programs to have a more substantial impact. This means that the work continues after providing the technical side of electricity access to ensure its usage. The study from Bastakoti (2003) is based on her field work from 1999. This is the case of a hydroelectric generation project that operated simultaneously with a community-development project in the same area in the hilly region of Nepal. These two had a symbiotic relationship where the aforementioned focused on rural electrification and the latter on the broader development of the region.

The following approaches were implemented to improve electricity use and demand of the area:

1. Promotion of electric cooking: Addressing the issues of reliance on firewood as a primary source of meeting energy needs by promoting cooking with electric appliances.
2. Power-based tariff: Structuring the tariffs to accommodate both low and high-load users.
3. User's organization: Reducing administrative burden and increasing self-reliance, through partly allocating distribution and maintenance responsibilities to local receivers through user's organizations.
4. Awareness building: Building awareness among the rural communities regarding the dangers and possibilities of electricity through programs before and after the electrification project.
5. Enterprise creation and support: Supporting the local people to start enterprises through identifying opportunities and ways to capitalize on these. This was done in six ways.
 - One such was by assessing entrepreneurs' applications for enterprises that would require a connection to the hydroelectric project.

- By having a clear presence among the community, district, and local government and banking institutions.
- Through training the local population in starting enterprises or developing their already existing ones.
- Because of the inconvenience of importing machinery a part of the project was dedicated to designing custom prototypes for businesses. This effort successfully converted eleven enterprises to electric operations.
- Furthermore, information regarding a variety of enterprises, machinery and equipment, relevant reports, and studies would be collected and provided to interested people.
- Lastly, entrepreneurs were upon request or by the perception of need linked with suppliers or relevant institutions who could provide machinery, training, and skill development.

Bastakoti (2003) describes the empirical observations made during her fieldwork in 1999 as unconventional people-centered approaches towards rural electrification with positive effects. The approaches were in her words innovative, the tariff policies practical and entrepreneurial activities fostered. As a closing statement Bastakoti (2003) concludes ‘Electricity left to grow in isolation or on its own in the rural area does not bring any conducive results but drains the rural economy instead’.

2.3. Research gap

As aforementioned the undergoing rural electrification in Nepal is recent and rapid. There is a need for research to keep up during this process and monitor the process. Much of the research on the topic of rural electrification, specifically what impacts creating access to electricity entails, is based on results gathered from the field. There is a complex interplay between dynamic factors that creates unpredictability in how transitions develop. As the electrification process continues, there is no guarantee that they will develop in the way described by research from the last two decades. The result of older research will still be important in understanding what direction the transition is taking and therefore needs to be studied. This study fills a gap related to understanding how the

current rural electrification process is developing in the context of Nepal, more specifically by looking at the Okhaldunga District. This serves to both verify and build upon conclusions drawn in prior research. Furthermore, having a systems perspective and investigating the current complex interactions between stakeholders in relation to Nepal's development is well-needed research. This was not found prominent during the literature review.

2.4. Research questions

Overarching research question

The following overarching research question guides this study to fulfill its aim:

- What are the socio-technical drivers and barriers of rural electrification in Nepal?

Sub-questions

This is divided into three sub-questions. They can be seen as steps to take to answer the overarching research question by understanding the situation and identifying gaps.

- How do people utilize electricity access in the rural context?
- What supporting factors influence how people utilize electricity access?
- What roles and responsibilities are stakeholders taking in rural electrification and what gaps relate to this?

3. Methods

With the research questions in mind, the methodology for this thesis can be addressed. It begins by explaining the epistemological framework as the basis for this research as well as the interview design. This is then complemented by describing the data collection, i.e. the details for the field study, the role of the interpreter, and the act of conducting the interviews. To understand the way the data was analyzed, a detailed explanation is given before ending with a notion on data limitation.

3.1. Positionality

As a basis to engineering and social science research, the need for anchoring it in a robust theoretical and epistemological framework was recognized. The goal was to harmonize the empirical rigor inherent in engineering with the nuanced insights valued by social scientists. Critical realism, a philosophical construct emerging from Positivism and Constructivism was identified as the anchoring framework for the thesis (Fletcher, 2017). Critical Realism defines an “objective reality as one that exists independently of individual perception but also recognizes the role that individual subjective interpretation plays in defining reality” (Taylor, 2018). It distances itself from the pure positivist view of reducing ontology to epistemology, i.e. reducing the nature of reality to the human knowledge of reality (Fletcher, 2017). In addition, it distances itself from social constructivism where it is assumed that reality is created solely by human knowledge (Fletcher, 2017).

Specifically for qualitative data gathering in the form of interviews and focus groups, a critical realist’s lens is beneficial. By grounding the exploration in an objective theoretical framework and enriching it with diverse subjective perspectives, a robust foundation for contextual understanding is laid. This approach becomes particularly crucial when delving into socio-technical dynamics within rural electrification. Here, deep-seated factors must be unearthed while respecting the existing structures (Fletcher, 2017). In the pursuit of shedding light on these socio-technical dynamics, Critical Realism serves as

the compass, guiding the researchers toward informed policy recommendations (Fletcher, 2017).

3.2. Interview design

The interviews were based on a qualitative semi-structured approach as the goal was to understand the underlying social dynamics of rural electrification. This structure allowed us to proceed with follow-up questions, adjust and tailor them to the background and the role of each interviewee, and focus on a few key questions in cases where the time was constrained. The interviews spanned from 15 to 90 minutes, varying with the time given by the respondent. Depending on the respondents' competence of the English language, translation was not always necessary (est. 20% of the interviews). Furthermore, the motivation of the interviewee determined how detailed the interviews could be.

Table 1 shows the stakeholders interviewed in the study locations and Kathmandu, the variability of the interview type, and the number of responses per stakeholder type.

Stakeholder	Type of interview	No. of responses
Private individuals	Normal questionnaire during the field study	42
Business owners	Normal & specialized questionnaire during the field study	9
Municipal government	Specialized questionnaire during the field study (contextual)	3
Banks / Loan institutes	Specialized questionnaire during the field study (contextual)	2
Site operators/ electricians	Normal & Specialized questionnaire during the field study	5
Women's / Mothers groups	Specialized questionnaire during the field study (General understanding)	11 (Rampur) 25 (Kosh Bhanjyang) 14 (Kakani)
NEA / AEPC officials	Contextual during the field study, follow-up on learnings from the field in Kathmandu	5
University professors	follow-up on learnings from the field in Kathmandu (Contextual)	2

Table 1: Stakeholders interviewed in the study locations and Kathmandu, the variability of the interview type, and the number of responses per stakeholder type.

The questionnaire was developed in collaboration with the supervisors from Chalmers and the German development cooperation office in Kathmandu, as well as experts from the AEPC. **Table 2** shows the iterative improvements and adjustments made to the questionnaire during and between the various field studies. Adopting multiple perspectives facilitated the continuous applicability and relevance of the topic. At this point, it must be noted that these questionnaires were not predetermined and were supported by follow-up questions in the moment. For reference, the four questionnaire versions were attached in the Annex.

Version	Reason for adjustment
1.0	The initial questionnaire was developed in collaboration with the supervisor at Chalmers and inspiration from questionnaires in similar study areas.
1.1	The interviews took a long time and people got impatient. The most important questions from version 1.0 that were most relevant to electricity were chosen and henceforth used.
2.0	Between the pilot study and the first field study, several points were adjusted. The numbering for quick notetaking was done more efficiently. Moreover, a list of assets (ownership of electrical appliances, animals, etc.) was prepared separately from the questionnaire for timesaving. Based on the pilot study, a smaller number of relevant areas to study was chosen. This updated version was checked for relevance by the supervisor as well as the engineer from the AEPC.
3.0	The goal for the second field study was to be sure about the understanding gained during the first field study. This meant going back to the site of the first field study and identifying patterns and topics as well as delving deeper into them. For additional relevance, different leading questions were developed for the various groups of people to be interviewed (government, businesses, NEA, banks, female focus groups). To check that the trends and patterns identified during the first field study, contextual interviews were held in Kathmandu that helped shape the questionnaire further.

Table 2: Presentation of different questionnaire versions and the reason for adjusting.

3.3. Data collection

This subchapter includes details about the field studies, the role of the engineer from the AEPC, as well as the way the interviews were conducted.

3.3.1. Field study details

This section will present information about the different study sites. The pilot study was conducted in Sikaribas (**Table 3**), located in the flatlands and close to the southern border of Nepal. Though not a remote and inaccessible area per se, the village is located inside Parsa National Park with reliable road access only in the dry season. Due to this unique

setting with strict rules about electricity infrastructure, the AEPC provided an SMG for Sikaribas. This village was deemed suitable for the scope of the pilot study as it was reachable by night bus from Kathmandu. In addition, the AEPC recently completed the project, likely offering more acceptance for conducting interviews. Regarding the technical details, Sikaribas was equipped with a 23 kWp SMG. In total, two interview days were spent in the study location.

During the main and follow-up field study, three villages in the Okhaldunga district of the eastern hilly region were visited. In an iterative process, these villages were chosen based on their proximity to each other and Kathmandu. Moreover, these villages were of different sizes, accessibility, and time since electricity arrived, which helped to see the influence of these factors.

