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Empowering Lives: Socioeconomic Transformations Through Grid Connection: A Case Study of Bajura District

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ABSTRACT

Bajura District, recently integrated into Nepal's national grid, lacks prior research evaluating the socioeconomic impacts of this connection. This study addresses this gap by employing a sequential explanatory research design, analyzing quantitative data from 456 households using SPSS, followed by qualitative exploration. Findings indicate a positive association between national grid electricity usage and various socioeconomic factors, including education, improved interpersonal connections, health benefits, reduced workloads, decreased incidents of gender-based violence (GBV), cost and time savings, and enhanced entrepreneurship. Despite these benefits, a significant challenge is that households predominantly use electricity for lighting, limiting its full socioeconomic potential. Issues related to reliable electricity access and the effectiveness of repair and maintenance services provided by the Nepal Electricity Authority (NEA) also persist. To optimize the socioeconomic impact and enhance return on investment, it is crucial to diversify electricity usage, particularly for cooking, by promoting induction stoves or rice cookers. This diversification aligns with national clean energy initiatives and is essential for achieving broader improvements in the socioeconomic status of rural communities. Further studies are recommended to assess the safe and viable implementation of modern electric cooking appliances in rural Nepali contexts.

1. INTRODUCTION

1.1 Energy and global socio-economic development

Energy stands as a pivotal factor in contributing to the socio-economic development of nations. The global energy landscape encompasses two primary sources: renewable and non-renewable. Hydroelectric power emerges as the most favorable among renewable sources [1]. The escalating global population has precipitated an augmented demand for energy, resulting in an increased reliance on non-renewable energy sources like petroleum products and coal [2]. Use of non-renewable energy carries substantial environmental repercussions, with 60% of Greenhouse Gases (GHGs) worldwide emanating from such sources. Addressing today's imperative to reduce GHG emissions necessitates a shift towards renewable sources [3].

Addressing those challenges are today's pressing needs to reduce GHG emissions necessitates a global shift towards renewable sources. Regrettably, a staggering percentage of energy, i.e., 80% of total energy, globally, comes from non-renewables such as Liquefied Petroleum Gas (LPG), dung, wood, coal, and charcoal for cooking and heating [4]. This reliance contributes to over 4 million premature deaths annually, especially due to air pollution [5]. These statistics indicate a profound public health crisis, highlighting that the transition to clean energy is not merely an environmental concern but a critical imperative for human well-being. The global commitment to SDG 7, which aims to ensure access to affordable and reliable, sustainable, and modern energy for all, further emphasizes the urgency of this transition, particularly in providing clean cooking solutions.

1.2 Nepal's energy landscape and hydropower potentials

Developing nations, exemplified by Nepal, encounter significant challenges in energy infrastructure development and management owing to complex geographical conditions. South Asian countries, including Nepal, face significant renewable energy deprivation challenges [2]. Despite being endowed with extensive freshwater resources, particularly from rivers, rivulets, watersheds, and ponds, providing abundant opportunities for hydroelectric power development, Nepal's vast potential remains largely untapped. The country has a theoretical energy harnessing potential of 83,000 megawatts (MW), of which 42,000 MW are economically viable [6]. However, Nepal's actual generation in 2024/25 stood only at 7.52% of the total potentiality [7], an increase from 6.34% in 2022/23, 5% in 2020/21, and 2% in 2016/17 [8].

This historical underutilization has led to significant energy challenges. Nepal faced severe load shedding until 2016, reflecting inefficient electricity supply, and in 2022, the country was ranked 137 out of 147 in the quality of electricity supply [9, 10]. The Nepal Electricity Authority (NEA) has been actively engaged in electricity generation and expansion, collaborating with the private sector. The consumer's base has nearly doubled, reaching 4.5 million households, and the total grid-connected population of Nepal reached 92.71% in 2022 [11] and 98% in 2024 [12]. Despite this progress, NEA still faces a deficit of 9.49% against total demand, partially met through imports from the Indian electricity market. The historical context of unreliable and insufficient supply indicates the significance of recent grid expansions. The vast untapped hydropower potential highlights a long-term national development opportunity, yet also the persistent challenges in harnessing it, emphasizing the importance of actual grid access and its impact.

