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Use of Green Supply Chain Management Principles in Household level in Nepal

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Abstract

Background: Environmental sustainability has emerged as a major global issue, triggered by industrialization and environmental pollution. Green Supply Chain Management (GSCM), which combines environmentally responsible practices in supply chain operations, has been identified as an important approach to counter environmental issues. Although GSCM has been widely researched in industrial settings, the use of GSCM principles in household settings has not been adequately investigated, especially in developing nations such as Nepal, where conventional energy sources and transportation practices create major environmental and health issues.

Objectives: The objectives of this research were to examine the use of GSCM principles in household settings in Nepal, specifically in terms of energy usage for cooking and lighting, as well as transportation trends.

Methods: The research design used in the study was quantitative, relying on secondary data analysis. Time series data ranging from 2012/13 to 2022/23 were sourced from various public sources in Nepal, including the National Population and Housing Census (2021), the Economic Survey, and Nepal Oil Corporation publications. The study aimed to analyze trends in household energy consumption (firewood, LPG, electricity, etc.), lighting types, vehicle registration, petroleum products, etc.

Findings: The results show a substantial dependence on conventional biomass fuels, with 51% of households and 75% in the rural areas using firewood for cooking. Although access to electricity for lighting is high (92.2%), there are regional inequalities. The transportation sector indicates a sharp rise in the number of vehicles, especially motorcycles, although there is a positive development in the use of electric vehicles such as e-rickshaws and safa tempos. The use of petroleum products, particularly petrol and diesel, has increased substantially, leading to air pollution. The use of cleaner fuels such as LPG and electricity for cooking has had limited success in the rural areas.

Conclusion: The research reveals an existing gap in the practical application of GSCM strategies, such as the use of cleaner inputs, energy efficiency, and minimizing waste and emissions, at the household level in Nepal. The ongoing dependence on polluting energy sources, coupled with an increasing trend of conventional vehicles, reveals an alarming situation of environmental and health hazards. Nevertheless, the increasing use of renewable energy sources for lighting and electric vehicles offers an opportunity for sustainable development.

Novelty: This research is novel in its approach as it attempts to break away from the conventional GSCM discourse, which is mainly centered around industries and businesses. This research offers a comprehensive analysis of household energy and transportation trends in Nepal, covering a decade, from a GSCM perspective.

Keywords: Energy, Household, Green Supply Chain Management (GSCM), Nepal, Sustainability

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1. Introduction

Environmental sustainability is a growing concern of world because of the increasing environmental pollution due to industrialization, modernization, and globalization. Globalization and industrialization, which are both on the rise, have accelerated the need for green and sustainable logistics (G&SL). G&SL projects have sparked discussions on a global scale over the past few decades to reduce negative transport externalities and enhance supply chain performance (Ren, Hu, Dong, Sun, Chen, & Chen, 2019). Nowadays, the concept of environmental sustainability comes along with the concept of supply chain management. The different dynamics of SCM have thus influenced researchers, policymakers, and activists to know the conceptual framework of sustainable supply chain practices. And, among different dynamics, green supply chain management (GSCM) is the emerging concept both in developing and developed economies. The worsening environmental conditions, such as the overuse of raw materials, spilling of waste places, and increasing contamination levels, are mostly to blame for the growing importance of GSCM (Srivastava, 2007).

The term "green supply chain management" refers to the integration of environmentally friendly methods throughout the entire supply chain, from the procurement of raw materials to the production, distribution, and product disposal. The main objective of GSCM is to increase overall efficiency, cost-effectiveness, and sustainability while reducing the environmental impact and resource consumption related to supply chain activities (Ananda, Astuty, & Nugroho, 2018). To create a sustainable supply chain, green supply chain management must use environment friendly inputs and turn those inputs into outputs that may be recycled and reused at the end of their life cycles (Dube & Gawande, 2011). The primary objective of GSCM is to decrease adverse environmental influences like air and water contamination as much as possible and to increase the ability to manage resource waste, including that of energy, materials, and goods (Eltayeb, Zailani, & Ramayah, 2011). GSCM makes sure that public and corporate policies are successful in encouraging environmental responsibility, expanding market share, strengthening brand awareness, and increasing profitability (Herrmann, Barbosa-Povoa, Butturi, Marinelli, & Sellitto, 2021). Green Supply Chain Management (GSCM) involves managing the supply chain to reduce negative environmental impacts and enhance sustainability through measures such as energy and water conservation, waste reduction, and the use of renewable materials. This practice also extends to assessing the environmental practices of suppliers and customers (Kumar & Rao, 2023).

Individual household is responsible to save the environment by considering their day to day activities. So, Green Supply Chain Management (GSCM) principles can be applied at the household level to reduce environmental impact, conserve resources, and promote sustainability in everyday activities. There are some practical ways to practice GSCM at the household level like implementation of the "3 Rs" mantra (Reduce, Reuse, Recycle) by reducing waste generation, reusing items when possible, and recycling materials like paper,

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glass, plastics, and aluminum. Proper waste disposal and recycling contribute to reducing the demand for new resources and minimizing landfill waste. Households may consider the energy efficiency by using energy-efficient appliances, LED lighting, smart thermostats, renewable energy for cocking. Daily household activities may significantly contribute in the surrounding environment. People are adopting green energy, also known as renewable energy that is generated from natural resources that are continuously replenished and have a minimal impact on the environment when compared to traditional fossil fuels like coal, oil, and natural gas. Green energy sources are considered sustainable because they do not deplete finite resources and produce significantly fewer greenhouse gas emissions, making them an essential component of efforts to combat climate change and reduce environmental pollution.