The first and most remote village was Kakani (Kakani: Main field study, Interview 1), where the AEPC commissioned a 70 kWp SMG for 170 households (AEPC, 2022). At the beginning of 2023, a road to Kakani was built, making the construction of the SMG possible (Kakani: Main field study, Interview 14). The households in Kakani were spread throughout a basin, sometimes including several hours of hiking to reach the more remote households. The majority of people were involved in agriculture and animal husbandry and only a small number of people had different occupations.

The second village was Kosh Bhanjyang (**Table 3**), where at the beginning of 2023, 105 households got connected to the national grid (Kosh Bhanjyang: Main field study, Interview 1). Before, 16 households had access to an SMG, while others relied on SSHS or non-electric fuels (Kosh Bhanjyang: Main field study, Interview 1). As Kosh Bhanjyang is located at an intersection of roads leading to several places, more traffic goes through the village. In addition, the local ward office and a police station are in the town. The households were located on two slopes, one uphill and one downhill of the main road.

Despite the fact the Okhaldunga district is only a day's drive away from Kathmandu, almost half of the drive to Kosh Bhanjyang and Kakani must be done on poorly

maintained dirt roads. This makes offroad vehicles essential and is a contributing factor to the location's remoteness.

On the contrary, the final village Rampur was accessible by a tarred road and thus also vehicles with less ground clearance. The national grid arrived 6-7 years ago in Rampur, but the first time somebody had access to electricity was 16 years ago (Rampur: Main field study, Interview 6). The long history of electricity and education provided Rampur with much development and for these reasons migration throughout the years. This can also be reflected in the assets owned, types of businesses, variety of institutions (banks, authorities, etc.), and knowledge about electricity.

The following tables (**Table 3 and 4**) provide an overview of the history of electricity leading up to the status quo as well as the location and geography of the studied places.

Study location	History of electricity access leading up to today
Sikaribas	SSHS → SMG
Kakani	SSHS → SMG
Kosh Bhanjyang	Pico hydropower plant → SSHS & SMG → National grid
Rampur	Diesel generator → Pico hydropower → Micro hydropower plant & SSHS → National grid

Table 3: History of electricity in study sites

Study location	Ward	Rural municipality	District	Province	Geography
Sikaribas	3	Thori	Parsa	2	Terai region (flatlands)
Kakani	9	Sunkoshi	Okhaldunga	1	Hilly region
Kosh Bhanjyang	9	Sunkoshi	Okhaldunga	1	Hilly region
Rampur	2	Molung	Okhaldunga	1	Hilly region

Table 4: Overview of all studied villages

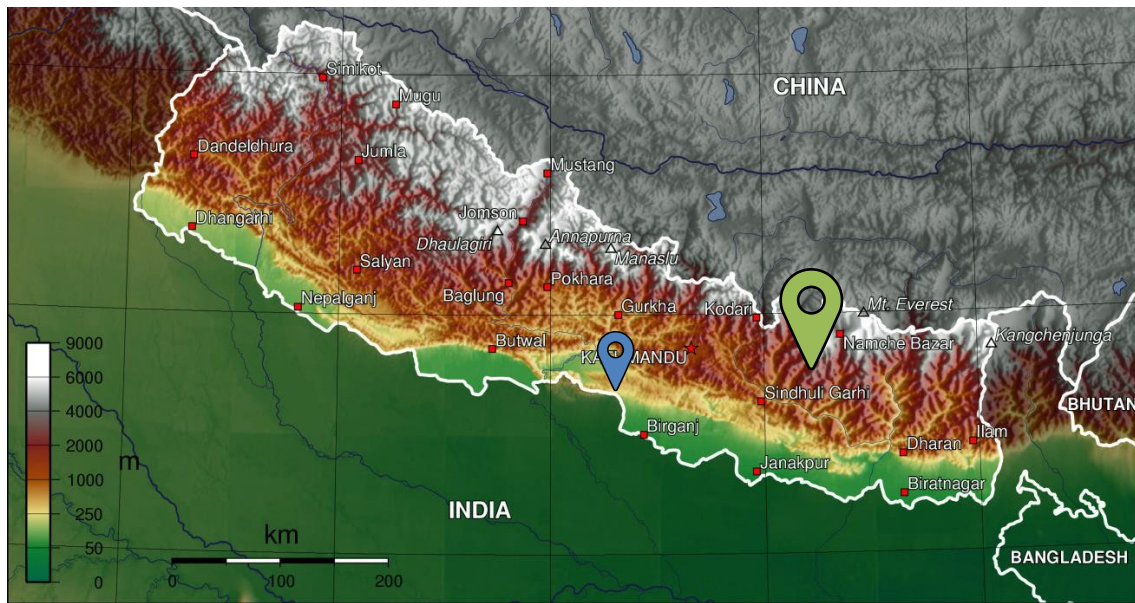


Figure 1: Geographical overview of study locations, the blue marker represents the location of the pilot study, and the green marker represents the area of the three villages where the main and follow-up studies were conducted

3.3.2. Role of the interpreter, guide, and engineer from the AEPC

This paragraph will explain the roles and responsibilities of the interpreter during the interviews. First, almost all interviews wouldn't have been possible without the engineer from the AEPC. He took charge of finding suitable locations for the field studies, organizing sleeping and eating arrangements, as well as facilitating and interpreting the interviews. Once in the field, he introduced us to the proposed interviewees, leading to a near 100% success rate in people agreeing to be interviewed (without them asking for any compensation in return). Being a respected governmental engineer from the AEPC, most

likely gave us access to many interview partners that would have been difficult to reach otherwise.

As it was the engineer's first time acting as an interpreter, questions sometimes didn't lead to the expected responses. This was mainly due to two reasons: First, the respondents didn't understand the question correctly or wanted to tell us something else they thought of in the moment. Second, there was a discrepancy between the questions the researchers asked and what the interpreter understood. The latter reason was mitigated throughout the trip as the cooperation got more aligned and smoother with more questions being repeated. Another issue during the interviews was that the researchers sometimes perceived that not everything was fully translated back. This was confirmed several times after the interview when new insights from the interview were disclosed. These two topics were addressed in bidirectional feedback sessions with the engineer from the AEPC which mostly mitigated the issues.

3.3.3. Conducting the interviews

During the day, there was a limited time window where interviews could be conducted. After 10 AM, when breakfast was traditionally consumed, and until 3-4 PM, when the children returned from school and agricultural and animal husbandry-related tasks peaked, was the usual interview window.

With this limited time, it was very useful to have two interviewers. Alternating to lead the interview and thereby reducing the number of involved people, ensured consistent interview quality. As respondents were usually interviewed alone, more balance was achieved by only having the engineer from the AEPC and one of the researchers involved. The researcher in the background took different roles: taking supplementary notes about the interview but also the situational context, finishing up notes from a previous interview (due to the limited time), asking follow-up questions, and occasionally taking care of children to not get the respondent distracted.

3.4. Data analysis

This section explains how the data was digitized and analyzed.

3.4.1. Digitization

Pilot Study

The pilot study aimed to refine interview techniques and establish an effective transcription method. Initially, interviews were documented using both paper and laptop while also being recorded. However, after the first interview, it became evident that using a laptop created a significant imbalance between the foreign researcher with advanced technology and the local respondents. Consequently, laptop note-taking was discontinued. Consent for data collection was obtained verbally due to the presence of several participants who were unable to read or write.

Upon returning to Kathmandu, interviews were digitized from handwritten notes. The recordings were deemed impractical because the mix of Nepali and English made transcription overly time-consuming. To ensure accuracy, responses were cross validated between the researchers and, in cases of discrepancies or uncertainties, verified by the engineer from the AEPC.

Main Study

For the main study, laptops were excluded in favor of handwritten notes, influenced by the pilot study findings and luggage weight restrictions. Consent was obtained on paper, with fingerprints used for participants unable to write their names. After returning to Kathmandu, it took approximately two weeks to digitize the interviews, compile the travel report, and extract initial insights from the data.

Follow-Up Study

Due to time constraints, laptops were brought to the field during the follow-up study. Anticipating more downtime, as fewer specific individuals were to be interviewed, handwritten notes were digitized each afternoon and evening. The travel report was also

compiled digitally on a daily basis. Upon returning to Kathmandu, a final digitization of the data was completed within a few days, allowing time for contextual interviews with additional stakeholders.

3.4.2. Analysis

For the analysis, two parts comforted the more efficient analysis of the gathered data. First, all quantitative data such as gender, household size, ownership of appliances, etc. were documented in Microsoft Excel. In that context, it was easily possible to create visualizations of demographics and trends to base the qualitative data analysis on and create a contextual framing for that purpose.

The qualitative data analysis was the most demanding part of the analysis. Therefore, the qualitative data analysis tool NVivo was employed with its process from importing raw interview data to inductive and deductive theme identification. The step-by-step approach as seen in the following was inspired by Kaefer et al. (2015).