1.3 Context of Bajura District and the research imperatives

Bajura District, situated in Nepal's far-western province, is one of the least developed among 77 districts, as per the Human Development Index [13]. This context is amplifying the potential impact of reliable energy access, making it a crucial case study for understanding the transformative power of gird extension in marginalized areas. The district was recently incorporated into the national gridline in the fiscal year 2022 by the NEA, despite significant geographical challenges and substantial investment in line extension in the hilly region.

Prior to this national grid connection, Bajura District was already partially electrified by micro-hydro electricity and solar photovoltaic systems. However, these local systems often provided unsustainable electricity access due to factors such as varying generation capacity, landslides, floods during wet seasons, and decreased water levels in rivers and streams during dry seasons. This means the recent national grid connection represents a transition from fragmented, unreliable local energy sources to a potentially more stable national grid [14-16]. The lack of previous research evaluating the socioeconomic consequences of this specific national grid connection in Bajura indicates a critical knowledge gap, particularly in understanding the incremental benefits and challenges of transitioning to a more robust energy infrastructure in a least-developed region. Therefore, this research article aims to analyze the existing energy landscape in Nepal, focusing on the utilization of hydropower potentials and challenges faced in electricity supply and grid expansion, and to examine the socioeconomic impacts through the utilization of electricity from national gridline, transitioning from fragmented sources of energy in Bajura District which could be significant information for similar rural and least developed regions.

2. METHODOLOGY

2.1 Research design

This study has employed sequential explanatory research design, integrating quantitative data collection and analysis followed by qualitative exploration. This mixed-method approach allowed for a comprehensive understanding of the socioeconomic impacts, where quantitative data provided breadth and statistical insights into the prevalence of impacts, and qualitative data offered depth and contextual understanding of the underlying reasons and lived experiences. This triangulation of findings enhances the credibility and robustness of the study.

2.2 Study area description

Bajura District, situated in the far-western province of Nepal, spans an area of 2,188 km², with its headquarters in Martadi. The district comprises 4 municipalities and 5 rural municipalities. Geographically, the district encompasses Himalayan, high hills, and mid-hill topography, with temperatures varying from 0℃ to 40℃. This challenging geographical terrain reinforces the significant economic and technical investment required for grid extension and provides crucial context for understanding the persistent challenges related to repair and maintenance, which are often exacerbated by difficult access.

This study focused on two municipalities within the district: Budhinanda Municipality, with 3453 households and a total population of 16,818, and Badimalika Municipality, with 3,446 households and a total population of 18,776. Badimalika Municipality also houses the district headquarters, Martadi. The total population for sample size calculation was 35,594. This research was conducted between August and November, 2022 in the study area (Figure 1).

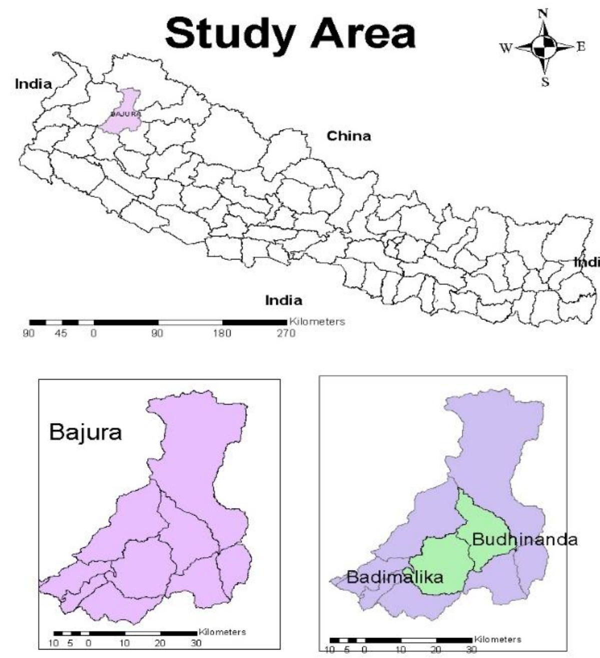

Figure 1. Map of the study area, far west, Bajura District

2.3 Sampling strategy and participants

For the quantitative survey, Cochran's random sampling for finite population was utilized to make inferences on population proportion [17]. The formula applied for calculating the sample size was:

$$n = \frac{n_0}{1+\frac{n_0}{N}} \tag{1}$$

$$n_0 = \frac{z^2 p(1-p)}{e^2} \tag{2}$$

where, z is the standard normal variate (1.96 for a 95% confidence interval), p is the estimated population proportion (0.5, a conservative estimate in the absence of prior knowledge), e is the stated margin of error (0.05), and N is the population size of the study area (35,594) (Table 1).

