Rupantaran: A Multidisciplinary Journal
Vol. VIII: PP 34-57, February, 2024
ISSN(Print) : 2091-0061, ISSN (Electronic): 2738-9960
DOI: https://doi.org/10.3126/rupantaran.v8i01.65199
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The Dynamics of Electricity Consumption in the Economic Prosperity of Nepal

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Abstract

The paper examines the relationship between the dynamics of electricity consumption and Nepal's economic prosperity. Descriptive methodologies and statistical tools are used in this quantitative study that gathers data from secondary sources. The patterns of power consumption are influenced by population increase, urbanization, government regulations, and technical developments, all of which affect Nepal's economic development and social well-being. This paper uses an interdisciplinary approach to show how crucial it is to address energy-related issues to realize socioeconomic potential. Economic growth is the main factor driving the dynamic of power consumption. The finding reveals that the autonomous electricity consumption is 4.13 kilowatt hours shows if income increases by USD 100, the estimated increase in average electricity consumption is 54 kWh. Indicates that increase in per capita income, increases the consumption of electricity, and economic growth are strongly correlated. The result from the forecast analysis shows that the unrestrained demand for electricity is projected to increase from an estimated 7,888 million kilowatt-hours (million kWh) in 2019–2020 to 13,831 million kilowatt-hours in 2029–2030 which seems closer and validates the Electricity Demand Forecast for 2014 to 2040 by Government of Nepal. The result shows that the dynamics of electricity consumption and

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economic prosperity are strongly correlated. Policymakers, energy planners, investors, and other stakeholders must acknowledge the issue and make a call to action to support initiatives that enhance economic growth, access to energy, and sustainable energy use.

***Keywords**:* Dynamics, electricity consumption, hydropower, economic prosperity

Introduction

Despite the abundant hydroelectric potential, Nepal faces several challenges such as electricity access, a long history of load shading, low per capita consumption of electricity, unreliable electricity due to distribution inefficiencies, low economic activities, socio-economic disparities, and environmental degradation. Lack of reliable electricity infrastructure causes low industrial growth, low productivity, poverty, poor socioeconomic development, and a slow pace of sustainable development of the country.

The question of the dynamics of power consumption and economic success is extremely important since it has the potential to significantly impact Nepal's socioeconomic condition. A variety of economic, social, technological, and environmental factors can have an impact on how much electricity is used and demanded in a given region, nation, or industry. These elements and patterns are collectively referred to as the "dynamics of electricity consumption." The patterns of power consumption are also influenced by population increase, urbanization, government regulations, and technical developments, all of which affect Nepal's economic development and social well-being.

Literature Review

The neoclassical economy reinforces economic growth and well-being in society, energy especially electricity functions as a catalyst for industrialization, infrastructure expansion, and the development of human capital. Through an analysis of power consumption patterns, we can figure out the complexities, stimulants, and limitations influencing Nepal's energy transition and economic course. This facilitates the formulation of well-informed policy interventions, strategic investments, and pathways for sustainable development.

Capital accumulation leads to economic growth by saving and investing income for future income generation, resulting in increased physical capital stock through new factories, machinery, and equipment. Physical capital expansion boosts output, while social and economic infrastructure investments like roads, electricity, water, sanitation, and communications integrate economic activities (Todaro & Smith, 2009).

The levels of electricity consumption primarily influence the economic prosperity of a country. The dynamics of this sector contribute to GDP growth and enhance the well-being of individuals. Economic prosperity refers to a country's economic growth, security, and competitiveness. Economic prosperity is important as it is a key element of quality of life and is also necessary for a country to be competitive in the global economy (Vision of Humanity, n.d.). Electricity consumption refers to the amount of energy consumed over time, measured in Wh (kWh), while demand is the rate at which energy is consumed for a required output rating (Energy Efficiency, 2019).

The econometric literature extensively explores the link between energy consumption and GDP growth, with studies on electricity consumption, hydropower projects, and economic development at national and global levels. Developing countries' electricity sector reforms and hydroelectric capacity expansion have only partially succeeded in promoting efficient pricing and broader electricity access. The economic impact of these reforms has been observed to be positive, with mixed effects on poverty, according to limited studies (Jamasb, Nepal, & Timilsina, 2017).

Electricity consumption offers numerous benefits, including increased efficiency in lighting, information and communication technologies, and more productive manufacturing processes. As incomes rise, people increasingly prefer higher-quality, cleaner, and more flexible energy sources, particularly electricity, which is crucial for sustaining social and economic activities (Burke, 2013; Csereklyei, Rubio, & Stern, 2016). This literature shows that numerous variables impact the economic development of emerging nations such as Nepal. These include trade imbalances, investments, energy infrastructure, political stability, regional cooperation, socioeconomic inclusion, infrastructure, human capital, technology, environmental protection, and the effects of climate change.

However, the trade deficit poses a significant challenge in Nepal. It requires immediate actions to mitigate trade deficits by increasing remittances, import-oriented revenue, and foreign aid to sustain economic growth. The Asian Development Bank's working paper 70 indicates Nepal's economic growth was less than 4% per annum in the 2000s, partly due to electricity supply shortages (ADB; 2022). The country experienced a 6% growth in 2013 and an average of 7.3% growth from 2016 to 2018, largely due to a slowdown caused by an earthquake in 2015 (Gunatilake, 2021).