1. Preparing the data

- 1.1. The documents were imported to NVivo and sorted by location, but also by pilot, main, and follow-up study.
- 1.2. The interviews were auto-coded by style to sort all responses to the same question together. Irrelevant questions were removed as they were already analyzed in Excel.
- 1.3. To get an initial feeling of the responses, word frequency searches (excluding the questions) were conducted. Additionally, NVivo was used to auto-code themes emerging in each of the questions but also in the same locations and all trips. However, this didn't yield much and only presented obvious themes such as electricity and was therefore discontinued.

2. Deductive start list and inductive addition

- 1.1. To sort the responses to themes, a start list was created a typical first step in deductive data analysis (Azungah, 2018). The start list was created by reading

through the questions of the questionnaire and supported by a short literature study to match the questions with relevant research.

1.2. Next, each line of code, i.e. each response was analyzed and if relevant placed in a theme within the start list. During the execution of this procedure, the start list was extended inductively by adding emerging themes and patterns.

1.3. Once the entire code was analyzed line-by-line, each theme was taken separately. Responses coded to the themes were analyzed and potential keywords were extracted. These keywords were then used to conduct a text search, to find more suitable responses that might have been missed before.

1.4. Afterwards, each response coded to every theme was re-evaluated for suitability.

1.5. Trying to limit personal bias as much as possible, the identified themes were cross-checked between both researchers and further refined.

1.6. Finally, the themes were categorized and in the case of missing or too small number of references excluded from presenting them in the results.

In the following subchapter, the data limitations are discussed to bring the analysis and results into perspective.

3.5. Data limitation

There are several limitations to the data throughout the process from gathering the data to reaching the results. For a better overview, the limitations are split into two parts, interview limitations, and data analysis limitations. Additionally, the mitigation techniques are discussed.

3.5.1. Interview limitation

Due to time constraints but also the scope of the thesis, a limited number of stakeholders were interviewed and the time available for each respondent was constrained. Furthermore, it must be acknowledged that most people were interviewed once. Recognizing that the respondents' opinions can evolve rapidly, the transient nature of the

insights gathered is recognized. In addition to this, conducting interviews with an interpreter can easily lead to misunderstandings and meanings that are lost in translation. These limitations were addressed in three ways: First, the researcher in the background tried to help understand the response better by explaining what they understood to the interpreter and interview-leading researcher. Second, both researchers asked follow-up questions. Last, some identified key respondents were reinterviewed during the follow-up field study.

3.5.2. Analysis limitation

To begin with, the auto-coding that arranged all responses to the same question, missed transfers by the software cannot be eliminated. Because of limited time, this was not checked but thus far no gaps in this area have been identified. Moreover, and most importantly, the coding involved a major human bias. The list of themes was created based on what the researchers found most relevant in research but also the responses. Additionally, the researchers sorted the responses into fitting themes. These coding limitations were attempted to be mitigated by referring to the literature and cross-checking the sorted themes with both researchers.

4. Results

This chapter presents four themes that were identified during the data analysis. For a better overview, each of the themes is split into subthemes. It addresses chronologically the three sub-questions ‘How do people utilize electricity access in the rural context?’, ‘What supporting factors influence how people utilize electricity access?’, and ‘What roles and responsibilities are stakeholders taking in rural electrification and what gaps relate to this?’. The themes and subthemes are then used in the discussion to be matched with relevant literature.

4.1. Utilization of electricity access

This theme includes all subthemes that relate to the sub-question ‘How do people utilize electricity access in the rural context?’. Specifically, aspects are presented that lead and have led to a change in electricity and clean cooking use.

4.1.1. Access to clean energy sources

Within this subtheme, physical access to electricity and LPG is presented which looked differently between the study locations. An issue raised several times was the fact that there are only markets for buying electrical appliances in Rampur, Okhaldhunga bazaar, or Kathmandu, depending on what type is sought. This means that the effort of acquiring an appliance is high and was stated as the main reason for not owning and using more electrical appliances. (Kosh Bhanjyang: Follow-up field study, Interviews 1 & 2; Kakani: Main field study, Interview 3)

Furthermore, the presence of repair and maintenance shops differed by study location. While Rampur’s repair and maintenance infrastructure was oversaturated (Rampur: Follow-up field study, Interview 4), Kosh Bhanjyang and Kakani lacked repair and maintenance facilities entirely. The difference in access to these facilities was reflected in the use and ownership of different types of kitchen appliances (Kakani avg. 0.8, Kosh

Bhanjyang avg. 1.4, Rampur avg. 5.3), showcasing the importance of supporting infrastructures when investigating appliance use. (Kosh Bhanjyang: Follow-up field study, Interview 1; Rampur: Follow-up field study, Interview 4)



Figure 2: Electricity repair shop in Rampur (Own photograph)

4.1.2. Cost of electricity compared to firewood

This subtheme covers three costs: the electricity tariff, appliances, and firewood. Regarding the cost of the electricity tariff, the opinions were divergent, independent of the study location. Several people responded that the tariff didn't feel expensive (Kakani: Main field study, Interviews 5, 7.1, 9 & 12), with one response adding that the NEA needs to pay their employees too (Kosh Bhanjyang: Main field study, Interview 5). Moreover, one respondent mentioned the flexibility in paying for the tariff, as they could sell more milk if the cost went up (Kosh Bhanjyang: Main field study, Interview 7.2). One respondent claimed to use an electric stove because of the lower cost compared to LPG or firewood (Rampur: Main field study, Interview 3.3). Nevertheless, there were

respondents only using the base charge as they feared a price spike if they used more electricity (Rampur: Main field study, Interview 11; Kakani: Main field study, Interview 16). Additionally, respondents were having a hard time paying for the tariff and felt the cost to be too high (Kakani: Main field study, Interview 17; Main field study, Kosh Bhanjyang Interviews 2 & 11).

When being asked about whether the increased monthly tariff or the cost of the appliance was the deciding factor in the ownership of appliances, the latter was stated. As a reason for not owning more appliances, multiple respondents argued that the cost of it was too high. This shows that the ones being asked this question were aware of the cost structures. Showing the difficulty of quantifying qualitative data, some respondents stated that several people in the area had a hard time paying for the electricity tariff while they did not struggle. (Kakani: Main field study, Interview 8 & Follow-up field study, Interview 1, Kosh Bhanjyang: Main field study, Interview 2, Rampur: Main field study, Interviews 5 & 11)

Moving on to the cost of firewood, it often was compared to being the free alternative to LPG or electric stoves, referring to their labor involving no cost for gathering firewood. Here, and often in the same sentence, respondents mentioned LPG to be very expensive. (Kosh Bhanjyang: Main field study, Interview 9; Rampur: Follow-up field study, Interviews 5 & 7)

Further looking into the economic conditions of the respondents could showcase reasons for diverse opinions about the costs. This analysis was, however, not conducted as it was not extensively covered in the questioning.

4.1.3. Electric or LPG cooking as exception

This subtheme covers the respondents who used electricity, electric appliances, and LPG only in rare cases with different reasoning. Mostly the older generation, but also younger ones, replied that they would use a water kettle to make tea or cook instant noodles to not have to make a fire for these small actions (Kosh Bhanjyang: Main field study, Interviews

5 & 9.). Moreover, two respondents mentioned that they prefer LPG or electricity as it is faster. A considerable number of respondents said to cook with electricity or LPG only in so-called “emergencies” such as wet firewood. For those not specifically mentioning the term emergency, the long duration for emptying an LPG canister indicated the dominant firewood use. (Rampur: Main field study, Interviews 2, 3.1, 4, 10 & 12; Kakani: Main field study, Interviews 6 & 15) **Figure 3** shows a traditional firewood stove as it was encountered many times during the field studies.



Figure 3: Traditional fireplace located outside of the main house (Own photograph)

4.1.4. Fuel stacking and alternative options

This subtheme covers data on fuel stacking as well as the presence of alternative options to the main source of electricity. As every respondent was asked about their assets and mode of cooking, data on owning two different fuels could be analyzed. Almost 60% responded to using at least two different fuels for cooking purposes, such as firewood and LPG (Reference: own analysis). One respondent had a SHS installed to avoid price spikes from the national grid. However, the main reason given for having or keeping alternative

options to the national grid or SMG, was due to regular outages (Kosh Bhanjyang: Main field study, Interviews 2 & 9; Rampur: Main field study, Interviews 2, 5, 6 & 13).

4.1.5. Ownership of ICT devices but not appliances

This subtheme examines indications in literature, stating that people possessing ICT devices often do not own kitchen appliances. The first hint in the interviews was that two respondents claimed TV repair to be the biggest part of their daily work at the repair shop (Rampur: Main field study, Interview 8 & Follow-up field study, Interview 4). Additionally, the list of assets owned by each individual was taken to compare ownership of ICT devices to kitchen appliances. As seen in **Table 5** below, at most 50% of the respondents with any ICT device also owned a kitchen appliance, with water kettles and blenders as the most dominant ones.

	Fan	Blender	Water kettle	Rice cooker	Electric heater	Iron	Vacuum
No. of ICT device and appliance owners	7	17	19	13	4	10	0
No. of ICT device owners	39	39	39	39	39	39	39
Share of ICT + appliance in total owners	18%	44%	49%	33%	10%	26%	0%

Table 5: Share of respondents with any ICT device together with a specific kitchen appliance.

