Original Article

Financial Feasibility of solar Energy for Household Consumption, impact and challenges in Nepalese economy

Sabita Bhandari [1]*

1. Asst.Manager, Rashtriya Bnaijya Bank, Singha Durbar Plaza Kathmandu, Nepal.

* Correspondence: sabita.bhandari@rbb.com.np

Abstract: As an economic good, Energy affects all sectors of the economy, so it is taken as a means of achieving sustainable development to address the issues related to carbon reduction. The financial feasibility of solar Energy through banks and financial support is the most relevant in the Nepalese context. The recently highlighted subject is the government's announcement of biogas using solar Energy and energy efficiency. This study determined the financial feasibility of utilizing solar Energy in household consumption in the rural sector of Nepal. The study also described the role of renewable energy (solar Energy) in the sustainable development of the Nepali economy. The study followed the mixed method; the quantitative method was used to explore public opinion about using renewable Energy (solar), and the quantitative method was used to explore the relationship between energy efficiency and financial feasibility. The study included N=100 household consumption uses, where simple random sampling was followed to select solar energy use for household consumption in Kathmandu Valley Valley Valley. The closed and open-ended questionnaires were used to collect information. Besides this, authentic secondary data and information based on the study's objective have been collected from the journals and publications of national and international organizations. Correlation techniques such as simple, partial, and multiple have been used to find the relationship between different variables, and regression analysis was done to predict the variables. Results show that the government of Nepal has set a goal to increase the share of renewable energy from less than 1% to 10% and further improve access to electricity from alternative sources, from 10 to 30%, within the next 20 years. The findings showed a significant long run relationship of product export diversification and GDP growth but the geographical export diversification had an insignificant relationship.

Keywords: financial feasibility, solar energy, economy, Nepal

1. INTRODUCTION

As an economic good, Energy affects all the sectors of the economy, so it is taken as a means of achieving sustainable development for addressing the issues related to carbon reduction, reducing production cost and consumption expenditure, reducing the energy gap, and ensuring energy security [1]. Alternative sources of energy practices implemented through government policy and change in human behaviour are one of the attempts for efficient energy conservation and management [2]. As the population is increasing daily, which results in high energy demand, from nearly 5000 years ago, people used to worship the sun as a god; later on, science defined solar Energy, which eased people's livelihood [3]. Solar Energy can be converted to heat and electricity using solar panels. The country's total annual energy consumption is estimated to grow by 1.9% (i.e., from 369 PJ in 2010 to 536 PJ in 2030). The sectoral final energy consumption would grow at 5.8%, 5.0%, 5.0% and 3.4% in the industrial, transport, commercial and agriculture sector respectively [4]. Such prediction creates ground for thinking about energy efficiency practices in Nepal. Energy efficiency practices impact trade balance, industry output, employment, Energy and GHG intensity, energy diversity, energy import dependency and so on [5]. While having energy efficiency practices, certain concerns regarding energy demand and price are to be given, which affect the energy efficiency level [6]. Energy efficiency supports the sustainable development of small and medium enterprises. Energy-intensive SMEs like food processing industries, bakeries, brick industries, steel industries, etc., massively use different forms of Energy. Sustainable use of Energy supports the growth of such