The author, Gunatilake, (2021) highlights that over the past two decades, the agricultural and industrial sectors have decreased Nepal's GDP, while the services sector

has experienced growth and now holds the largest share. Nepal needs to increase its industrial sector contribution to GDP to create productive employment, as the global economy contracted due to Covid-19, as seen in other countries (Gunatilake, 2021). The global economic slowdown has led to a decrease in employment opportunities, exacerbated by poverty and inequality in Nepal.

Nepal, a least developed country, is aiming to achieve developing nation status by focusing on electricity production and consumption as key economic drivers. However, Nepali citizens' basic energy needs are only partially met, resulting in a form of energy poverty. It shows that the prosperity of economic development in Nepal relies heavily on the production and consumption of electricity, which requires an adequate, affordable, and reliable supply of quality electricity (Gunatilake, 2021). Nepal experienced 18-hour power cuts due to low production capacity, affecting economic growth and consumption, highlighting the need for improvement in the electricity transmission and distribution system. Efficient utilization of energy consumption, especially in electrical energy, is crucial for Nepal's economic development, both domestically and commercially.

The literature revealed that there are abundant water resources in Nepal. More than 6,000 rivers discharge an average annual water runoff of 220 billion cubic meters. It provides a hydropower potential of 83,000 MW. Nepal's hydropower potential is estimated at 83 GW, but due to constraints, it is economically viable to develop around 42 GW of capacity (Surendra et al.2010).

Fiscal policy, 2078-79, Government of Nepal shows Nepal's energy sector is predominantly reliant on traditional sources, with fuelwood accounting for over three-quarters of total consumption, and all fossil fuels are imported. Nepal's installed electricity generation capacity is 2,205 megawatts, with 94% of the population having access, primarily powered by hydropower, in 2022. Nepal's per capita electricity consumption has increased from 115.38 kWh in 2012 to 304 kWh in 2021, yet only 5% of its 42 gigawatt economic hydropower potential has been utilized.

This study investigates the relationship between per capita electricity consumption and GDP, analyzing factors like consumption status, access, trend analysis, and GDP over the next five years. This study forecasts electricity consumption and economic growth in Nepal using secondary sources, providing insights for policymakers, researchers, and scholars. In this context, this paper investigates the correlation between electricity

consumption and economic growth, a crucial issue for Nepal and other developing nations aiming to boost their economic development.

Production necessitates energy to perform work, convert materials into desired products, and transport raw materials, goods, and people. The second law of thermodynamics, known as the entropy law, dictates that energy cannot be recycled, and there are limits to how much energy efficiency can be improved. These limitations can be approximated using a production function with an elasticity of substitution significantly below one (Stern, 1997).

A meta-analysis of existing empirical literature confirms that the elasticity of substitution between capital and energy is indeed less than one (Koetse, de Groot, & Florax, 2008). Energy is an essential factor of production, and continuous supplies of energy are required to maintain existing levels of economic activity and promote economic growth and development (Stern, 1997). There may also be macroeconomic limits to substituting other inputs for energy. The construction, operation, and maintenance of tools, machines, and factories all demand a consistent flow of materials and energy. Similarly, the individuals overseeing these capital assets consume energy and materials. Consequently, producing more substitutes for energy necessitates an increase in the very resource it is meant to replace, thereby limiting potential substitutability (Cleveland et al., 1984). While there are limitations to substituting energy for other inputs, a meta-analysis of existing studies suggests that inter-fuel substitution possibilities are promising (Stern, 2012). Transitions between different energy sources have occurred in the past and can occur in the future

Successful case study analysis is a qualitative research method that involves the detailed examination and analysis of real-life success stories involving individuals, organizations, or nations. Its goal is to identify the factors that contributed to their success. The purpose of this analysis is to gain insights into the key factors or practices that led to successful outcomes, with the aim of replicating them in similar situations.

A study regarding the relationship between electricity consumption and development has been conducted on a broader scale. Electricity serves as a high-quality energy carrier, offering greater productivity and flexibility compared to other energy sources, with zero pollution at the end-use point. Electricity is also significantly more thermodynamically efficient than alternative technologies, especially in applications like lighting. In many high-value applications, such as computing and telecommunications,

there are no substitutes for electricity. In cases where alternatives exist, the high cost of electricity limits its use to relatively high-value applications (Kaufmann, 1994). However, in situations where electricity is subsidized, it may also find use in lower-value applications.

In the 19th century, electric motors proved to be much more flexible than steam engines, enabling the reorganization of work in factories and resulting in significant productivity gains (Kander, Malanima, & Warde, 2014). Other early applications included lighting and telecommunications, starting with the telegraph and later advancing to telephones. Communications, lighting, and industrial power are still likely to be among the first applications when introducing electricity in regions that were previously underserved.

Traditional fuels are polluting and often require significant household labor for collection, processing, and use. The development of electricity provides market opportunities for employment and a means to mitigate the negative effects of traditional fuels. Consequently, as incomes increase, households gradually transition up an 'energy ladder' by adopting higher-quality fuels like electricity (Hosier, 2004). However, this doesn't necessarily mean completely abandoning traditional fuels (van der Kroon, Brouwer, & van Beukering, 2013), nor does it imply that income is the sole determining factor in household energy transitions (Burke & Dundas, 2015).