4.1.6. Utility and support of appliances

This theme shows the different ways electrical appliances support respondents in their daily lives and which utility they get from them. In several interviews, reduced stress and an easier daily life because of appliances was highlighted by the respondents (Kakani: Main field study, Interviews 15 & 17; Kosh Bhanjyang: Main field study, Interview 6.1; Rampur: Main field study, Interviews 3.1, 3.3 & 6; Follow-up field study, Interview 5). This can be supported by many respondents who stated that the electric rice mill could reduce the time and effort spent on de-husking and grinding grains. **Figure 4** shows a rice mill that looked similar every time it was encountered. Some respondents went as far as to call the rice mill a new basic need. (Kakani: Main field study, Interviews 1, 15 & 16; Kosh Bhanjyang: Main field study, Interviews 5, 7.1 & 7.2; Follow-up field study,

Interview 2; Rampur: Main field study, Interviews 2 & 10) In addition, one respondent emphasized that a rice cooker increased efficiency as other tasks could be performed while the rice was being cooked (Rampur: Main field study, Interview 3.1).



Figure 4: Rice mill that was used for de-husking and grinding rice and other grains (Own photograph)

One major improvement that 24 hours of electricity provision brought was the ability to work under artificial light, both in the morning and in the evening. Several people mentioned this to be important for them as tasks previously difficult to perform in insufficient light could be done more efficiently. Here, improvements in leisure were also mentioned where hobbies such as bamboo basket weaving could be done in the evening under artificial light. (Kakani: Main field study, Interviews 4, 7.1, 7.4, 8, 11 & 15; Rampur: Main field study, Interview 11)

4.2. Influence of supporting factors on the utility of electricity access

This category summarizes all themes fitting to education, knowledge, and culture. It describes the change that occurred according to the respondents in the three studied villages.

This theme addresses the second sub-question ‘What supporting factors influence how people utilize electricity access?’. It includes a wide range of socio-technical factors that give insights into the underlying reasons for utilizing electricity access.

4.2.1. Educational improvements

Having interviewed several teachers as well as students, this theme includes views from both parties. One teacher stated that electricity and access to the internet has helped them prepare information more efficiently (Rampur: Main field study, Interview 6).

Multiple students stated that studying online largely supported their learning. They also mentioned that this knowledge is often passed on to classmates and sometimes to teachers. (Rampur: Main field study, Interviews 1, 4, 7 & 16)

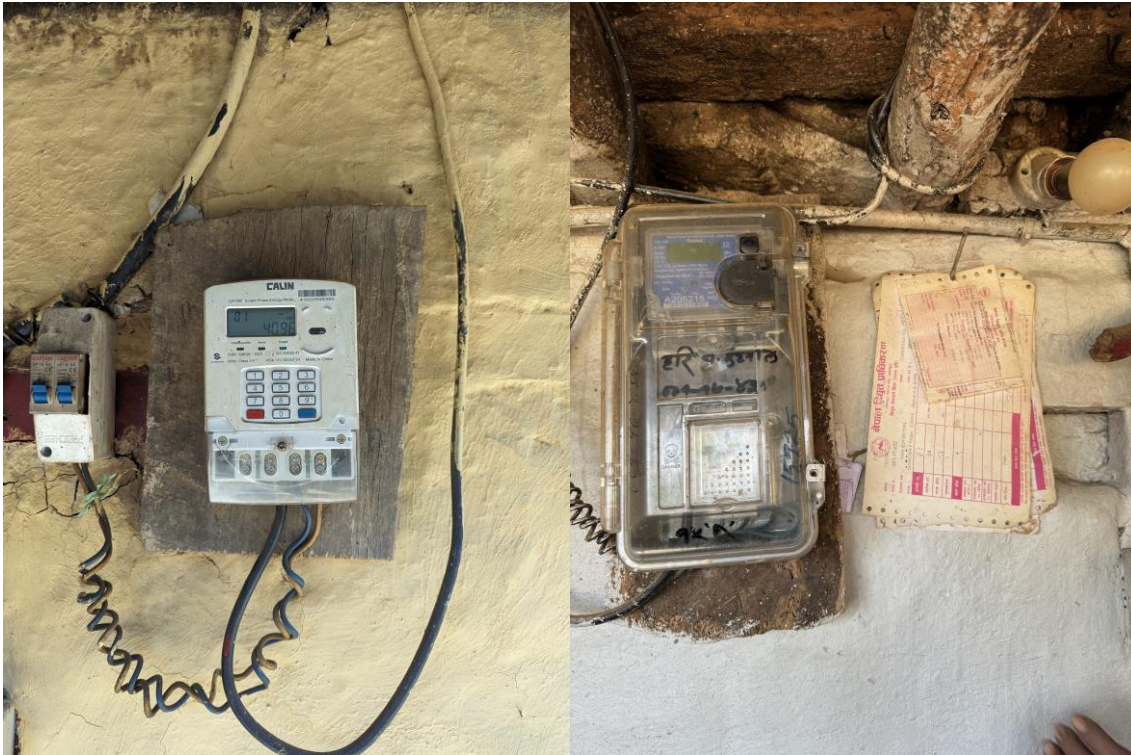
Students, their teachers, and their relatives found that the biggest improvement that electricity brought was the ability to study in the evening and at night. Easier conditions like not requiring kerosene lights seem to provide significant improvements for studying and doing homework. (Kakani: Main field study, Interviews 5, 6, 8, 12 & 13; Kosh Bhanjyang: Main field study, Interviews 4, 7.3 & Follow-up field study, Interview 2, Rampur: Main field study, Interviews 3.3, 7, Kosh Bhanjyang: Follow-up field study, Interview 2)

4.2.2. Knowledge about electricity

This theme covers both the positive as well as negative effects that knowledge about electricity incorporates.

The leader of a mother's group stated that their bill was very high when the national grid first arrived. By trying different usage patterns and currently reading the meter, they learned to decrease the electricity bill by still benefiting sufficiently from electricity. This knowledge was then shared with the group, showing the importance of strong communities in this context. (Rampur: Follow-up field study, Interview 5) In addition, one respondent found the TV to be beneficial for local, national, and international information gathering (Kakani: Main field study, Interview 5).

However, the most dominant observation was that citizens lack sufficient knowledge about reading the electricity meter. **Figures 5 and 6** show two typical electricity meters as observed during the field studies. In interviews with the local ward office, it was confirmed that the majority of citizens living in the studied locations did not know how to read the electricity meter i.e. make use of the reading (Rampur: Follow-up field study, Interview 4; Kosh Bhanjyang: Follow-up field study, Interview 1).



Figures 5 (left) and 6 (right): Two electricity meters as observed during the field studies
(Own photographs)

Moreover, both citizens and the local government confirmed that knowledge about using electricity was missing (Kosh Bhanjyang: Main field study, Interview 7.2, Rampur: Main field study, Interview 7 & Follow-up field study, Interview 2, Kakani: Follow-up field study, Interview 1). As an example, one respondent at a focus group discussion asked whether it was more efficient to turn the fridge off overnight to save money on the monthly electricity bill. Following this question, the members of the focus group discussion asked for more tips related to the efficient use of electricity. (Rampur: Follow-up field study, Interview 5)

4.2.3. Traditions and historic norms

This theme shows the interplay of traditions and historic norms and how they changed with electricity. The statement “If we do not cook with firewood, we are not Nepali.” (Rampur: Main field study, Interview 4) was in different phrasing presented during several interviews, representing the cultural aspects. The placement of firewood in

traditions was emphasized multiple times (Kosh Bhanjyang: Main field study, Interview 2; Rampur: Main field study, Interviews 3.1, 4 & 6). However, cooking rice over fire causes the cooking pot to turn black. Traditionally and for the taste, the pot needs to be cleaned with much effort after every use, which leads to higher workloads. Those respondents, having made the change to LPG stoves, valued the saved time due to the pot not turning black. (Rampur: Main field study, Interviews 3.1 & 3.3; Kosh Bhanjyang: Follow-up field study, Interview 2)

Respondents mentioned several times that the use of traditional hand-played instruments was exchanged for electronic music speakers, resulting in decreased job opportunities for musicians but increased flexibility for gatherings (Kakani: Main field study, Interviews 5, 13, 15, 16; Rampur: Main field study, Interview 6). Rituals and weddings now happen in artificial light, enabling them to last longer and be conducted in improved circumstances (Kakani: Main field study, Interview 15; Rampur: Main field study, Interview 4). According to some respondents, these changes are combined with the increased influence of Indian and Western traditions. This was explained as people who worked abroad returned with the different cultures they were exposed to and exchanged that culture with the Nepali traditions. (Rampur: Main field study, Interviews 4, 8, 10) In addition to this, respondents returned with knowledge about electricity and electrical appliances, showing an additional channel of knowledge acquisition (Kosh Bhanjyang: Main field study, Interview 7.4).