Table 1. Sampling calculation of the study area

Z	1.96	
CI	95%	**3.84**
Alpha divided by 2	0.025	
P	0.5	
Error	0.05	
Population size	35,594	
Sample	384	
20 percent added on the sample	77	
Total sample	460	

The calculated sample size was 384. An additional 20% (77 households) was added to account for potential non-response or data quality issues, resulting in a total target sample of 460 households. The actual number of households surveyed was 456, closely aligning with the target.

For qualitative data, two Focused Group Discussions (FGDs) with electricity consumers and one in-depth interview (KII) with a municipality authority were conducted. These qualitative methods served to validate and further explain the results obtained from the quantitative survey, providing rich contextual understanding of the community's experiences.

2.4 Data collection procedures

Initially, a feasibility assessment was conducted in the field to understand local dialects and contextual words, which informed the development of a questionnaire aligned with the research objectives. Experts' opinions were sought and considered in the finalization of the questionnaires.

Subsequently, the finalized set of questions was configured in the Kobo Toolbox, an online platform tailored for humanitarian workers and researchers, facilitating efficient and paperless data collection and analysis [18]. Enumerators were recruited, underwent contractual agreements, and received comprehensive training on utilizing the Kobo Toolbox for digital survey implementation. In adherence to pilot test requirements, a preliminary test was conducted among 30 households. Enumerators provided reflections and feedback, which were documented and used to adjust the questionnaires, enhancing their context and relevance. Following this refinement, the final household survey was officially launched, adhering to a predetermined schedule, timeline, and specified sample numbers for each ward in both municipalities. This systematic approach to data collection aimed to ensure accuracy and reliability.

2.5 Validity and reliability measure

To ensure the reliability of perception-based questionnaires, a reliability test was conducted using SPSS, Cronbach's Alpha (α) was employed to assess construct reliability, with an acceptable threshold for reliability coefficients set at ≥ 0.77 [19]. The results indicated that the construct reliability for the national gridline, consisting of 6 items, was α = 0.873, meeting the acceptable criterion. This high Cronbach's Alpha indicates strong internal consistency for the perception-based measures, lending credibility to the quantitative findings related to perceptions of gridline impact and challenges (Table 2).

Table 2. Reliability test result of perception-based statements

Construct	Number of Items	Alpha (α)
National gridline	6	0.873

Additionally, other survey and focus group discussion questionnaires underwent validation by experts in quantitative survey and research, further strengthening the methodological soundness.

2.6 Data analysis techniques

Data collected via the Kobo Toolbox underwent initial cleaning within the platform, with active collaboration with enumerators in the field to rectify errors and correct typographical errors. Subsequently, the dataset was exported to SPSS for further analysis. Within SPSS, additional data organization and cleansing were required due to the differing formats of the Kobo Toolbox and SPSS, with values manually arranged.

Descriptive features such as frequency tests, and cross-tabulations were employed to examine data pertaining to demographics, assets, and perception or rating scales. Correlation functions were utilized to analyse dependent variables, specifically social and economic aspects, in relation to independent variables such as hydroelectricity. Distinct output files were generated, and the outcomes derived from SPSS were tabulated in an Excel file for future reference.

Quantitative data obtained through this process were supplemented and validated through qualitative methodologies with community. FGDs were conducted with electricity users to know 'why and how' parts of the quantitative results, while interviews were conducted with Municipality authorities. Field notes containing qualitative data were transcribed into a Word document, organized, and tabulated in Excel under different categories/themes aligned with the research objectives. Ultimately, all qualitative information was consolidated, theme-wise in Quirkos software, a tool designed for qualitative data analysis, and the findings were integrated into the Results and Discussion section. This mixed-methods analysis approach, combining statistical rigor with qualitative depth, allowed for a comprehensive and nuanced understanding of the complex socioeconomic impacts in the study area.

3. RESULTS AND DISCUSSION

3.1 Demographic characteristics of respondents

The study included a total of 456 households, with 228 systematically selected from each of the two municipalities (Budhinanda and Badimalika), ensuring a balanced and comprehensive representation in the research sample (Figure 2).