industries. However, in most developing countries, Energy has become one of the significant obstacles to the growth consumption of solar Energy for financial feasibility. The sustainable growth of SMEs for Solar Energy is questioned due to the negative environmental impact of inefficient use of available energy [7]. The financial feasibility of solar Energy through banks and financial support is the most relevant in the Nepalese context [8]. The recently highlighted subject is the government's announcement of biogas using solar Energy and energy efficiency. Existing literatures on solar Energy's feasibility mainly focus on the relationship between solar Energy and house hold consumption, growth and income. However, most of the research on solar Energy is not connected with household consumption of energy efficiency [9]. These studies mainly focus on the relationship between export solar energy and economic growth and determinants of using solar Energy feasibly. They have mainly used macroeconomic variables like GDP growth, trade openness, human capital, domestic credit, trade, finance and terms of trade as the major determinants of financial feasibility. Energy efficiency variables are rarely used as the determinants of export diversification [10]. Hence, the linkage between energy efficiency and export diversification is a new area of research. There is a lack of sufficient empirical research on the financial feasibility diversification and energy efficiency of using solar Energy as an alternative source in Nepal [11]. The deployment of renewable Energy through the AEPC has primarily relied on public finance. Investments exceeding NPR 158 billion are required to achieve the renewable energy targets outlined in Nepal's second NDC. However, the current annual investment by AEPC represents less than 5% of this total. Firewood consumption and lessening indoor pollution (smoke) have health grounds linked to income generation and reduction of women's drudgery. This study is based on the use of solar energy in different rural sectors in Nepal. It focuses on the sustainable development of the energy supply and solar Energy. The financial feasibility looks over the pros and cons of using solar Energy in terms of monetary value, which benefits the entrepreneur for the long run. The new body of knowledge in this study is that it links the financial aspect with solar energy generation and consumption. This study would have also link solar Energy with energy efficiency which help in the sustainable development of solar Energy for household consumption in rural areas. Due to the geographical territory and remoteness the extension of electricity transmission line is more difficult and not financially feasible. Hence, this study focuses on solar energy development in rural Nepal.

2. MATERIALS & METHODS

Using a multi-method approach, the study employs various qualitative and quantitative methods to understand the chosen topic better. The study followed the mixed method; the quantitative method was used to explore public opinion about using renewable Energy (solar) in various sectors and to explore the feasibility of solar Energy. At the same time, the quantitative method has been used to explore the pattern of energy consumption using solar Energy by the individual household and the relation between energy efficiency and financial feasibility. The major Kathmandu Valley has been taken as the population to study the status of solar energy efficiency practices in rural and urban sectors. Kathmandu Valley includes three districts: Kathmandu, Bhaktapur and Lalitpur. The study included at least N=100 household consumption uses representing the three districts. Simple random sampling was followed when selecting solar Energy for household consumption in Kathmandu Valley. The closed and open-ended questionnaires were used to collect information. Besides this, authentic secondary data and information based on the study's objective have been collected from the journals and publications of national and international organizations working in the energy sector. Both primary and secondary data sources are considered for the study, and the validity of secondary sources is considered static compared to the primary data source. An empirical test was done based on secondary data, and a qualitative method was used to find the energy efficiency behaviour of household consumption. The survey collected qualitative and quantitative data related to individual households and firms. Energy policy was analyzed based on a key informant interview. In order to acquire the required knowledge, various experts and institutions reviewed existing literature reports, related information bulletins, leaflets, booklets, brochures, etc. Moreover, to understand in detail experts consulted and interviewed in depth to grab firsthand information. Both the primary and secondary data used for further research. A skilful use of qualitative and quantitative techniques gives a more comprehensive understanding of the topic. Quantitative research collects numerical data to explain, predict, and control phenomena of interest,

and data analysis is mainly statistical. Qualitative research involves using and collecting various empirical materials, case studies, personal experiences, and observational studies. The information collected has been analyzed and presented using different qualitative and quantitative methods to analyze data systematically. Qualitative data is analyzed descriptively, whereas simple statistical tools like percentage and average are applied for quantitative analysis. Correlation techniques such as simple, partial, and multiple are used to find the relationship between different variables, and regression has been done to predict the variables.