4.2.4. Electricity and LPG empowering businesses

This subtheme summarizes the benefits of electricity and LPG that empower businesses. Electricity and LPG compared to firewood to be more efficient was stressed by several respondents with businesses, or as stated by one respondent: “Being able to cook food fast is important.” (Rampur: Main field study, Interview 5). **Figures 7 and 8** show an example of fridges being used and a typical setup of an LPG stove used at a Homestay. When asked how much time they would lose if the electricity went away today, they estimated two to three hours more work (Rampur: Main field study, Interview 5). In Kakani, several respondents agreed that the carpenter benefitted the most from the SMG.

Specifically, electricity enabled them to go to different homes and use their electric tools for construction. (Kakani: Main field study, Interviews 7.4, 16 & 17)



Figure 7 (left): Use of fridges in a small restaurant business and **Figure 8** (right): typical setup of an LPG stove used by a homestay business. (Own photographs)

Businesses involved in agriculture stressed the importance of electric water lifting, creating new agricultural areas (Rampur: Main field study, Interviews 6 & 11). This creation of opportunities is also reflected in poultry farming, where heat lamps for raising the chicks are a necessity for this type of business (Rampur: Main field study, Interviews 12).

Respondents owning an electric rice mill were positive about the investment, showing that both users and owners of the rice mill benefited (Kosh Bhanjyang: Main field study, Interviews 3 & 7.1; Rampur: Main field study, Interviews 10 & Follow-up field study, Interview 6).

4.2.5. Empowerment for women

This subtheme delves into empowerment for women, also being brought up in several instances outside the scope of this subtheme. In a recent computer training that was organized by the local ward office, 20 out of 22 attendees were women (Kosh Bhanjyang: Follow-up field study, Interview 1). Additionally, respondents working at the ward office pointed out lower taxes for female business owners and an increase in women seeking opportunities (Rampur: Follow-up field study, Interview 5). Regarding education programs targeted at (older) women being the dominant groups in all studied locations, there were none (Kosh Bhanjyang: Follow-up field study, Interview 2). One thing being repeated in several instances was the statement that women generally have an easier life thanks to electricity (Kakani: Main field study, Interview 5; Rampur: Main field study, Interview 3.3).

Women's and mother's groups that were interviewed in focus group discussions stated that they have strong support structures within their groups. This support spanned from collecting monthly fees from every woman to hand out loans to those in need, to the sharing of appliances such as electric heaters for infants. (Kosh Bhanjyang: Main field study, Interviews 2, 6.2 & 7.2, Rampur: Follow-up field study, Interview 5) **Figure 9** shows one focus group discussion with a mother's group in Kosh Bhanjyang.



Figure 9: Focus group discussion with a mother’s group in Kosh Bhanjyang (Own photograph)

4.2.6. Migration and brain drain

Here, responses pointing towards migration are presented. A large share of the respondents wanted to move to bigger cities in Nepal such as Kathmandu or abroad. The reasoning for this varied, but the main drivers for planned migration were education or improved work opportunities. For barriers, missing trust in the region's development potential was given. (Kakani: Main field study, Interviews 6, 8, 11, 12 & 16; Kosh Bhanjyang: Main field study, Interviews 2, 7.3 & 8; Rampur: Main field study, Interviews 7 & 8; Kosh Bhanjyang: Follow-up field study, Interview 2, Rampur: Follow-up field study, Interviews 1, 4, 7 & 8)

Connecting this with the brain drain of the area, respondents said “The ones who know about using electricity to their advantage, leave [...]” (Rampur: Follow-up field study, Interview 4). The intention to migrate in the future can already be observed looking at the youth, where a foreign language such as Korean is studied years in advance in preparation for a planned migration (Kakani: Main field study, Interview 6).

As an example of how strong the urge to migrate is, one respondent stated that it was very difficult for them to find employees for their business. Specifically, “People in the village do not want to wash dishes and do service work in their village, because it is embarrassing to them. They are okay with doing that in Kathmandu.” (Kakani: Main field study, Interview 16), additionally showcasing that employments with worse conditions are chosen over taking up local opportunities.

In some cases, however, (temporary) migration is seen as the only option for individuals. Both banks and individuals stated that to repay loans people migrate for work and return as soon as the loan is repaid. (Rampur: Follow-up field study, Interviews 1 & 6)

4.3. Roles and responsibilities of stakeholders

This theme presents the findings associated with the work of the government / governmental organizations and the relationship with the people. It relates to the third sub-question ‘What roles and responsibilities are stakeholders taking in rural electrification and what gaps relate to this?’ by looking at both the supply and demand side of rural electrification.

4.3.1. Roles and responsibilities of the government, NEA, and AEPC

In this subtheme, the responses relate to primarily one interview each as it focuses on the roles and responsibilities according to the government, NEA, and AEPC. The first duty according to the local government is to fulfill the demands of their people as well as to provide basic electricity to everyone (Kosh Bhanjyang: Follow-up field study, Interview 1). In Nepal, the NEA i.e. everything surrounding electricity, works separately from the local government that is responsible for the other basic duties such as water, road infrastructure, health, and education. On the local level, there is no collaboration between the NEA and the government. (Kosh Bhanjyang: Follow-up field study, Interview 1) The chain of command for e.g. knowledge programs related to electricity utility starts with a demand letter from the citizens to the local government, followed by a recommendation

letter from the local government to the NEA. However, there have not been any programs from the NEA, which was explained by stating that an initiative from the citizens is needed. (Kosh Bhanjyang: Follow-up field study, Interview 1; Rampur: Follow-up field study, Interviews 2 & 7) Being aware of the lack of knowledge about electricity, the NEA conducts planned outages aiming to protect the appliances of their citizens (Kosh Bhanjyang: Main field study, Interview 5).

During the interviews, differences in the amount of responsibility taken by each ward office were exposed. For instance, one ward office collects the payment for the monthly electricity bill from their people and brings it to the payment office, while another ward office provides no service (Kosh Bhanjyang: Follow-up field study, Interview 1; Rampur: Follow-up field study, Interview 7). Aiming to increase the use of electricity after the SMG was completed in Kakani, the AEPC provided six light bulbs for free to every household (Kakani: Main field study, Interview 1).

4.3.2. Trust in and demands to the government, NEA, and AEPC

This subtheme complements the roles and responsibilities of the government, NEA, and AEPC with the views from the demand side. Respondents complained that training and knowledge programs related to computers and appliances are insufficient and in parts missing (Rampur: Main field study, Interviews 3.3 & Follow-up field study, Interview 2). Furthermore, it was stated that demand letters were left unanswered leading to the view that the government cannot fulfill the demands of their people (Rampur: Main field study, Interview 4; Kosh Bhanjyang: Main field study, Interviews 7.4 & Follow-up field study, Interview 2; Rampur: Follow-up field study, Interview 5). When asked about support for businesses, respondents stated to had received no support and even asked the researchers for programs that they could attend in Sweden (Rampur: Main field study, Interview 14 & Follow-up field study, Interview 4).

5. Discussion

This chapter focuses on the previously presented sub-research questions to answer the overarching research question ‘What are the socio-technical drivers and barriers of rural electrification in Nepal?’. This is done by connecting themes that have factors influencing each other, creating dependencies between the themes, and analyzing them by using the literature review. The aim is to explain the situation and set up for how gaps can be addressed.

5.1. Infrastructure and utilizing electricity

Connecting the subthemes from the results ‘Access to clean or modern fuels’ (4.1.1.) with ‘Utility and support of appliances’ (4.1.6.) shows the importance of supporting infrastructure for repairing, maintaining, and acquiring appliances to provide real utility to the user. Here, the theoretical concept of material culture (Stephenson et al., 2010) together with the complexity surrounding an innovation (Rogers, 2003) become relevant. As covered by the existing research, access to electricity also includes the reliability of it (Riva et al., 2018). Subthemes ‘Access to clean or modern fuels’ (4.1.1.) and ‘Fuel stacking and alternative options’ (4.1.4.) are connected. These show that electrical outages, meaning low-quality electricity access, influence the user’s practices. It becomes clear in the studied case, how energy practices relate to the material culture, as in the energy source and infrastructure delivering it (Stephenson et al., 2010). A less reliable electricity supply makes the use of electrical appliances less advantageous. The perceived relative advantage of an innovation (diffusion theory) may be negatively affected by external factors such as material culture, leading to slower adoption rates (Rogers, 2003). More barriers to higher adoption of electricity use related to cooking can be seen as subthemes ‘Cost of electricity compared to firewood’ (4.1.2.) and ‘Traditions and historic norms’ (4.2.3.) are connected. The results show that many respondents were reluctant to pay for clean cooking when they could gather firewood for free. In addition to this, firewood was the traditional and culturally anchored method of cooking, influencing the decision process. A connection is apparent through the Energy Cultures framework with

the connection between cognitive norms and energy practices (Stephenson et al., 2010). This can be used to further explain why the transition towards clean cooking moves at the rate observed. Then the idea of changing the material cultures to see changes in cognitive norms and energy practices reoccurs as it did when analyzing subthemes ‘Cost of electricity compared to firewood’ (4.1.2.) and ‘Traditions and historic norms’ (4.2.3.) In practice that change is dependent on the reliability of the electricity infrastructure. This point has been highlighted by existing research as important for improving electricity-related activities in rural areas (Riva et al., 2018).