The World Health Organization (WHO) defines air pollution as the introduction of chemical, physical, or biological agents into the indoor or outdoor environment, leading to alterations in its natural characteristics. Common sources of air pollution encompass household combustion devices, motor vehicles, industrial facilities, and wildfires (World Health Organization (WHO), 2017). Air pollution constitutes a complex blend of numerous components, primarily comprising airborne Particulate Matter (PM) and gaseous pollutants such as ozone (O3), nitrogen dioxide (NO2), volatile organic compounds (e.g., benzene), carbon monoxide (CO), sulfur dioxide (SO2), and more (Newby, Mannucci, & al., 2015). Electric Vehicles (EVs) are regarded as a green transportation solution (Chan C. , 2002). So EV is called a green car also. A green car is an environmentally well-disposed vehicle, for it has low harmful emissions and it is eco-friendly. Four kinds of green cars are accessible in the market, including crossbreed vehicles, solar vehicles, electric vehicles, and hydrogen vehicles (Joshi & Rao, 2013). Electric vehicle is important to lower greenhouse gas emissions and mitigate climate change. It is regarded that petroleum-based vehicles produce around one-third of carbon dioxide gas. In Nepal, Kathmandu city is also known as one of the most polluted capitals in the world (Saud & Paudel, 2018).

This issue of green energy is particularly severe in developing nations across Asia, where 65% of the global population, totaling 1.7 billion individuals, lack access to clean fuels (International Energy Agency, 2019). Nepal's energy consumption profile reflects this prevalence of traditional fuels, constituting 68.6% of the country's energy consumption in 2018–19 (MoF, 2019). Within this context, the residential sector, encompassing activities such as space heating, cooking, and lighting, accounted for 42.6% of the total energy consumption in 2018–19, with 69% of the population relying on solid biomass for cooking (MoF, 2019). Efforts to diminish this dependence include the deployment of improved cooking stoves (ICS), LPG, and biogas technologies, while electricity and solar cooking technologies remain relatively underutilized (AEPC, 2019).

One study conducted in Lamjung district of Nepal shows that 38% of the households surveyed had adopted biogas and LPG as alternative energy sources. Notably, the utilization of these

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alternative energy sources was significantly correlated ($\chi 2 = 45.6934$, p value = 0.0001) with the economic well-being of the households. Specifically, 82% of well-off households, 26% of medium-income households, 24% of poor households, and none of the very poor households had chosen to use biogas or LPG as an alternative energy source. Additionally, 20% of the interviewees mentioned that they had started using insecticides, pesticides, and fungicides more frequently on their crops (Gentle et al. 2018). Nepal exhibits low per-capita energy usage, with a significant portion of its rural populace relying primarily on firewood as their energy source. The overuse of firewood in poorly ventilated dwellings has detrimental effects on indoor air quality and the health of residents. This research seeks to evaluate how hourly patterns of firewood consumption impact CO2 emissions and resultant concentrations within rural households in Nepal.

The findings indicate that most households tend to consume more firewood during the morning and evening hours. Factors such as family size and the number of animals kept by the households displayed a positive correlation with firewood consumption, while family size exhibited a negative correlation with per-capita firewood consumption. The per-capita firewood consumption rate was measured at 1.8 kg per capita per day. Household firewood consumption amounted to 12 kg per family per day, resulting in CO2 emissions of 14.26 kg CO2 equivalent per household per day. Interestingly, larger households spent more time on cooking, although their consumption rate (1.3 kg per hour) resembled that of smaller households. The heightened indoor CO2 emissions during the morning and evening hours, stemming from increased firewood use, can pose significant health hazards to the residents (Pokharel & Rijal, 2020). The practice of using firewood is gradually improving in the urban areas. The census report of Nepal (2021) shows that still 51% household of Nepal are using firewood for cocking, among them 75% are from the rural areas. It can negatively affect the environment and contribute to climate change. So, such practices should be controlled by providing alternative energy sources.

Clean cooking energy plays a crucial role in achieving climate mitigation objectives and various development goals, particularly in enhancing the well-being of women and children. The inefficient combustion of solid biomass for cooking contributes to household air pollution with adverse health effects and strains forest resources. This paper offers an overview of Nepal's household-cooking-energy transition thus far. Despite government and other stakeholders' concerted efforts to expedite this transition, data from 2000 to 2018 reveal that approximately 69% of households nationwide still rely on solid fuels for cooking today, with rural areas showing an even higher reliance, exceeding 80%. Alarmingly, if the current pace of change persists, the prevalence of solid-fuel usage is expected to remain high even in 2030, impeding the achievement of Sustainable Development Goal (SDG) 7. Access, demographics, and socioeconomic factors significantly limit cooking-fuel choices. Consequently, this paper urgently recommends the implementation of evidence-based and integrated policies and

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strategies to facilitate a more efficient and rapid transition towards clean energy, a vital component in realizing SDG 7 (Paudel, Jeuland, & Lohani, 2021).