3. RESULTS AND DISCUSSIONS

3.1. Per-Capita Electricity Consumption

Electricity is a modern energy resource used for various purposes with modern technology; in Nepal, almost all the electricity is generated via clean hydroelectric resources. Access to electricity is a determining factor for improving quality of life. There has been a recent substantial increase in the electrification rate, reaching up to 82% of the population in 2016. In the rural areas of developing countries, people use electricity to light and charge mobiles. In contrast, in urban areas, people also use electricity for cooking, as well as for mechanical heating and cooling purposes. The figure shows the annual rate of per-capita electricity consumption and per-capita gross domestic production (GDP) from 2000 to 2018 in Nepal. Vertical bars show the per-capita electricity consumption and the line graph shows the GDP. Both values grew steadily during that period, and per-capita electricity consumption increased from 63 kWh/y in 2000 to 238 kWh/y in 2018; however, this per-capita electricity consumption remains the lowest among contemporary global societies. These data imply that per-capita electricity consumption substantially increase over the next decade, increasing the country's electricity demand. A recent study carried out by using energy modelling predicted that the per-capita electricity consumption of Nepal will increase to 496 kWh in 2025 and 1070 kWh in 2030. The electricity demand forecast report also predicted similar increasing trends of future electricity demand.

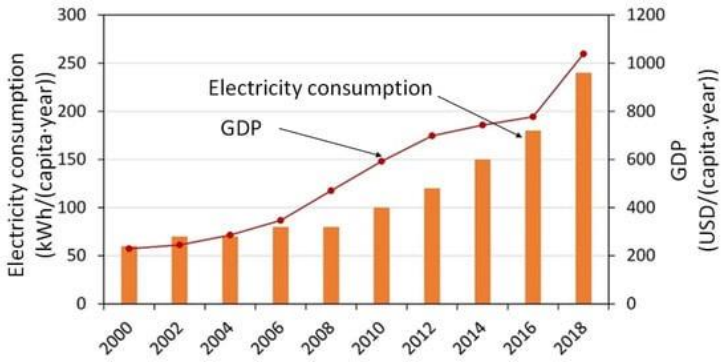

Figure 01: Per-capita electricity consumption trends from 2000 to 2021

The table presents the per-capita energy consumption of some neighbouring countries and the global average. This shows that Nepal consumes marginally less per-capita electricity than other developed and developing countries. Several reasons are associated with the low per-capita electricity consumption in Nepal. First, Nepal relies heavily on locally available traditional energy sources, such as firewood and agricultural residues, which represent 78% of the total energy consumption in Nepal. Second, low-income levels and high electricity prices also impact poor people who cannot fully use electricity for cooking and space heating upon gaining access to electricity. The cost of electricity was 0.90 USD/kWh for end-users in 2018, which is among the highest in the world. Such a high price for electricity and low-income levels may also minimize per-capita electricity consumption. Third, the electricity crisis in Nepal disrupts the daily lives of individuals and businesses through frequent power outages. As a result, residents must face 12–14 h of load shedding daily, especially during winter.

3.2. Trends in Electricity Consumption for sustainable Development in Nepal

Hydropower has been considered one of the sources of clean electricity because it does not emit polluting materials into the air or onto land. Nepal is characterized by significant hydropower resources, where more than 6000 perennial rivers and rivulets flow with an average annual water runoff of 225 billion m3, providing a substantial energy potential. Previous studies have estimated that the feasible potential of Nepal for hydropower generation is approximately 83 GW, of which approximately 43 GW are considered technically and economically viable. It shows the installed hydroelectricity capacity in Nepal from 1995 to 2019 by the NEA and the private sector. This shows that the growth in the installation capacity of hydroelectricity began to occur visibly from 1997 to 2002, and is characterized by a continuously increasing trend. The first hydropower development policy was announced in 1992 to attract the private sector for hydropower development. The private sector started to develop hydropower projects shortly after that. During 2000 and 2001, the private sector completed large projects, such as Khimti Khola (60 MW) and Upper Votekoshi (45 MW)); these projects contributed to an increase in the hydroelectricity installation capacity. In 2002, the NEA also completed the 144 MW Kaligandaki hydropower project, which played a significant role in partially fulfilling the electricity demand.