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Literature on Case Studies of Electrification Success Stories

Interesting research performed by Stern, D. I., Burke, P. J., & Bruns, S. B. (2019) entitled "The Impact of Electricity on Economic Development: A Macroeconomic Perspective". UC Berkeley could be a good lesson for Nepal.

Case Studies of Electrification Success Stories (Countries with Relatively Low GDP per Capita in 1971)

South Korea

In 1965, only 12% of rural households had access to electricity. A concerted electrification program saw this increase to 98% by 1979 reports that large improvements in the quality of life were seen, with rural household incomes increasing at a real annual average rate of 27% in the 1970s. Electricity has underpinned the development of modern manufacturing and services sectors.

China

Rural electricity access is reported to have reached 61% by 1978, although the quality and quantity of supply were limited. A large-scale investment program brought rural electricity access to 97% by 1997. Found that provinces with greater investment in rural electricity infrastructure experienced faster poverty reduction and higher incomes.

Thailand:

In the early 1970s, only around 10% of households outside the Bangkok Metropolitan Region had access to electricity. In 1973, Thailand launched a National Plan for Accelerated Rural Electrification to extend electricity access to all villages. Thailand has since achieved near universal electricity access. Now an upper-middle-income economy, the (World Bank 2016) refers to Thailand as "one of the great development success stories".

Vietnam

World's most successful electrification program, Vietnam increased access from below 5% in the mid-1970s. Vietnam has also made remarkable development progress, reducing extreme poverty from around half of the population in the early

1990s to 3% in 2014 (World Bank, 2016). The benefits of rural electrification have included higher incomes, boosted school enrolment, and time savings from the use of appliances such as rice cookers.

Case studies of the aforementioned success stories, supported by more rigorous statistical evidence, demonstrate the significant role of electricity in economic development. These findings offer valuable lessons for Nepal, a least developed country (LDC), and other developing economies. Therefore, various pieces of literature suggest that hydropower holds substantial potential for economic development in a broad sense. On one hand, GDP growth leads to increased electricity consumption in developing countries, while on the other hand, electricity consumption boosts GDP in developed countries. For any country, such as Nepal, striving to increase its GDP, electricity consumption is essential.

Methods and Materials

This paper is based on positivist research paradigms and quantitative research approaches that lead to descriptive research design. This paper also uses secondary data sources. An empirical growth analysis method spans the review of the Economic Survey (2012–2021) that was published by the Ministry of Finance in Nepal. Secondary data were collected from the critical reviews of books, journal articles, and data from authoritative secondary sources. The study analyzed data from various government agencies, including the Central Bureau of Statistics, Nepal Electricity Authority, and the Ministry of Finance, to critically examine the topic. The analysis was enriched by utilizing reports and websites from the International Energy Agency (IEA), Asian Development Bank (ADB), and World Bank (WB) were used to gather information. The review analyzed electrification success stories, providing insights into hydropower production's potential and its contribution to rapid economic development.

The methodology used time series data, including trends, correlations, and regression analysis, to identify and understand the problem through a review of relevant previous research studies. Statistical tools were used for data processing, tabulation, presentation, and creation of graphs and pie charts. The data was analyzed using statistical techniques, including correlation and linear regression, to determine the relationship between two quantitative variables.

Data presentation and analysis

Hypothesis setting

This paper aimed to validate the empirical hypothesis that electricity consumption doesn't significantly impact economic growth, based on literature reviews (Table 1).

Table 1

Hypothesis Testing (5% level of Significance)

Alfa (α)			
H1	$\alpha = 0$	If P > 0.05	If P > 0.05, we accept the null hypothesis, so Ho that $\alpha = 0$
H0	$\alpha \neq 0$	If p < 0.05	If p < 0.05, we reject the null hypothesis Ho that $\alpha = 0$ and accept the alternative hypothesis (H1) that $a \neq 0$
Beta (β)			
H1	$\beta = 0$	If P > 0.05	If P > 0.05, we accept the null hypothesis (Ho), so Ho that $\beta=0$
H0	$\beta \neq 0$	If P < 0.05	If p < 0.05, we reject the null hypothesis (Ho) that $\beta =0$ and accept the alternative hypothesis H1 that $\beta \neq 0$

Source: Author

Note. Table 1 shows the statistical details of hypothesis testing where Null hypothesis (HO), electricity consumption has no positive significant relationship with GDP growth of Nepal at a 5% level of significance (P > 0.05) and Alternative hypothesis (H1), there is a significant relationship between electricity conscription and GDP growth of Nepal at a 5% level of significance (P > 0.05).

Result and Discussion

Hydropower Potentialities in Nepal

The paper explores the macroeconomic impacts of Nepal's hydropower expansion, highlighting its potential to boost economic growth, reduce energy costs, alleviate poverty, and mitigate climate change. Nepal has 42 gigawatts of hydropower potential, currently utilizing 1.2 gigawatts, according to the Asian Development Bank, which could enable the country to become energy self-sufficient and sell excess energy to neighboring countries. Hydroelectric power could benefit the environment by replacing firewood as the primary energy source in rural areas, reducing the need for unsustainable wood cutting, erosion, and landslides. Gurung and Oh (2011) present the potential hydropower generation capacities

from various river basins, including SaptaKoshi, Karnali, Sapta Gandaki, Mahakali, and Southern Rivers (Table 2).