The gender distribution of respondents showed a notable representation of female respondents, surpassing that of male respondents, which highlights the diverse representation of gender perspectives within the study (Figure 3). This is particularly relevant in rural Nepali contexts where women often bear the primary responsibility for household energy management.

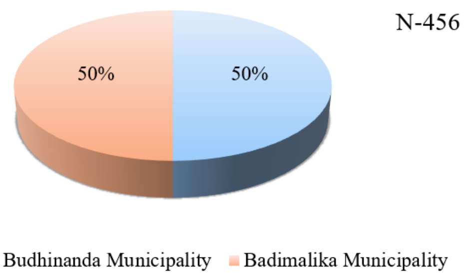

Figure 2. Geographical distribution of respondents

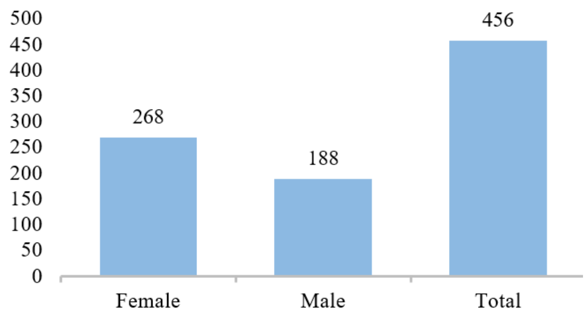

Figure 3. Gender-wise distribution of respondents

Regarding education status, the majority of respondents had limited formal education. A significant portion fell within the categories of Illiterate (27.2%), Simply Literate (28.5%), and Basic Education (22.6%), collectively representing 78.3% of the study population (Table 3). This demographic profile provides crucial context for interpreting socioeconomic impacts, suggesting that interventions are reaching a vulnerable and traditionally underserved population.

Table 3. Respondents by education status

S.N	Education Status	Frequency	Percent
1	Illiterate	124	27.2
2	Simply Literate	130	28.5
3	Basic Education	103	22.6
4	High School	92	20.2
5	University	7	1.5
	Total	456	100.0

The ethnic distribution of respondents showcased the diverse representation within the study. Chhetri constituted the majority (53.1%), followed by Dalits (27.9%), Brahmin (13.2%), Janajati (3.9%), Thakuri (0.4%) and other ethnic groups (1.5%). Understanding the ethnic composition is vital in a country like Nepal, where caste and ethnicity can influence access to resources, opportunities, and the distribution of development benefits (Table 4).

Table 4. Respondents by caste and ethnicity

S.N	Ethnicity	Frequency	Percent
1	Chhetri	242	53.1
2	Brahmin	60	13.2
3	Dalit	127	27.9
4	Janajati	18	3.9
5	Thakuri	2	0.4
6	Other	7	1.5
	Total	456	100.0

3.2 Evolution of electricity usage patterns

The study area has experienced a significant shift in electricity usage trends. A substantial percentage (83.3%) of the population is currently utilizing hydroelectricity in conjunction with the grid connection in 2022, marking a four-fold increase from 22% in 2011 (Figure 4). This indicates a notable growth in clean energy users over the years, accompanied by a sharp decrease in the use of traditional sources of lighting, which fell from 49.42% in 2011 (CBS, 2018) to 3.7% in 2022 during this survey.

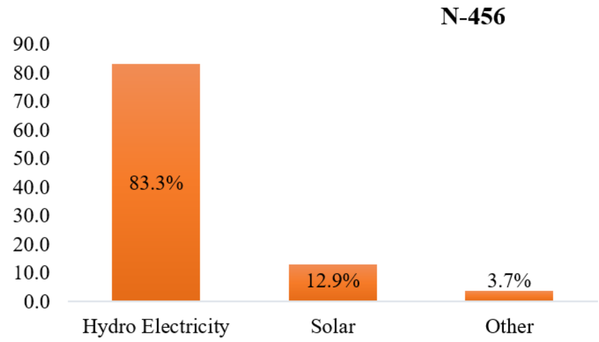

Figure 4. Respondents based on sources of lighting in their houses

Among hydroelectricity users, 45.5% of households reported relying on the national gridline system, while a significant 54.5% utilized electricity from local gridlines, particularly micro hydropower systems (Figure 5). This depicts a diversified electricity usage pattern within the surveyed population, indicating that the national grid connection is an additional, rather than a sole, source of electricity for many households. This highlights that the energy transition is ongoing and not monolithic, implying varying levels of reliability and capacity among households.