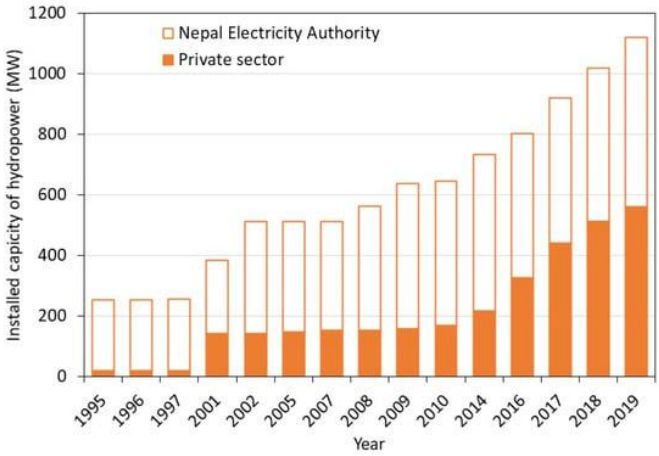

Figure 02: Installed capacity of hydroelectricity in Nepal from 1995 to 2019.

During the political unrest, investors were unwilling to take risks for hydropower development; from 2001 to 2010, the private sector could not develop hydropower projects. After 10 years of civil war, a peace agreement was signed in 2006, and the political environment became stable, allowing hydroelectricity development. In recent years, Nepal's rapidly increasing trend of hydroelectricity production shows that the energy situation has changed to an optimistic attitude toward clean resources; however, replacing traditional fuels for cooking and heating is challenging. The transition toward modern, clean energy sources can improve the future of Nepalese citizens in various ways. For example, using electricity for cooking and heating, instead of traditional fuels, can benefit millions of people regarding respiratory health risks caused by indoor air pollution. There must be improvements to the current state of low per-capita electricity consumption and the high dependency on traditional fuels for cooking and space heating. The Nepalese government must implement policies to enhance electricity use in all households for cooking and heating by providing subsidies to adopt new and clean technologies. They must simultaneously promote clean and renewable energy development in the country. As the installed capacity of hydroelectricity grows slowly and then accelerates rapidly, this study carried out exponential regression analysis on the installed capacity of hydroelectricity and time (year of establishment). Therefore, it combined the installed hydroelectricity capacity yearly and obtained 28 plots. The result showed a positive correlation ($r = 0.73$, $p < 0.001$) between installed capacity and time. The regression line showed the continuously increasing trend of hydroelectricity capacity in Nepal. It speculate that, in the coming years, hydroelectricity will fulfil a significant amount of the country's electricity demand. However, it is still below the current electricity demand, which is being fulfilled by importing electricity from India.

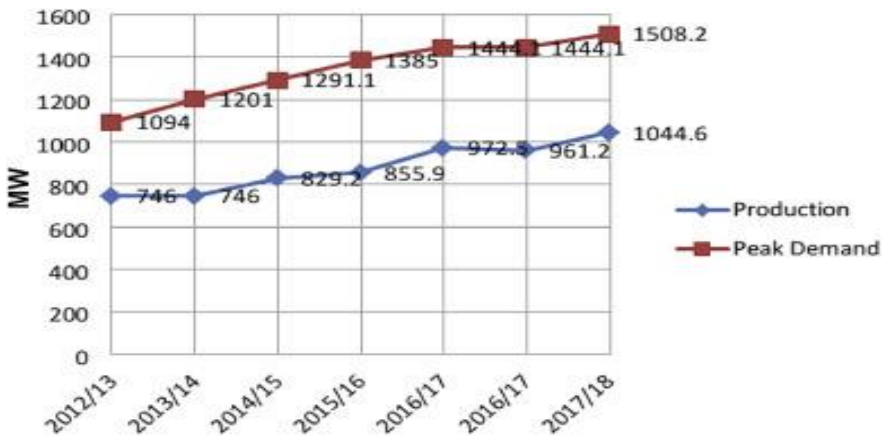

Figure 03: Hydropower development trends from 2012 to 2018; (a) number and capacity of individual hydropower plants developed by NEA and private sector and (b) total annual installed capacity of hydroelectricity in Nepal.