The previously mentioned barrier of increased electricity usage may be analyzed through subthemes ‘Fuel stacking and alternative options’ (4.1.4.) and ‘Utility and support of appliances’ (4.1.6.). Cooking with firewood was often accompanied by the ownership of LPG stoves that were used in specific circumstances such as emergencies or to boil water for tea fast. This shows that a relative advantage is perceived by adopting innovations instead of solely relying on firewood. Having made the choice of occasionally using clean cooking alternatives to firewood may be an indication of a transitional phase stage and that the innovation-decision process is underway. Looking at the process, this type of use could be said to be in between two of the steps, (2) persuasion and (3) decision. The transition in Nepal is towards electrification, meaning LPG while an improvement on firewood, the goal is rather more widespread cooking with electricity (NEA, 2021). For diffusion to take place, information needs to be communicated to the social system showing that this innovation is desirable. This need stems from the innovation-decision process being about seeking and processing information. Furthermore, trialability and observability are needed for individuals to be persuaded to adopt an innovation (Rogers, 2003). From the individuals’ point of view, it needs to be at least as or more desirable than LPG. It may also be providing different advantages making it desirable to adopt.

Access to electricity spans, however, to more areas than those surrounding clean cooking. For this reason, subthemes ‘Access to clean or modern fuels’ (4.1.1.), ‘Utility and support of appliances’ (4.1.6.), and ‘Educational improvements’ (4.2.1.) are connected. Access to modern light sources has been shown to facilitate a better education infrastructure, which was highly valued for and by students. Using electricity for lights may be described as

diffused in the visited villages. Electric lights provide a relative advantage to the predecessor, the kerosene light. It is easy to understand and use and observable since its purpose is to shine light. These explanations may be called trivial. However, it has also been communicated efficiently to the villages as they have gained access to electricity as the theme ‘Roles and responsibilities of the government, NEA, and AEPC’ (4.3.1.) indicates. Initially providing appliances or making them easier to acquire may be a way to increase their diffusion as it offers trialability and observability. In Bastakoti's (2003) case study part of supporting enterprise creation and development was to provide prototypes for businesses that would otherwise be inconvenient to acquire. This effort proved successful in converting eleven enterprises to electric operations. The same may apply to electric appliances for households. Similarly to the light bulbs given out or as in Bastakoti's (2003) case, there may be a need to help individuals get appliances to try them out and observe their advantages.

5.2. Local opportunities

Electricity has seemingly enabled new types of businesses that previously were impossible. To name one, poultry farms using heat lamps were one such example. This illustrates how ‘Access to clean or modern fuels’ (4.1.1.) and ‘Electricity and LPG empowering businesses’ (4.2.4.) relate to one another. Here, the innovation’s relative advantage as well as the compatibility with the type of business is demonstrated. Responses also show that the cost of using electricity from the national grid can get high for businesses. Therefore, private installations to avoid price spikes such as SHS could be observed sparsely in the field. Furthermore, respondents with businesses owned and used appliances to improve efficiency, and productivity which is in line with what existing research indicates (Riva et al., 2018). Awareness and knowledge related to these two points are needed for the individual business owner to benefit. Thus, a linkage between the subthemes ‘Cost of electricity compared to firewood’ (4.1.2.), ‘Utility and support of appliances’ (4.1.6.), ‘Knowledge about electricity’ (4.2.2.), and ‘Electricity and LPG empowering businesses’ (4.2.4.) can be made. The complexity related to knowledge but also the compatibility of electricity and electrical appliances for the business can decide on the successful diffusion of the innovation (Rogers, 2003). These

are additional reasons existing research (Bastakoti, 2003) (Riva et al., 2018) points to the importance of capacity building and support in spread of information. Observing businesses successfully adopting electricity is important as non-successful attempts could defer others from trying to adopt or even start businesses. As in Bastakoti's (2003) case, a strong support structure for enterprises may be needed. The results show that governmental educational programs for businesses are insufficient. Connecting subthemes 'Roles and responsibilities of the government, NEA, and AEPC' (4.3.1.) with 'Electricity and LPG empowering businesses' (4.2.4.) show on the one side the need and demand for programs and on the other side the missing capacity on the institutional level. Even in the case of educational programs that are provided barriers exist. It is difficult for business owners and individuals, especially women, to make time to attend these programs due to responsibilities and the programs are of low quality. Tying this to diffusion theory (Rogers, 2003), there are complexities that need to be overcome and the ineffective use of communication channels does not ease overcoming these complexities.

5.3. Knowledge sharing and educational programs

Bastakoti's (2003) field study from 1999 exhibits that the idea of the need to spread information regarding electricity is not novel in Nepal. Both Riva et al. (2018a) and Bastakoti (2003) proposes that some of the complementary activities implemented should focus on awareness building and the spread of information. This is also identified in the results of this study as key points of focus. These proposals are based on studies done on the relationship between rural development and electricity access but are also supported by Rogers' (2003) theoretical argument that information about an innovation is key for its diffusion. There are two aspects of knowledge regarding electricity identified from the results of this study to be lacking in the field sites: 'Utility and support of appliances' (4.1.6.) and 'Knowledge about electricity' (4.2.2.).

The results show that some households had a good understanding of electrical appliances and perceived them to have advantages in enhancing their daily activities and work, as seen in the subtheme 'Utility and support of appliances' (4.1.6.). This is an indication that some diffusion has taken place and more could be built on that. The time element as

described by diffusion theory (Rogers, 2003) entails that the individuals' decisions to adopt or reject innovations vary from each other with some showing a greater degree of innovativeness. Even after the decision to adopt, there is a period of implementation. With households adopting electrical appliances, their relative advantage can be observed by other members of the social system, which relates to the subtheme 'Knowledge about electricity' (4.2.2.). The electric rice mill is one appliance implemented in all three visited sites. Its fast adoption in Kakani could be partly accredited to it offering an observable relative advantage compared to its predecessor while being compatible with the Nepali culture. Interpersonal communication channels between neighbors, members of a group, or from other villages may add to that diffusion.

Since the utility of electrical appliances extends to mundane household activities that women do Cecelski (2000), electricity access can benefit them greatly. This requires that the women know about the innovations and their benefits. How this information is spread and already available can be seen in the subtheme 'Empowerment for women' (4.2.5.) The mother's and women's groups are good forums for interpersonal communication. Then the issue lies in providing information to at least one of the individuals in those groups. Targeted programs for educating women about how electricity use can be to their benefit could be important in empowering women and was identified in the subthemes 'Knowledge about electricity' (4.2.2.) and 'Trust in and demands to the government, NEA, and AEPC' (4.3.2.) as current barriers. Riva et al. (2018) mentions gender relations can be a limiter in how much say women have on how to spend household money. Subtheme 'Utility and support of appliances' (4.1.6.) reveals several observed utility gains from electricity access being related to activities women are performing. Therefore, the issue of gender relations hindering electrical appliance purchase does seem to be surmountable through knowledge about the advantages the appliance can offer. If women are aware of the relative advantages, the adoption rate of electric appliances may increase according to the learnings from diffusion theory (Rogers, 2003).

Monitoring electric meters for efficient use was found in the subtheme 'Knowledge about electricity' (4.2.2.) to be underutilized by households. This seems to be related to the complexity involved in navigating these meters. As seen during the field visits, if one

individual takes the initiative, they can try using the meter and experimenting with their electricity usage to be more efficient and reduce their monthly electricity expenses. Even if there is some degree of complexity involved, these meters are included with basic wiring installation and have trialability. Learnings from diffusion theory (Rogers, 2003) indicate that reducing uncertainties regarding the cost of using electrical appliances could increase electricity usage in households. This is especially relevant if the household is of a lower socioeconomic background and cannot afford the risk of high monthly bills. In a social system with a structure that supports social cohesion, the information regarding meter monitoring and the actual cost of using appliances compared to the feared expectation should be spread according to Rogers' (2003) description of interpersonal communication channels. That is of course if someone in the community takes an early initiative to acquire appliances and try using the meter box. This person could act as an accelerator of innovation adoption in their social system. The example of meter monitoring identified in these field visits had been spread by one individual to other members of a group this individual was involved in. With time, this information could potentially spread outside of this group to other members of the village. This observation was made in Rampur which has had electricity access longer than Kakani and Kosh Bhanjyang indicating that the energy practice of meter monitoring may take a long time to diffuse. This leads back to the necessity of complementary activities that again point to the gap identified in the subtheme 'Knowledge about electricity' (4.2.2.) Steps should perhaps be taken towards spreading information about meter monitoring if it shows signs of increasing electricity. The Energy Cultures framework identifies interactions between material cultures and energy practices. Material culture is changing in Nepal with electricity having been introduced as an energy source. As electricity usage is a goal of the ongoing transition (NEA, 2021), meter box monitoring can drive changed energy practices. Communication through interpersonal channels appears to not spread the information fast enough, relating to the subthemes 'Utility and support of appliances' (4.1.6.) and 'Knowledge about electricity' (4.2.2.). There may be a need for communication through mass media channels or similar efforts to offer information on a larger scale.