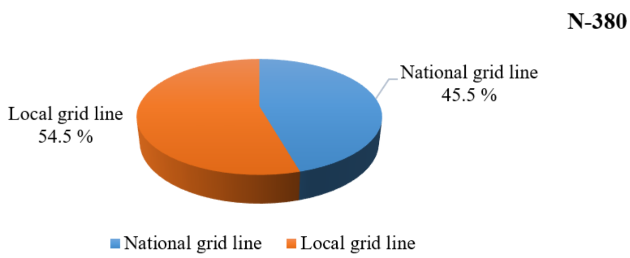

Figure 5. Respondent's desegregation by the type of hydroelectricity used

3.3 Social impact of national gridline electricity

The connection of Bajura District to the national gridline in 2022, despite geographical challenges and substantial investment, has brought about notable social impacts as evidenced by the quantitative survey, FGDs, and key informant interviews.

3.3.1 Education advancement

Electricity access has positively influenced education in rural areas. The provision of electricity has motivated teachers to contribute to rural schools, as it enables them to access the internet and stay updated, which was previously a deterrent

[15]. Schools now benefit from printing facilities, crucial during examination times, and have access to computers and internet connections. Furthermore, children are more motivated to attend school and complete their assigned tasks in the evening due to reliable lighting, leading to increased learning achievements as highlighted in Peru and Ghana [20, 21]. As one of the FGD participants noted: “we have significantly realized the vital contribution of electricity to school going children for reading and doing their homework until late night increasing their learning achievements”.

Fisher's exact test revealed a statistically significant association between sources of light and the education status of respondents ($p = 0.008 < 0.05$) (Table 5). These statistical findings, coupled with qualitative data on teacher motivation and student learning, suggest a multi-faceted causal pathway. Reliable electricity not only extends study hours but also improves educational infrastructure and attracts qualified personnel, creating a positive feedback loop for human capital development in rural areas. The literacy rate in the study area increased from 61.07% in 2011 (CBS, 2018) to 72.8% during this survey in 2022, indicating a positive trend aligned with improved electricity access. This improvement is further supported by the increased reliability of the national grid compared to previous local micro-hydropower, which experienced average outages of 66.90 hours in the last seven days, versus 26.84 hours for national grid users during this survey. This comparative reliability provides a tangible explanation for why the national grid is more beneficial for sustainable educational activities.

Table 5. Association between sources of lights and education status of respondents (Chi-square tests)

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	21.274[a]	8	0.006	0.011		
Likelihood Ratio	24.913	8	0.002	[b]		
Fisher's Exact Test	**19.503**			**0.008**		
Linear-by-Linear Association	11.990[c]	1	0.001	0.000	0.000	0.000
N of Valid Cases	456					

Notes: a means that some of the cells in the chi-square test had an expected count of less than 5. b indicates that the exact significance for the Likelihood Ratio wasn't calculated for this test. c signifies that the chi-square value was calculated using the 'Linear-by-Linear Association' method.

3.3.2 Enhanced social cohesion and safety

Electricity has been instrumental in improving interpersonal connections, enabling individuals to connect with friends and relatives who are abroad or outside the community via mobile phones and internet access. Mobile phone ownership among hydroelectricity users is remarkably high, with 96.9% of 291 users possessing mobile phones. This represents a significant increase in district-wide mobile phone users, from 40% in 2018 to 76.6% in 2022 across the district. A Fisher’s exact test showed a significant association between sources of light and mobile phone users (**$p = 0.001 < 0.05$**). As one of the FGD participants stated: “Electricity has helped to be connected with family and relatives who are out of the houses whether they are abroad or in the country. Electricity has made mobile charging easier and browsing news through mobile data”. Other participants added, “The internet has also helped to be aware of the things happening around the world” as evidenced by internet self-efficacy as a mediator [22].

Beyond connectivity, electricity has significantly improved community safety. Street lights have helped residents see things from afar at night, whether wild animals or potential wrongdoers, leading to a significant reduction in incidents like theft, looting, and open waste dumping that previously occurred in the dark. Furthermore, electricity fosters social cohesion by making it easier to organize religious and social events with sound systems, allowing community members to stay until late in the evening without fear of theft, fights, or wild animal attacks, and to return home harmoniously, as evidenced by Mathur [23]. The ripple effect of electricity extends beyond direct utility to fundamental aspects of social life, including communication, personal safety, and community bonding, highlighting the multi-dimensional social benefits [23, 24].