Total electricity consumption in 2021/22 was 6422 GWh, a slight increase over the corresponding value of 6303 GWh in 2018/19, of which 22% was imported from India. It suggested that the current electricity production is still too low to meet the energy demand of the people in Nepal. Therefore, energy policy should encourage hydropower development to get clean Energy and reduce the country's financial burden of importing electricity and other fuels.

3.3 Discussion

The empirical result found that export diversification had been almost steady during the study period in East Asian economies. Trade in the observed countries concentrated on manufacturing products [12]. Exchange rates and tariff rates had significant negative impact on specialization and GDP of the exporting country was found positively related with specialization of that economy [13]. It concluded that greater economic integration in East Asian economies leads to export diversification. The study used a fixed effect panel data model for the period 2000-2008 for eight countries and SITC Rev.3, 2-digit level data. Herfindahl index was used as the dependent variable [14]. Financial development (domestic credit) and exchange rate variables (exchange rate volume and overvaluation) did not affect export concentration [15]. Regarding human capital, the result was robust across indicators and specifications that higher schooling helps to diversify exports. It examined the causal relation between trade variables and energy consumption in Taiwan [16]. They showed causality from Energy to total imports, total exports, export value of the industrial sector and heavy-chemical industrial products export value [17]. The study found negative environmental implications of India's energy-intensive industrial clusters (brick-making SMEs) [18]. The per capita real GDP, price of substitute, real price of electricity, population, air temperature, financial development variables, industrial development, capital stock, and efficiency variables are identified as the determinants of energy consumption [19]. They stated that the three policy methods, increased energy efficiency, increased use of renewable resources for generating electricity, and creation of a market for carbon credits, were used by the EU to reduce CO2 emissions. They suggested using the same policy as the U.S. [20]. The Vector Autoregressive (VAR) model investigates the causality between export diversification and economic growth in Cameroon. Using data from 1980-2012, the paper revealed that export diversification has positively and significantly affected economic growth in Cameroon [21]. The study suggested continuing to implement trade liberalization policies, showing the reduction in energy intensity in Cameroon, Cote d'Ivoire and Togo due to increased imports [22]. Electricity is one of the five biggest obstacles realized by managers of firms in 119 developing countries [23]. The study applied probit model and was based on the enterprise survey data of World Bank. Fernando and Hor found energy management practices at the infant stage in ISO 14000-certified

firms in Malaysia [24]. They also highlighted energy audit and energy efficiency as the critical factors for reducing carbon emissions. Similarly, energy awareness, knowledge and commitment were linked to energy efficiency. The study in rural Ghana showed the productivity of solar energy feasibility as a major driver of energy efficiency [25]. To measure export diversification, the Herfindahl-Hirschman Index (HHI) was used for the period covering 1972 to 2015, and co-integration was observed using the 17 ARDL approach. The nature of the long-run relationship was estimated through Dynamic. The study used an analysis hierarchy process (AHP) multi-criteria decision-making tool for critically analyzing energy policies and strategies [26]. The study found household socioeconomic characteristics like household size, primary employment status, annual gross household income, and household composition/type to be more important determinants of energy consumption (gas consumption) than dwelling characteristics in the UK [27]. Several factors for energy-efficient practices have been identified. They found that the investment and legislation cost factors must be considered first while changing energy policies [28]. A study found that green gas emissions, gross domestic product, population and labour growth positively correlate with primary and final energy consumption. Using the Autoregressive Distributed Lag (ARDL) technique, the study showed a positive but 18 insignificant relationship between export diversification and economic growth. The dominance of the oil sector was the major cause behind such an insignificant relationship [29].