Table 2

Major River Systems of Nepal and Hydropower Potential

Major River Basin	Theoretical Potential		Technical Potential		Economic Potential
	Megawatts	Project sites	Megawatts	Project sites	Megawatts
Sapta Koshi	22,350	53	11,400	40	10,860
Sapta Gandaki	20,650	18	6660	12	5270
Karnali and Mahakali	36,180	34	26,570	9	25,125
Southern Rivers	4110	9	980	5	878
Total	83,290	114	45,610	66	42,133

Source: Adopted from K.C. Surendra et al.2010.

*Note.*Table 2 shows the potential hydropower generation from different rivers of Nepal. The data reveals that the Karnali and Mahakali basins have the largest potential capacity (25325 MW) and the least in the southern rivers (878MW). The table comprises three types of potentialities, such as theoretical potentiality (83,290 MW), technical potentiality (45610 MW) megawatts, and economic potentiality (42133 MW) from different rivers of Nepal.

Correlation analysis

The correlation analysis between electricity consumption and GDP (Table 3).

Table 3

The simple correlation between electricity consumption and GDP

	Per capita GDP in US Dollar	Per capita electricity consumption (Kwh)
Per capita GDP in US Dollar (Y)	1	0.985
Per capita consumption (Kwh) (X)	0.985	1
N=10		

Source: Author

Note. Table 3 shows the calculation of a simple correlation between electricity consumption and GDP in Nepal. The result indicates that there is a high degree of positive correlation, i.e., r = 0.985, between two variables, an increase in per capita GDP leads to an increase in electricity consumption. There exists a two-way relationship between hydropower development and a country's economic growth. Within this relationship, each factor influences and is influenced by the others. Hydropower development can act as an economic driver, providing a significant source of clean and renewable energy. Therefore, hydropower exports could serve as an instrumental tool in addressing trade deficits.

Status of energy consumption

The amount of energy consumed in Nepal for the 2020–2021 fiscal year, expressed in thousands of tonnes of oil equivalent (ToE), along with the percentage that each energy source will account for in terms of share (Table 4 and Figure 1).

Table 4

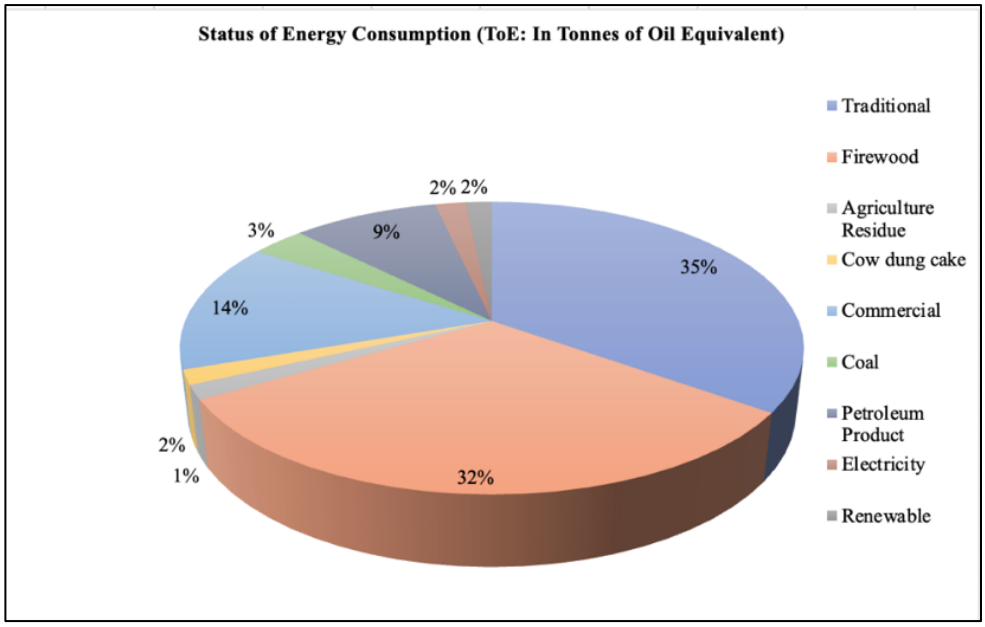
Status of Energy Consumption (ToE: In Tonnes of Oil Equivalent)

Source	2020/21	Share %
	000 ToE	
Traditional	6587.00	68.63
Firewood	5986.40	62.38
Agriculture Residue	295.30	3.08
Cow dung cake	305.40	3.18
Commercial	2704.90	28.18
Coal	636.40	6.63
Petroleum Product	1707.20	17.79
Electricity	361.30	3.76
Renewable	305.32	3.18
Grand Total	9597.22	100.00

Source: Ministry of Finance, Nepal 2020/21

Figure 1

Pie diagram showing the status of energy consumption by energy sources 2020/21



Source: Data adapted from Ministry of Finance, Nepal 2020/21

Note.Table 4 and Figure 1 highlight that the energy sector is still dominated by traditional sources (35%) of energy, where fuelwood accounts for over three-quarters of total energy consumption (share of electricity is only lower (2%) in the total energy mix.