3.3.3 Public health improvements

National grid electricity contributes significantly to public health by making kitchens and households smoke-free. It has replaced traditional lighting sources like ‘Jharro’ (a part of pine tree used as a candle) and kerosene, which are carbon-emitting and generate smoke. The use of these traditional sources has drastically decreased from 49% in 2011 to 3.7% in 2022, during survey time. Additionally, the adoption of electric rice cookers and electric irons reduces the use of LPG, firewood, and coal, which are major sources of indoor air pollution. This directly addresses critical global health issues, as air pollution contributes to approximately 4 million premature deaths annually worldwide [5], with 26,000 in Nepal alone [25].

Moreover, electricity is vital for enhancing healthcare services in rural areas. It enables health posts to keep vaccines refrigerated, operate essential equipment like X-ray machines, and connect with other medical experts through social media for improved patient care [26, 27]. The direct replacement of polluting fuels with clean electricity for lighting, cooking, and other household tasks leads to improved indoor air quality, which directly translates to better health outcomes, particularly for women and children who spend more time indoors.

3.3.4 Reduction in household workloads

Electricity significantly reduces the time women spend on household chores, particularly collecting firewood for cooking and ‘jharro’/‘guitha’ for lighting, which previously took over six hours of time daily. With electric rice cookers, cooking becomes faster and less dependent on traditional fuels, freeing up surplus time for women to engage in agricultural or other economic activities [28, 29]. As one of the FGD participants articulated, “it is faster in cooking food in the rice cookers, not all but those who have rice cookers can cook food without firewood or gas, can cook in clean energy”. This gender-specific impact is a significant social benefit, empowering women by freeing up their time for productive activities or leisure, directly contributing to gender equality and economic participation.

3.3.5 Mitigation of gender-based violence (GBV)

The connection to the national grid has also contributed to a significant reduction in GBV cases in Bajura, a district that historically faced a higher number of such incidents. Inadequate lighting was identified by participants as one of the contributing factors to domestic violence. With electricity, household tasks become easier and more efficient, particularly cooking at night, which can now be done with sufficient light and electric appliances like rice cookers. This reduces friction within households and instances of physical violence. One of the FGD participants explicitly shared, "as a daughter in law, it was difficult to cook in the traditional light after a day-long work in the field, however, I had to prepare food for the family even if I returned late in the evening. Sometimes there used to be external particles in the food, as light was not so bright, which used to be a starting point of disputes among the father/mother in-law followed by the husband's physical violence. But now, I can cook even late at night with light from hydroelectricity, everyone is happy in the family". This highlights a profound, often-unanticipated social impact, where improved household efficiency and reduced stress, enabled by electricity, can directly de-escalate domestic tensions and contribute to a safer home environment.

3.4 Economic impact of national gridline

Hydropower has been identified as a reliable source for Nepal's economic development, particularly through internal and external electricity generation and distribution [14]. The national grid connection in Bajura, despite the substantial economic and technical investment required due to geographical challenges, has initiated positive economic impacts for the communities. However, it is observed that electricity usage is not yet fully diversified, limiting its broader economic potential.

3.4.1 Cost and time efficacies

National grid electricity has made its consumers more cost-effective. One reason for this is NEA's policy of exempting tariffs for households consuming less than 20 units per month. Additionally, there is a reduction in the time and cost associated with collecting firewood and 'jharro' from the forest, as well as a decrease in the cost of buying kerosene for traditional lighting systems and LPG cooking.

Table 6. Perception around the use of energy efficient bulbs

I Am Using Energy Efficient Bulbs to Save the Electricity	Frequency	Percent
Strongly Disagree	1	0.2
Agree	6	1.3
Strongly Agree	166	36.4
Total	173	37.9

A perception-based survey among national gridline users revealed that 96% of 173 users strongly agreed with the statement "I am using energy efficient bulbs to save electricity" (Table 6). This is a significant finding, as Compact Fluorescent Light (CFL) bulbs consume approximately 78.8% efficiently compared to traditional incandescent bulbs [30]. This difference indicates that a single household is saving a significant amount of energy annually by switching to CFL bulbs.