9. CONCLUSION

The Government of Nepal has set a goal to increase the share of renewable energy from less than 1% to 10% and further improve access to electricity from alternative sources, from 10 to 30%, within the next 20 years. The findings showed a significant long run relationship of product export diversification and GDP growth but the geographical export diversification had an insignificant relationship. The study included three variables, human capital, terms of trade and domestic credit to the manufacturing sector as the determinants of export diversification. According to the Energy Progress Report 2019, 1.3 million people have no access to electricity, and Nepal has targeted to achieve 100% electricity for all by 2030 (Nepal Electricity Authority, 2021. Hence, the PV system would be a game-changer and help achieve such targets. This study indicated that an energy transition is taking place in Nepal towards clean energy resources, particularly in providing more of its citizens with electricity access, boosting renewable energy services, and taking steps to utilize clean energy resources. However, it is still insufficient to ensure affordable, reliable, and sustainable modern energy resources for everyone by 2030. For example, many households in Nepal still rely on traditional cooking fuels and use very low electricity per-capita. Moreover, 68% of total energy consumption was still attributed to traditional sources. Thus, the government should focus on long-term energy planning to maximize hydro-electricity production and solar energy consumption to fulfil the modern lifestyle of people.

REFERENCES

[1] Neupane, D., Kafle, S., Karki, K. R., Kim, D. H., & Pradhan, P. (2022). Solar and wind energy potential assessment at provincial level in Nepal: Geospatial and economic analysis. Renewable Energy, pp. 181, 278–291.

[2] Timson Kam Tim Sher & Markus Patrick Chan (2024). Insurance as the First step in Financial Planning: A Review on Developing World. Dinkum Journal of Economics and Managerial Innovations, 3(01):65-71.

[3] Sedai, A., Singh, G., Dhakal, R., Khatiwada, A., Khanal, K., Kumal, B., ... & Mishra, A. K. (2021, November). Technical and economic feasibility of a fully solar-powered airport in Nepal. In 2021 IEEE International Conference on Intelligent Systems, Smart and Green Technologies (ICISSGT) (pp. 122-127). IEEE.

[4] Thapa, L., Durrast, H., Gyawali, S., & Techato, K. (2022). A review on solar Energy photovoltaic (PV) system potential and challenges in Nepal. Available at SSRN 4282393.

[5] Asmit Raj Pandey (2024). Determinants of Foreign Direct Investment (FDI) in Nepal: Analysis of macroeconomic and institutional factors. Dinkum Journal of Economics and Managerial Innovations, 3(01):45-53.

[6] Lohani, S. P., Gurung, P., Gautam, B., Kafle, U., Fulford, D., & Jeuland, M. (2023). Current status, prospects, and implications of renewable Energy for achieving sustainable development goals in Nepal. Sustainable Development, 31(1), 572-585.