ICT devices play a critical role in modern communication and together with the internet enable the communication channel Rogers (2003) describes as interactive. As Riva et al. (2018a) identifies, that the connection to the outside world is positive for innovation adoption. Through the internet, be it social media or other platforms, someone in rural Nepal can follow and gain information on what is happening in the world. This can make the observability of the potential utility offered by electrical appliances easier. When an individual first receives information about an innovation through this interactive channel, they can spread it throughout their social system through interpersonal communication. Furthermore, ICT devices such as smartphones open a new way of mass media communication targeting a larger audience.

The theme 'Roles and responsibilities of stakeholders' (4.3.) indicates a gap between the electricity utility, local government, and households regarding the responsibilities of asking for and facilitating information programs. Rogers (2003) argues that the spread of information is naturally from the one having more knowledge to the one having less. Based on this, the responsibility to spread information regarding electricity would fall to those with knowledge and responsibility, i.e. local authorities, and the electricity authority. Learnings from Bastakoti's (2003) study points toward the need for rural electrification and rural development to be treated as a part of each other. This would mean that the local government and NEA would create greater benefits by collaborating to establish programs and spread information. Subtheme 'Trust in and demands to the government, NEA, and AEPC' (4.3.2.) partly explains why electricity usage is not increasing at a faster rate. More worrisome than there being a gap, it points to a conflict and lack of trust slowing down the rate at which information is spreading. Individuals see the local government as being unable to answer their demands for more training programs of better quality. Therefore, indicating that the local government itself might lack the knowledge or capacity to provide programs to complement the established electricity access.

5.4. Influence of (re)migration

Subtheme 'Educational improvements' (4.2.1.) reveals that students and teachers experience education to be more supported because of electricity. According to Riva et

al. (2018), this is a benefit of electricity access that should be seen, although it is said to be due to complementary activities. In this study, the improvements were mostly mentioned to be because of electric light and the internet. Internet usage for learning is diffusing as students see the advantages of it and share it with their peers and teachers, which is an example of interpersonal communication. The concept of cognitive norms in the Energy Cultures framework is affected by education. It is observed that ICT devices coupled with the internet are changing the education of the youth interviewed in this study, meaning that changes in their cognitive norms are to be expected. Once again since the three concepts of Energy Cultures are connected, changes in material culture and energy practices are facilitating the changes in cognitive norms. As cognitive norms change, they will eventually influence material culture and energy practices.

Electricity access in the context of rural development may with the right complementary activities improve the opportunities in the rural areas (Riva et al., 2018) (Bastakoti, 2003). Subtheme ‘Migration and brain drain’ (4.2.6.) indicates that individuals in the visited villages still seek better education and job opportunities elsewhere. This begs the question if the established electricity access is being underutilized and lacks complementary activities to support the improvement of local opportunities. Once again, Bastakoti's (2003) case had electricity accommodating development, deliberately working towards rural development. One part of that is to bolster the local economy through income-generating activities. The responsibility to do this could be allocated to the local government. However, they need to collaborate with the utility that is providing the electricity if learnings are drawn from Bastakoti's (2003) case. There is a lack of trust in the authorities to take the right steps and a lack of belief in the area's potential as seen in subthemes ‘Trust in and demands to the government, NEA, and AEPC’ (4.3.2.) and ‘Migration and brain drain’ (4.2.6.). This begs for a more hands-on approach from the local government and electricity utilities to show the people that electricity can lead to opportunities. The observability factor of diffusion theory indicates that this mistrust can be turned if positive cases of success are observed. Subtheme ‘Electricity and LPG empowering businesses’ (4.2.4.) indicates that electrification is empowering business activities which could then be built upon. To successfully increase opportunities in the area, awareness building through educational programs and enterprise creation and

support are needed from the one responsible for the development of the area (Bastakoti, 2003). Since individuals with knowledge are leaving, creating trust in the area's potential may be specifically important to retain talented people and avoid the brain drain. Even if some of the youths are seeking improved educational opportunities elsewhere, the goal would be to show them that they can come back and apply the knowledge and learnings they gain.

The outflux of men from rural areas opens the opportunity for the women who stay behind to take on more responsibilities. Because of this, there is an improved potential to empower women by offering educational programs and other complementary activities supporting rural electrification. As mentioned before spreading the knowledge of electricity is important for women since their tasks and roles are shown to improve by the subtheme 'Utility and support of appliances' (4.1.6.) and as aforementioned, existing research from Cecelski (2000). Furthermore, activities to support enterprise creation and development may include a larger proportion of women because they stay behind in rural areas. This is not to say that women's empowerment happens unintentionally. It indicates another way the change in the material culture of rural Nepal can affect cognitive norms.

Women having larger roles and more responsibilities might not be the only change in Nepal's culture. ICT devices and (re)migration do show signs of increased knowledge regarding the utilities of electricity and how it can be used to benefit rural life. Moreover, impressions from observing other cultures affect the cognitive norms of Nepali people, which is supported by 'Traditions and historic norms' (4.2.3.) These changes in cognitive norms return with the people re-migrating and changing the energy practices and material culture further. Subtheme 'Migration and brain drain' (4.2.6.) shows that people usually migrate to places with better expected opportunities, which have features that are more desirable than back home. As captured in the subtheme 'Traditions and historic norms' (4.2.3.), individuals who then return may do so with new social aspirations or expected comfort levels that would require changes in material culture and energy practices to accommodate. This way the energy culture of Nepal could experience an inertia pushing for change. Furthermore, the new information and ideas brought back with individuals

remigrating could increase the rate of diffusion through interpersonal communication channels.

It seems that many of the enterprises in the area were made possible by migration. Individuals who were away gained more knowledge and capital than if they had stayed and upon their return, they were more capable of initiating entrepreneurial activities.

6. Recommendations

The results identified various themes emerging from the field studies that happened within the scope of this thesis. Cross-linking them in the discussion showed the potential for recommendations to provide for increasing the benefits for stakeholders. As stated in chapter 1.1., this research aims to produce recommendations for stakeholders to empower themselves and each other by strengthening the drivers and mitigating the barriers related to the utilization of rural electrification. In the following, three identified recommendations all relating to the umbrella term ‘Need for complementary activities’ are presented that can be used as guidance for further action. At this point, it must be noted that the recommendations solely focus on complementary activities that were not observed during the field study. The following recommendations can therefore be seen as support to stakeholders involved in development efforts related to electricity in Nepal.

Targeted education and knowledge programs

Education and knowledge programs, if existent, do not target groups traditionally staying in the rural area, as recognized and discussed in the subchapters ‘Local opportunities’ (5.2) and ‘Knowledge sharing and educational programs’ (5.3). Targeted programs that support older women as well as those with young children, have the potential to drive local opportunity generation while empowering women. This can, in turn, increase the attractiveness of the region. Training many people is very costly, it is therefore recommended to target leaders of women’s or mother’s groups that can act as multipliers for spreading knowledge.

Local opportunity generation

Within local opportunity generation, two recommendations can be made which relate to the subchapters ‘Local opportunities’ (5.2) and ‘Influence of (re)migration’ (5.4). To retain businesses locally as well as generate new ones, research and the results of the field studies show the need for knowledge programs, financial support structures, and better infrastructure. Strengthening these three pillars was identified as a strong driver in local opportunity generation. Furthermore, businesses related to improved electricity access such as shops selling and repairing electrical appliances have been shown to drive the

adoption of higher electricity usage patterns. The recommendation for the government would be to provide incentive programs for these businesses.

Need to improve trust and communication

Lastly, communication and cooperation gaps between the local government, utilities, and citizens were identified and discussed in the subchapters 'Local opportunities' (5.2) and 'Knowledge sharing and educational programs' (5.3). Missing trust in the abilities of the utilities and local government was one of the reasons mentioned. Investing in increased communication activities such as providing better transparency to the citizens can help generate stronger rural communities and develop them further. As a possible means for increased trust, leveraging ICT devices such as smartphones, TVs, radios, etc. can prove especially useful. Moreover, it is recommended to invest time and resources in setting up cooperation structures between the local governments and utilities to achieve more transparency and benefit for the users.

7. Further study

As a master's thesis with limited time spent in the field, it is hard to delve deep into the identified themes and factors from the field. While giving an overview of the themes and factors identified, there is a large potential for them to be studied further and thoroughly by themselves. The socioeconomic capabilities of households are one of the factors that would benefit from further study. A quantitative study to complement the answers given by people during the interviews would indicate how electricity is prioritized compared to other expenses. Further effort could be made towards understanding gender relations' role in the ongoing rural electrification. This would require more time spent in the field and creating trust to break down the barriers people have when it comes to talking about the topic. Alcohol and local politics were occurring topics during field studies. There was not enough time to understand if and how they are related to this transition.

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Appendix A – Questionnaire Version 1.0

General information

Personal details

- What is your name?
- How old are you?
- Are you married?
- How many are in your household?
- Can you please provide some basic information about your household, such as the number of family members and their ages?
 - Does your family live in the same household? (some away for work/studies)
 - How old are your family members?
 - How many of them work and what is their occupation?