Participants in the FGD reported relief from the burden of paying higher electricity charges to local gridlines, as electricity from the national gridline is comparatively cheaper, with a perceived 20% decrease in per-unit cost. These saved costs are reportedly utilized for buying stationeries for children. Furthermore, the surplus time saved from energy-related chores is spent in agricultural activities and participating in saving groups and cooperatives. The combination of tariff incentives, reduced expenditure on traditional fuels, and adoption of energy-efficient technologies creates tangible economic savings for households. This disposable income and freed-up time can then be reinvested in human capital (education) or productive economic activities (agriculture, savings), creating a positive feedback loop for development.

3.4.2 Stimulation of local entrepreneurship

Reliable national grid electricity has significantly boosted local entrepreneurship, supporting businesses like furniture workshops, tailoring shops, and welding services, as the electricity supply is more consistent and sufficient for operating these businesses. This encourages individuals to start businesses with relatively little initial investment, providing employment opportunities to other people in the community and fulfilling local needs rather than relying on external markets, thereby contributing to the local economy [24].

Survey data indicated that some respondents have started their own businesses, such as carpentry 2 families, poultry 1 family, pumping water 2 families. Further inquiry during FGD validated that the grid connection has created opportunities to open electric shops, mobile repair and maintenance centers, printing and photocopy shops, operating grinding mills, and tailoring shops, all of which contribute to household expenses and children's education. Entrepreneurs who have established these businesses expressed confidence in keeping their shops open until late in the evening due to the reliable electricity from the national grid, a significant change from when businesses had to close early due to a lack of power. Electricity acts as a catalyst for local economic diversification and job creation, shifting the economy from subsistence to more value-added activities. The ability to operate businesses for longer hours directly translates to increased income and local economic growth [24].

3.5 Persistent challenges in gridline access and service delivery

Despite the numerous benefits brought by the national grid connection, challenges remain as highlighted in the renewable energy technologies [14, 31]. A survey conducted in 2022 revealed that among the 173 households connected to the national grid, all reported electricity cut-offs in the last 7 days. The duration of these outages varied, ranging from a minimum of 4 hours to a maximum of 54 hours, with an average of 26.84 hours per week. In comparison, households relying on micro hydropower experienced significantly higher average outages of 66.90 hours in the last 7 days of the survey time (Table 7).

Users also expressed dissatisfaction with the repair and maintenance work when issues or disturbances occur. As shown in Table 8, 90.1% of total national gridline users experienced repair and maintenance work of electricity when disturbances are not addressed on time.

This dissatisfaction was further validated during FGDs, where a primary reason cited for the lack of timely repair and maintenance was the absence of a dedicated district electricity distribution office in Bajura. Services are managed through the adjoining district electricity office in Achchham. This logistical challenge, coupled with a limited number of staff, means technical personnel often have to travel for half a day or even a full day to resolve problems.

Table 7. Summary of electricity outage hours (National gridline vs. micro-hydro)

Source of Electricity	Minimum Outage (hours/week)	Maximum Outage (hours/week)	Average Outage (hours/week)
National Gridline	4	54	26.84
Micro-hydro Power	0	168	66.90

Table 8. Perception of respondents on repair and maintenance of national gridline

Rating Scale	Frequency	Percent
Strongly disagree	11	2.4
Disagree	49	10.7
Neutral	95	20.8
Agree	14	3.1
Strongly agree	3	0.7
Total	172	37.7

Due to these delays and the resulting unreliability, respondents remained largely neutral regarding the sufficiency of electricity from the national grid for their household requirements. As shown in Table 9, 71.3% expressed a neutral perception on the statement "distributed electricity from the national gridline is good enough as per the requirement of my house".

Table 9. Perception of respondents on sufficiency of electricity from national gridline

Rating Scale	Frequency	Percent
Strongly disagree	2	0.4
Disagree	17	3.7
Neutral	122	26.8
Agree	26	5.7
Strongly agree	4	0.9
Total	171	37.5

Other challenges include the difficult transportation of essential equipment like electricity poles and wires due to the challenging terrain. Moreover, there is a concerning lack of awareness about the higher voltage of national grid electricity compared to the lower voltages of micro hydropower and solar PV systems [32]. This lack of awareness has led to tragic consequences, with at least one reported fatality from an electric shock at home.