Status of Access to Electricity

The status of access to electricity is vital to electricity consumption and economic growth (Table 5 and Figure 2).

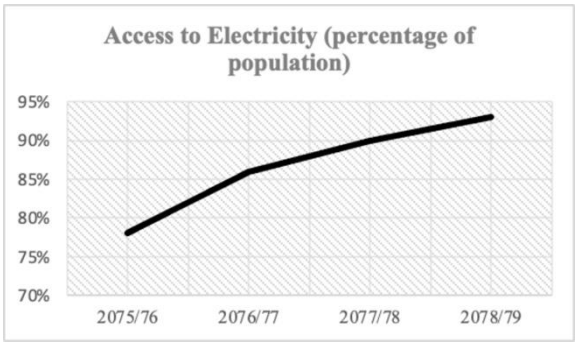
Table 5

Access to Electricity

Fiscal year	Access to electricity in percentage
2075/76	78%
2076/77	86%
2077/78	90%
2078/79	93%

Figure 2

Line Chart of Access to Electricity



Source: Data adapted from the Ministry of Finance Nepal, 2020/21

Note. Table 5 and Figure 2 show an increasing trend of the population to electricity access from the fiscal year 2075/76 to 2078/79. From the fiscal years 2075–2076 to 2078–

2079, Nepal's percentage of the population with access to electricity has been rising significantly. It increased from 78% in 2075–2076 to 93% in 2078–2079, demonstrating a notable advancement in the nation's efforts to increase access to energy throughout this time. This growing trend is a result of continuous efforts by the government and other stakeholders to advance rural electrification projects, increase grid connectivity, and upgrade energy infrastructure. These efforts have boosted socioeconomic development and the standard of living for Nepalese inhabitants.

Analysis of GDP and Electricity Consumption

Understanding a nation's economic development and energy dynamics requires an understanding of the link between GDP and electricity usage. Normally, a growth in a country's GDP is associated with a proportional rise in the usage of energy. This situation is a result of the need for energy for economic activities, primarily the creation of electricity, which includes manufacturing, industrial output, commercial operations, and home consumption. Demand for goods and services rises in cycles with GDP growth, necessitating greater energy use to maintain production and satisfy consumer demands. On the other hand, since electricity powers the industry, boosts productivity, and allows technical improvements, it can also propel economic growth. Status of GDP growth in USD and Electricity consumption in KWh presented for the period from 2067-2070 to 2078-79 (Table 6 and Figure 3).

Table 6

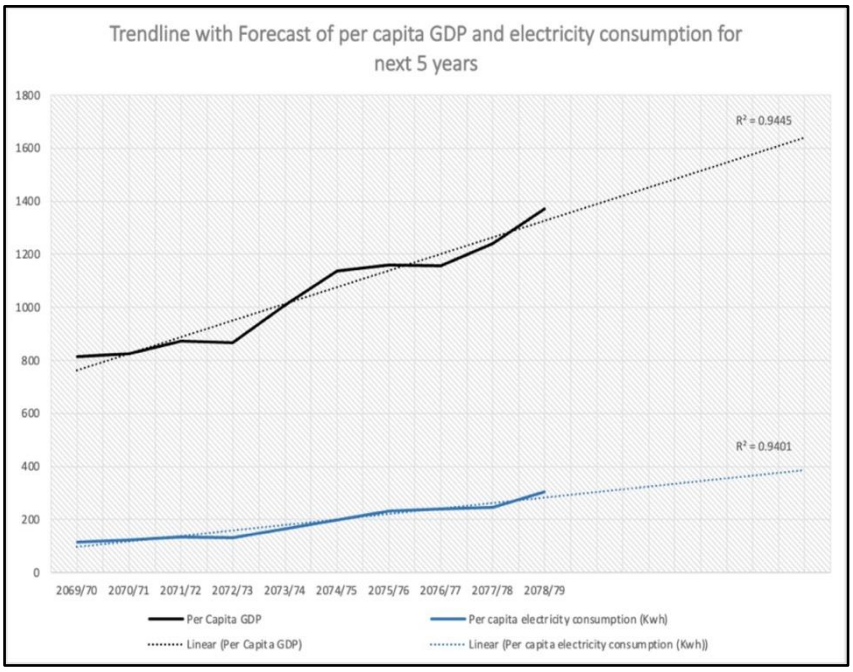
GDP in USD and Electricity Consumption in kWh (2069/70 to 2078/79

Fiscal year	GDP (USD)	Electricity consumption (Kwh)
2069-70	814	115.38
2070-71	824	123.98
2071-72	871	132.98
2072-73	882	130.78
2073-74	1032	164.32
2974-75	1168	198
2075-76	1194	233
2076-77	1156	240
2077-78	1239	246.4
2078-79	1372	304

Source: Data adapted from the Ministry of Finance Nepal, 2020/21

Figure 3

Trendline of per capita GDP (USD) and Electricity Consumption (kWh) 2069-70 to 2078-79