Socio-economic and status

- Do you travel by foot/animal/bus/car to the next town?
- How much do you travel to bigger towns/cities?
- What is your level of education?
 - No school/elementary school/high school/university
- How do you make a living?
 - Occupation?
 - Ownership of land/animals/money?
 - Own business? Do you have people employed?
- What machinery do you use? (Related to occupation) *e.g. hand plow, tractor*

Feeling about technology implementation

- How long before the technology was implemented did you know about the plan?
- Compared to before the system was there, what things changed in your life?
 - What kind of people live in the village (age change, education, immigration)
 - Calm/hectic life
 - Improved well-being/health?
- What was better before?/what is better now?
- Describe in one word what this project made you feel.

Daily life and routines

- Does your village work together/meet when you are trying to solve problems?
- How do you receive important information about the village or government programs?
- Can you provide details about your primary occupation and the tasks associated with it?
 - Self-employed/employed?
 - Where is the work located?
 - How many hours a day do you work?

- What kind of work do you do?
- What household chores or responsibilities do you typically manage daily?
 - Laundry
 - Cooking
 - Cleaning
 - Children education
- How do you cook?
 - Indoor/outdoor fire, stove, electric
- How many hours a day does the fire burn?
- Do you know how your **grandparents** used to cook food and how did they light the room? What source of energy was used?
- Do you know how your **parents** used to cook food and how did they light the room? What source of energy was used?
- How are you cooking food now and how are you lighting the room? What source of energy are you using?
- What technology that you know and have seen in other places would you like to have in the village that simplify your daily life and routines?

Electricity usage

- Does access to electricity impact your daily routines and activities? How?
- Has access to electricity changed the way you perform certain tasks or activities?
- Can you share the main purposes for which you use electricity in your household?
 - Lighting → What times do you use it and what is the daily duration?
 - Charging of phone/else → What times do you use it and what is the daily duration?
 - Cooking → What times do you use it and what is the daily duration?
 - Farming → What times do you use it and what is the daily duration?
- How much electricity do you use? What is the cost of electricity for your household?
- Are you always able to pay for the electricity tariff?
- What electrical appliances do you use?
 - Rice cooker/water boiler/etc.
- Are you satisfied with your life and changes in your community since the implementation of electricity?
 - Is your village better or worse? Please explain what is meant by better or worse in your opinion.
 - Are you happier living in this village or not? Please explain what happiness is to you.
- Are there specific aspects of electricity access that you find particularly beneficial or challenging?

Economic impacts

- Have you observed any changes in your economic opportunities or income since the introduction of electricity?
 - Are you struggling now more or less with money than before? Why?
- Have you seen ideas/inventions coming from electricity access in the village?

- In what ways has electricity influenced local businesses and job opportunities?

Social and educational impact

- How has electricity availability affected educational opportunities for you and your family members? E.g. do more people go to university/high school now that you have access?
- Have you noticed any changes in social interactions or community gatherings since the introduction of electricity?
- How have people's roles changed in the community since the implementation of electricity?
- Do you feel an ethnicity/gender/age group saw more of the benefits than another? Why do you think that is?
- Do you feel stronger in the community since you gained access to electricity?

Challenges and Suggestions

- What challenges or limitations do you currently face in accessing and making use of electricity?
 - Why do these challenges exist? → e.g. Is it about who controls/owns the electricity?
- What aspects of your culture and traditions are important to preserve for future generations?
 - Does the new technology make this more difficult?
- Do you have any suggestions or preferences for improving the current state of electrification in your village?
- What is missing for a good life?
- What do you not want to have a better life?

Infrastructure and reliability

- Can you share your experiences regarding the reliability of electricity supply in your village?
- Do electricity outages hinder you from performing your daily routines and activities? How would your day change if the electricity system broke today? How dependent on electricity are you?

Environmental and health Awareness

- Does your community/government regulate the use of firewood to not deplete the resource?
- Are you aware of the health risks of indoor open fires?
- What natural resources are important for your village's livelihood?

Future expectations

- What was better before electricity?
- What changes or improvements would you like to see in the future regarding electricity access in your village?

Appendix B – Questionnaire Version 1.1

Basics

- What is your name?
- Gender?
- How old are you?
- Are you married?
- How many people live in your household?
- What is your level of education? E.g. No school/elementary school/high school/university
- How do you make a living?
- Do you have an electric stove/LPG stove?
 - Do you use it? Why?/Why not?

Changed behavior/routines/social dynamics

- How has electricity changed your life?
- Did electricity change your daily routines and activities? How?
- Are you always able to pay for the electricity tariff and how much electricity do you use?
- Did electricity change your financial situation?
- Are people less social because of electricity (e.g. more phone use)?
- How have people's roles changed in the community since the implementation of electricity?
- Did you sleep more or less before electricity? Why is it different now?

Opinions about electricity

- Describe in one word what access to electricity made you feel.
- For what is electricity most important to you and why?
- Who saw most benefits because of electricity? Why do you think that is?
- Did electricity change cultural traditions in your village?
- What would change in your life if electricity didn't work anymore?

Security/Supply/Stability related to electricity

- Are there any problems with the stability of electricity?
- Do you feel more or less safe with electricity? Why?
 - Would you feel less safe if power went out?
- Do you have outages? If yes, how does that affect you?

Suggestions/entrepreneurship/innovation related to electricity

- What would you do if you had infinite power supply?
- What other uses of electricity would improve your village?
- Have there been any new ideas or inventions in the village since getting electricity? Is anyone doing something interesting with electricity?

- What things do you need to have a good life?
- What things are missing from your life that would make it better?

Only women

- How would you spend your day if someone else would take care of all household chores?
 - More leisure time/sleep/personal care
 - More income-generating work
 - More agriculture
 - Provide better direct person care (e.g. children)
 - Engage in community activities or social life
 - Help neighbors/friends
 - More education/training
 - More religious activities
 - Other
- Why are the men not helping you in household/domestic chores?

Only men

- Are you involved in any household/domestic chores (children education, laundry, cooking, etc.)?
 - Why are you not involved?/What is stopping you?
- If your wife had to spend less time on caring for people and domestic work, what would she do with her extra time?
 - More leisure time/sleep/personal care
 - More income-generating work
 - More agriculture
 - Provide better direct person care (e.g. children)
 - Engage in community activities or social life
 - Help neighbors/friends
 - More education/training
 - More religious activities
 - Other

Appendix C – Questionnaire Version 3.0

Questionnaire – Business owners

- What skills do you want to learn that would help you grow your business more (related to using/utilizing more electricity)?
- How should a program look like that support your efforts as a businessperson?
- How do you feel about the work of the local government?
- What policies support you currently?/Which policies need to be changed?
- Do you get electricity access in a way that supports your business?
- What allowed you to start this business and succeed? What is your recipe for success? Do you think you started with any kind of advantage?
- Suppose you lose your business due to an earthquake. How long would it take for you to build a new business and can electricity support you with that? Why can you do it and other people can't?
- Why are other people scared of starting a business? Is there a one-chance mindset in this area? → Is electricity changing this/did electricity change this?
- What do other people need to see in terms of opportunities in this area for them to start a business? I.e. What do you see that other people don't see?
- E.g. Is your profession special due to its connection/disconnection to electricity?
- What knowledge about electricity do you have and is this knowledge prevalent for everybody?

Questionnaire – Bank/loan institute

- What are the main reasons people ask you for loans?
- Did access to electricity change the type of loans asked for?
- What are the sizes of loans people apply/ask for?
- How is collateral handled in the area?
- How long does it usually take for people to pay back the loans?
- Where is the money usually coming from for repaying the loans?

Questionnaire – Ward office

- How is electricity access defined? Why are there such big gaps in the load capacity between different villages (e.g. compare Kakani and Rampur)
- Are there any financial incentives? Are they targeted?
- What is being done to empower women? e.g. education, employment, division of labor, responsibilities for care
- Are the programs targeted for women (or groups of people) that traditionally stay in the area instead of moving away? → e.g. women with young children
- What is being done to move society away from the patriarchal mindset?
- Where is the gender equity fund going?
- Why are there only few-day vocational programs?

- Success stories mostly come from returnees, how can people see and make use of chances without having to move elsewhere first?
- What are the chances/opportunities for people if they stay? What is being done to retain local talent locally?
- How are people migrating contributing to the local economy?
- How do you support local businesses? Trainings, funds, etc.
- When gaining access to electricity, what programs exist to teach people about the benefits but also risks of the use? *e.g. Risks of open wires, useful appliances*
- What programs/measures are in place to promote the use of appliances? *e.g. support for rice mills, financial aid for useful kitchen appliances, etc.*
- Is good use of electricity a priority? What is the (monetary) prioritization for:
- Electricity, Health, good roads, Drinking water, Education

Questionnaire – (Women) Focus Groups

- What do you discuss at your meetings?
- Do you talk with each other about what electric appliances everyone uses in their household?
- Which electric device would make your life easier?
- What would you do with the free time?
- Who decides in your household what money is spent on?
- Do you think that men drinking a lot of alcohol is making this area worse?
- Do you work more during the day than the men?
- Who will stay here in this area? Why?
- Do you who are staying here want more support to open up businesses?
- Do you want to learn vocational skills like stitching/sewing/basket making?
- Are you open to learn about more manly vocational skills like carpentering/plumbing/etc.?
- Why? Why not?
- Why are there no opportunities in the area? What is needed to change this?

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