The persistent unreliability and poor maintenance services create a significant barrier to fully realizing the grid's potential. This fosters a "trust deficit" in the grid, as discussed by Vindegg [9], which discouraged diversified usage and investment in appliances, average use of electricity of Nepal was 231.4 kWh [33] and reached 400 kWh in 2024 stated by Economic Survey [7] which is apparent that Nepal needs to maximize the use of electricity in a diversified way. The safety concern further highlights a critical gap in public awareness and infrastructure safety protocols, which could undermine public confidence and adoption. The neutral perception on sufficiency indicates that despite access, the quality of supply is not yet meeting the full needs or aspirations of the households.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The augmentation of national gridline electricity in Bajura District through the extensive investment of the NEA exhibits great potential for the advancement of rural development. However, a thoughtful examination of the return on this investment uncovers a possible disparity, considering that communities primarily utilize electricity solely for illumination purposes. This limited utilization prevents the full realization of the grid's transformative socioeconomic potential.

Moreover, the NEA's policy of exempting tariffs for households consuming less than 20 units per month, while intended to promote initial access, inadvertently presents challenges to the fiscal feasibility of the project by potentially disincentivizing broader electricity adoption for higher-consumption activities. This highlights a paradox where policy aimed at affordability may hinder the broader goal of diversified and productive electricity use.

Furthermore, the effectiveness of the grid connection is significantly hampered by persistent challenges related to unreliable electricity access, evidenced by substantial outage hours, and inefficient repair and maintenance services. These operational shortcomings, largely attributed to institutional and logistical issues such as the absence of a dedicated district electricity office in Bajura, erode user confidence and limit the integration of electricity into daily life beyond basic lighting. Despite these challenges, the national grid connection has demonstrated clear positive impacts on education, health, gender equality (through reduced workloads and mitigation of GBV), improved social cohesion, and enhanced local entrepreneurship, marking a significant step towards modern energy access in a least developed district.

The study concludes that while national grid connection is a necessary step for rural development, its full transformative potential in a context like Bajura is currently constrained by a disconnect between infrastructure investment, policy incentives, and operation realities. Achieving optimal socioeconomic impact requires a holistic approach that addresses not only access but also usage diversification, service reliability, and community safety awareness.

4.2 Policy recommendations for optimizing socioeconomic impact

To optimize the socioeconomic impact and ensure a higher return on the substantial investment made in grid expansion, a multi-pronged policy approach by the three-tier government is imperative:

1) Diversify Electricity Usage: it is crucial to actively foster diversified electricity usage beyond basic lighting. Households should be motivated to embrace electric cooking appliances, such as induction stoves

or rice cookers. This requires comprehensive awareness campaigns on the benefits of diversified electricity usage and targeted subsidies or accessible financing mechanisms for these energy-efficient appliances to make them affordable and accessible to rural households. This shift aligns with NEA's 'quit LPG and use electricity' initiative and possesses the capability to substantially diminish carbon emissions and enhance the socioeconomic status of rural communities.

2) Enhance Service Reliability and Maintenance: establishing a dedicated NEA district electricity distribution office in remote districts like Bajura, equipped with sufficient technical staff and resources, is critical to ensure timely repair and maintenance services, reducing prolonged outages. This requires adequate staffing, technical training for local personnel, and efficient transportation of equipment to address geographical challenges.
3) Review Tariff Structure: the current tariff exemption policy for low consumption (<20 units/month) should be re-evaluated. While beneficial for initial access, it may inadvertently disincentivize higher, more diversified electricity usage. Consideration should be given to tiered tariffs that encourage increased consumption for productive uses while maintaining affordability for basic needs, or implementing targeted subsidies for energy efficient appliances.
4) Promote Electricity Safety and Awareness: develop and disseminate comprehensive public safety guidelines and conduct awareness programs on the safe use of high-voltage national grid electricity, especially given reported incidents and the community's prior experience with lower-voltage micro-hydro systems, to prevent accidents and build public confidence in the grid's safety.

4.3 Directions for future research

As a subsequent step, additional studies are recommended to investigate the technical viability, economic feasibility, and safety aspects of implementing induction stoves and other electric cooking appliances in rural Nepalese contexts. Further research could also explore the long-term impacts of improved grid reliability on local economic diversification and the development of new value chains beyond basic entrepreneurship. Additionally, investing optimal institutional models for decentralized energy management and maintenance in remote, geographically challenging areas could ensure sustainable service delivery.

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