Source: Data adapted from the Ministry of Finance Nepal, 2020/21

Note. Table 6 and Figure 3 shown above display a linear trend analysis and a forecast of both GDP and electricity consumption for the next five years. The trend reveals that per capita GDP has risen from 814 USD in the fiscal year 2069/70 to 1372 USD in 2078/79. Similarly, electricity consumption has increased from 115.38 kWh in 2069/70 to 304 kWh in the fiscal year 2078/79. Based on the current trend, the forecast indicates a GDP of 1600 USD and electricity consumption of approximately 390 kWh in the next five years (by fiscal year 2083/84). Statistically, the R-Square (R2) value is 0.934 for GDP, signifying that about 93 percent of the variation in GDP can be explained by the model. Additionally, for electricity consumption, R-Square (R2) is 0.94, indicating that 94 percent of the variation in electricity consumption can be explained by the model.

Analysis of Electricity Consumption Trend and Forecast

The electricity consumption trends of Nepal from 2010/11 to 2019/20 are analyzed, along with a trend forecast for the next ten years. Government of Nepal have forecasted electricity demand need for 2014 to 2040. Normal trend forecasts through graphical methods and Excel computation are widely used techniques in research works (Table 7 and Figure 4).

Table 7

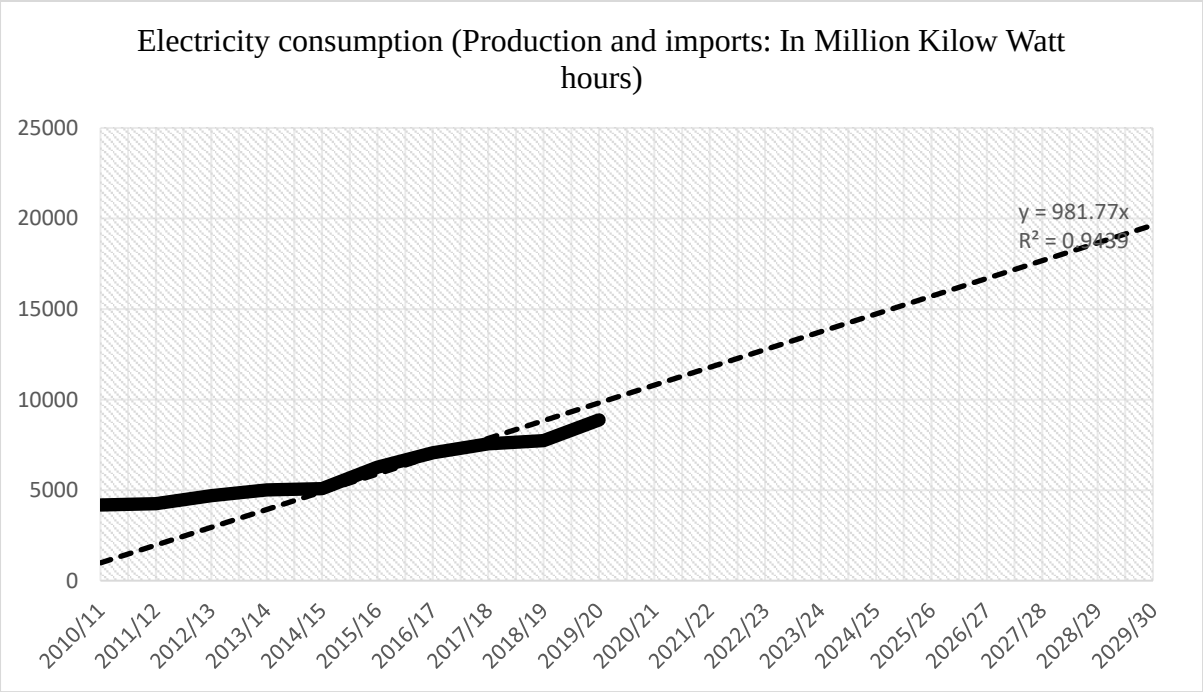
Electricity consumption (production and imports) in Million Kilowatt-hours with forecast for the next 10 years

Fiscal Year	Consumption (ToE:Tonnes of Equivalent)	Fiscal Year	Trend growth for 10 years
2010/11	4179	2020/21	9014
2011/12	4258	2021/22	9549
2012/13	4687	2022/23	10084
2013/14	5007	2023/24	10620
2014/15	5077	2024/25	11690
2015/16	6258	2025/26	12225
2016/17	7058	2026/27	12761
2017/18	7551	2027/28	13296
2018/19	7741	2028/29	13831

Source: Data adapted from Ministry of Finance, Nepal, Year, 2078-79

Figure 4

Electricity consumption (production and imports) in Million Kilowatt-hours with forecast for the next 10 years



Source: Author

Note. Table 7 and Figure 3 a linear trend analysis indicating that, based on the current pattern of electricity consumption, the growth trend in the electricity sector is expected to persist for the next five years. This trend is anticipated to continue alongside rapid urbanization and the expansion of energy-intensive industries. The unrestrained demand for electricity is projected to increase from an estimated 7,888 million kilowatt-hours (million kWh) in 2019–2020 to 13,831 million kilowatt-hours in 2029–2030. This forecast validates that forecasted where 12,242.23 are needed for 4.5 percent GDP, 16550.47 for 7.2 percent GDP, and 16550.47 for 9.2 percent GDP (Water and Energy Commission Secretariat, Government of Nepal, 2014).