[7] Rajkarnikar, N., Cheng, J., Tao, H., Ye, J., van Ree, T., & Wu, Y. (2021, February). Prospects and challenges of renewable Energy: A case study of Nepal. In 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT) (pp. 1-8). IEEE.
[8] Poudel, P., Bae, S. H., & Jang, B. (2022). Designing Study on Techno-Economic Assessment of Solar Photovoltaic Mini-Grid Project in Nepal. Journal of the Chosun Natural Science, 15(2), 89-97.
[9] Karna, S. K., & Singh, R. (2021). A framework for assessing the viability of solar PV in province-2 of nepal using system dynamics approach. In Advances in Systems Engineering: Select Proceedings of NSC 2019 (pp. 827-836). Springer Singapore.
[10] Al-Moontasir Shifat, Hyunsu Agnihotri, Ming Chen and Yasir Rafique (2023). Reforming data into decisions: investigating the integrated paradigm of business intelligence (B.I.). Dinkum Journal of Economics and Managerial Innovations, 2(08):490-496.
[11] Lohani, S. P., Gurung, P., Gautam, B., Kafle, U., Fulford, D., & Jeuland, M. (2023). Current status, prospects, and implications of renewable Energy for achieving sustainable development goals in Nepal. Sustainable Development, 31(1), 572-585.
[12] Bhandari, S. Financial Feasibility of Solar Energy for Household Consumption and Its Impact.
[13] Bhattarai, U., Maraseni, T., Apan, A., & Devkota, L. P. (2023). Rationalizing donations and subsidies: Energy ecosystem development for sustainable renewable energy transition in Nepal. Energy Policy, 177, 113570.
[14] Mostafizur Rahman Mustafa, Shahir Ahmmed (2023). Critical reflection to broaden the conversation about generating employment across entrepreneurship in South Africa. Dinkum Journal of Economics and Managerial Innovations, 2(07):406-415.
[15] Suriana Saleh and Md Ibrahim (2023). A review on impact of financial knowledge management on organizational financial performance along with leadership and development training. Dinkum Journal of Economics and Managerial Innovations, 2(06):397-405.
[16] Pant, A. Feasibility of Commercial Green Hydrogen Production in Nepal: A Comprehensive Analysis of Economic and Technological Viability. Available at SSRN 4499257.
[17] Cheng, S., Lohani, S. P., Rajbhandari, U. S., Shrestha, P., Shrees, S., Bhandari, R., & Jeuland, M. (2024). Sustainability of large-scale commercial biogas plants in Nepal. Journal of Cleaner Production, 434, 139777.
[18] Subedi, N. (2023). Suitability and Techno-Economic Feasibility of Hybrid—Solar and Wind—Power Plant in Nepal (Doctoral dissertation, IOE Pulchowk Campus).
[19] Ghimire, R., Niroula, S., Pandey, B., Subedi, A., & Thapa, B. S. (2024). Techno-economic assessment of fuel cell-based power backup system as an alternative to diesel generators in Nepal: A case study for hospital applications. International Journal of Hydrogen Energy, 56, 289-301.
[20] Bilal Ahmad Sheikh, Ferooq Ahmad, & Amna Qureshi (2023). Net-value management of bank financial products: a review of management strategies. Dinkum Journal of Economics and Managerial Innovations, 2(02):93-99.
[21] Cheng, S., Lohani, S. P., Rajbhandari, U. S., Shrestha, P., Shrees, S., Bhandari, R., & Jeuland, M. (2024). Sustainability of large-scale commercial biogas plants in Nepal. Journal of Cleaner Production, 434, 139777.
[22] Bhusal, S., Dangol, M., Bhatta, M., Maraseni, T., & Mathew, S. (2024). Pathways towards net zero: Assessment of enablers and barriers in Nepal. Research in Globalization, p. 8, 100226.
[23] Zhao, C., Dong, K., Wang, K., & Nepal, R. (2024). How does artificial intelligence promote renewable energy development? The role of climate finance. Energy Economics, p. 133, 107493.
[24] Adhikari, D. R., Techato, K., & Jariyaboon, R. (2024). A systematic literature review on renewable energy technologies for energy sustainability in Nepal: Key challenges and opportunities. International Journal of Renewable Energy Development, 13(2), 206-222.
[25] Ghimire, B., Muneenam, U., & Techato, K. (2024). Preference for renewal energy by operators of tourist standard hotels in Kathmandu, Nepal. International Journal of Energy Economics and Policy, 14(2), 277–286.
[26] Best, R., Nibedita, B., & Nepal, R. (2024). Energy transitions across household distributions in northern India. Economic Analysis and Policy.

[27] Mishra, U., Rathnasiri, M. S. H., & Dewasiri, N. J. (2024). Net-Zero Economy and Energy Sustainability: A Nepalese Perspective. In Net Zero Economy, Corporate Social Responsibility and Sustainable Value Creation: Exploring Strategies, Drivers, and Challenges (pp. 145-161). Cham: Springer Nature Switzerland.

[28] Bhattarai, U., Maraseni, T., Devkota, L. P., & Apan, A. (2024). Evaluating four decades of energy policy evolution for sustainable development of a South Asian country—Nepal: A comprehensive review. Sustainable Development.

[29] Mostafa, N. A., & Aboelezz, A. (2024). Feasibility-sustainability study of power generation using solar Energy at an industrial site: a case study from Egypt. Energy, Sustainability and Society, 14(1), 36.