Role of hydro-electricity in economic growth

Hydroelectricity plays a pivotal role in driving economic growth by serving as a reliable and sustainable source of energy that powers industries, facilitates infrastructure development, and enhances productivity across diverse sectors. As a renewable energy resource, hydroelectricity offers several advantages, including low operating costs, minimal environmental impact, and long-term stability in energy supply. By providing a stable and affordable source of electricity, hydroelectric power plants enable industries to operate efficiently, attract investment, and stimulate economic activity. Moreover, the development of hydroelectric infrastructure creates employment opportunities, fosters technological innovation, and promotes local economic development in regions where projects are located. Additionally, hydroelectricity contributes to energy security by reducing dependency on imported fossil fuels and mitigating the risks associated with volatile energy markets. Furthermore, by powering critical infrastructure such as transportation networks, healthcare facilities, and educational institutions, hydroelectricity plays a fundamental role in improving living standards, enhancing socio-economic well-being, and fostering sustainable development initiatives in communities around the world.

Nepal's economic growth was less than 4 percent per annum during the 2000s. This slow growth can be partially attributed to shortages in the supply of electricity for both traditional and modern industries. However, there have been positive changes since then, with approximately 6 percent growth recorded in 2013 and an average growth rate of about 7.3 percent from 2016 to 2018. This period of growth followed a significant slowdown in 2014 and 2015, mainly due to the impacts of the earthquake.

Over the past two decades, the contribution of the agricultural and industrial sectors to the gross domestic product (GDP) has decreased (Government of Nepal). In contrast, the services sector has experienced significant growth and currently accounts for the largest share of Nepal's economy. In 2017, services contributed 51.6% to GDP, followed by agriculture at 26.2% and industry at 13.4%. It is believed that recent improvements in electricity supply to the industrial and service sectors have played a role in driving better economic growth. Regarding the economic growth rate for the period from 2010 to 2021 and the GDP trend forecast for the next 10 years using a linear method, Table 5 and Figure 3 illustrate that Nepal's average GDP growth trend, based on the linear method, indicates an average growth rate of 4.33 percent under the business-as-usual scenario.

Market Expansion Opportunities

The market plays a vital role in the utilization of potential hydroelectricity in Nepal by serving as a key driver for investment, development, and sustainability. A competitive market environment stimulates private and public sector stakeholders to invest in the exploration, development, and operation of hydroelectric projects, thereby unlocking hydroelectric potential. Through market mechanisms such as power purchase agreements, feed-in tariffs, and competitive bidding processes, electricity producers can access reliable revenue streams, mitigate investment risks, and ensure financial viability for hydroelectric ventures. Furthermore, access to regional and international energy markets offers opportunities for Nepal to export surplus electricity, generate revenue, and strengthen economic ties with neighboring countries, thereby positioning hydroelectricity as a strategic asset for sustainable energy development and economic growth in the region. Nepal occupies a strategic location between the two largest countries in Asia: India and the People's Republic of China (PRC). Both countries face an annual demand for electricity of approximately 5 million GWh. Additionally, neighboring Bangladesh is experiencing a growing energy demand while also grappling with energy deficits. Within Nepal itself, the energy demand is also on the rise.

Over the long term, the expansion of hydropower generation leads to increased domestic incomes, reduced real domestic energy prices, substantial poverty alleviation, and serves as a hedge against rising oil prices. Furthermore, the aforementioned study underscores Nepal's potential to make a significant contribution by providing environmental

services to the South Asian region through the delivery of clean, renewable energy while simultaneously mitigating the effects of climate change.

Electricity usage and access are strongly correlated with economic development, as economic theory would suggest. Despite a substantial body of empirical literature (Stern, D. I, Burke, P. J, & Bruns, S. B. (2019)) and suggestive case evidence, there are, however, few methodologically rigorous studies that establish causal effects on an economy-wide basis. Some evidence suggests that the reliability of electricity supply plays a crucial role in fostering economic growth.

In addition to domestic and industrial applications, Nepal also has considerable potential to utilize electricity for transportation. To date, Nepal has developed less than 1.2 GW of hydropower, representing only a tiny fraction of its total economic potential. Even with ongoing hydropower developments, approximately 88% of the economic potential of hydropower remains untapped. India, the PRC, and other neighboring Asian countries, such as Bangladesh, could readily absorb any additional electricity supply beyond Nepal's requirements, provided that the necessary transmission infrastructure is in place.

Regression analysis

Table 6

The Summary Output of Regression Analysis

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.98							
R Square	0.97							
Adjusted R Square	0.97							
Standard Error	0.03							
Observations	10							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	0.31	0.31	260.05	0.00			
Residual	8	0.01	0.00					
Total	9	0.32						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	4.13	0.17	23.66	0.00	3.73	4.54	3.73	4.54
Per capita consumption(kWh)	0.54	0.03	16.13	0.00	0.46	0.62	0.46	0.62

Source: Author

Table 7

Interpretation of Regression Analysis

	Y=α+β X	Interpretation
R-Squared (R2)	0.97	R2=0.97 indicates that about 97% of the variation in the per capita electricity consumption is explained by per capita income.
Intercept α	4.13	The autonomous electricity consumption is 4.13 kwh i.e. If income is 0 USD, the average level of electricity consumption is 4.13 kwh. The coefficient of the X variable. For stance, β1 =0.54 measures the slope of the electricity consumption line. It indicates that if income increases by USD 100, the estimated increase in average electricity consumption is 54 kWh.
Slope β	0.54	
Regression Equation	Y=4.13+0.54X	
Standard Error (α)	0.17	The standard error is an estimate of the standard deviation of the coefficient and is a measure of precision. Coefficient 4.13 is larger compared to 0.17 and so it does not very much. The slope coefficient of 0.54 is also larger compared to its standard error. Both are different from 0.
Standard Error (β)	0.03	
P-Value (α)	0	The P-value is less than 0 in both. We reject the null hypothesis that the coefficients equal 0. Both coefficients are statistically significant.
P-value (β)	0	
C Intercept (α)	3.73 to 4.53	We are 95% confident that the real underlying value of intercept lies between 3.73 and 4.53 and that the real underlying value of slop lies between 0.46 and 0.61.
CI (β)	0.46 to 0.61	

Source: Author

Nepal possesses the potential for substantial production and electricity consumption can significantly boost various economic activities mainly job creation, increased government revenue, foreign investment attraction, reduction in unemployment rates, mitigation of trends in foreign migration, and trade deficit by utilization of electricity. Hydropower development can serve as an economic catalyst, providing a significant source of clean and renewable energy. Harnessing abundant hydropower resources creates economic development through multiple avenues, infrastructure development, job creation, agricultural mechanization, transportation services, domestic and industrial energy consumption, fossil fuel substitution, export potential, and overall economic advancement. Consequently, hydropower exports could be an instrumental tool in addressing trade deficits.

It has been observed that a strong correlation exists between electricity consumption and GDP growth, indicating a high degree of positive correlation between these two variables. In other words, an increase in per capita GDP leads to a corresponding increase in electricity consumption. This relationship can be interpreted as follows: as income levels rise, consumers tend to improve their living standards, leading to increased purchases of household electrical appliances such as modern cooking devices, air conditioning units, heating systems, mixers, juicers, vacuum cleaners, lighting fixtures, washing machines, dishwashers, and various other devices, consequently driving up electricity consumption.

Case stories of South Korea, China, Thailand, and Vietnam (also known as Asian miracles) speak a good lesson for Nepal that electricity access and electricity consumption are essential for the economic growth of any developing country. Statistical evidence underscores the pivotal role of electricity in economic development. These findings provide valuable lessons not only for Nepal but also for other developing economies. Regression analysis further indicates that for every increase of $100 in per capita income, there is an estimated increase of 54 kWh in average electricity consumption. Moreover, the trajectory of a country's development path significantly influences its electricity consumption.

The predictions of future energy and electricity requirements for a country are largely guided by its plans, policies, and overarching national vision. In the context of this forecast study, it's worth noting that implementing policy interventions and creating an enabling environment for electricity usage in urban areas, such as for cooking and water heating, agricultural mechanization, and electric train operations, can lead to an increase in electricity demand. Surplus production of electricity holds export potential, allowing Nepal to export its excess hydropower to neighboring countries like India and Bangladesh, both of which are experiencing growing electricity demands. More electricity consumption can also reduce reliance on imported fossil fuels, leading to long-term cost savings. Hydropower, as a clean and renewable energy source, positions Nepal to achieve energy self-sufficiency and diminish its dependence on imported fossil fuels. Additionally, it aligns with Nepal's commitments to address climate change and reduce its carbon footprint, contributing to climate change mitigation efforts.

Conclusion

This study deep-dived on the dynamics of electricity consumption and economic prosperity of Nepal, revealing that economic development can be achieved within a short period. Summarized case stories of South Korea, China, Thailand, and Vietnam (also known as Asian miracles) speak a good lesson for Nepal that electricity access and electricity consumption are essential for the economic growth of any developing country. Correlation, regression, and forecast analysis show that per capita income stimulates electricity consumption and electricity consumption boosts economic growth which are strongly correlated. The finding of the result of Nepal is that the autonomous electricity consumption per USD 100 increased in per capita income, with the estimated increase in average electricity consumption to 54 kWh using linear regression analysis. Forecast analysis shows that the unrestrained demand for electricity is projected to increase from an estimated 7,888 million kilowatt-hours (million kWh) in 2019–2020 to 13,831 million kilowatt-hours in 2029–2030 which validates with the Electricity Demand Forecast for 2014 to 2040 by Government of Nepal. The massive consumption of electricity in the domestic, industrial, and transportation sectors can boost Nepal’s economic prosperity. The study concludes that Nepal's economic development can be greatly aided by the dynamics of electricity consumption in a sufficient, reasonably priced, and dependable supply of high-quality electricity. Hydropower development and the advancement of a nation's economy are strongly correlated and can contribute significantly to economic prosperity by offering a clean, sustainable energy source.

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