Air quality in Nepal, particularly in its urban centers, is deteriorating at an alarming rate, leading to severe health consequences. In 2019, air pollution, including both ambient and indoor pollutants, was responsible for a staggering 42,100 deaths in the country (State of Global Air, 2020). During the fiscal year 2021/22 (BS 2078/79), health facilities (HFs) and Primary Health Care Outreach Centers (PHC/ORCs) recorded a total of 702,504 cases of acute respiratory infections (ARIs). Among these cases, 13.3% were classified as pneumonia cases, and 0.18% was identified as severe pneumonia cases. In children under the age of five, the national incidence rate of pneumonia, which includes both pneumonia and severe pneumonia cases, was 55.1 cases per 1000. This represents an increase of more than 10% compared to the previous fiscal year (DoHS, 2022). These concerning trends are further underscored by daily measurements, which consistently rank Kathmandu as one of the top 10 most polluted cities in recent years. Urgent and comprehensive measures are imperative to combat this critical environmental and public health challenge in Nepal (Paudel, Jeuland, & Lohani, 2021). Governments, businesses, and individuals around the world are increasingly investing in and adopting green energy solutions as a means to reduce their carbon footprint and transition toward a more sustainable and environmentally responsible energy system. In this regard, Nepal, like many other countries, has been increasingly recognizing the importance of sustainable practices due to environmental concerns and global efforts to address climate change. There are some challenges to implementing GSCM practices, like limited resources, infrastructure, and technology. Financial constraints and a lack of expertise might also play a role in the slower adoption of GSCM principles in household level. Though people are becoming conscious about their surrounding environment and climate change impact in their day-to-day life, they are doing their best to practice climate change adaptation practice from household level. There is a research gap in household level, so the study analyzed the secondary data to explore the use of GSCM principles in household level for environmental sustainability.

2. Research questions

The study reviewed the many related literatures of GSCM, but it was found that more study was done in industrial sectors or institutional practice of GSCM; very few studies were done in household level. In the Nepalese context, the study of GSCM is very limited, so there is a research gap in household level. Considering this gap, the main research question is, ‘How do Nepalese households use GSCM principles in the use of energy?’

2. Objective of this study

The main objective of this study is to identify the use of green supply chain management (GSCM) principles in household level by analyzing the secondary data.

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3. Methodology

3.1 Research Design

The study is based on the quantitative design because it has collected the secondary time series data and did the trend analysis.

3.2 Data sources and collection process

The study was based on the analysis of secondary data published by Nepal government. It has collected the household-level data published from the Census report 2021, the Economic Survey 2079/80 (2022/23), and the report of the National Oil Cooperation. The study used an online search engine to search the data. Basically, the webpage of the concerned organizations was used to collect the data. The Census data is published online in a dedicated online system of the National Statistics Office. As well as the data of the Economic Survey is published by the Ministry of Finance, and the use of petroleum products from Nepal Oil Corporation Limited. Basically, the last 10 years of data (from 2012/13 to 2022/23) were collected and analyzed. The study reviewed the various related literature and policies documents to know the use of green supply chain management principles in household levels and business.

3.3 Data analysis

The study analyzed the data related to the use of different types of energy for cooking and lighting, as well as number of transportation and use of petroleum oils. The statistical analysis was done from the Excel. Basically, descriptive analysis was done to know the increasing trend in use of energy in household level and other purposes. The analysis was focused to link the use of energy with environmental impact.

3.4 Ethical Considerations

The study used the online public data which were already published and accessible for the all people. This is the regular publication of Nepal government so this study will not violate the privacy and confidentiality of government data. This study had not manipulated any original data. It had only filtered the data as required for this study and only analyzes the trend of use of energy in last 10 years. Researcher is fully aware about the ethical consideration of research and use and analysis of secondary data.

3.5 Limitations of this study

The study has the following limitations:

- It has only focused on the use of energy (firewood, agricultural residues, LPG, Electricity, Cow dung, Bio-gas, Kerosene, coal, and other renewable energy) from the secondary sources ranging from 2012/13 to 2022/23 in household purpose and others.
- The study has analyzed the increasing trend in the use of energy, import of transportation, and use of petroleum oils.
- It has analyzed the use of green supply chain management principles in energy and transportation sectors and its impact on environment and public health in Nepalese context.

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4. Findings and Discussion

4.1 Number of households by type of fuel usually used for cooking

This section provides data on the various types of fuel used for household energy needs. The types of fuel included are Wood/Firewood, Liquefied Petroleum Gas (LPG), Electricity, Cow Dung, Biogas, Kerosene, and Other (unspecified).

The data presented in Table 1 shows that 51% households were using wood/firewood for cooking in Nepal. From the urban and rural perspective, higher numbers (75%) household of rural households were using firewood compared to 39.3% of urban households. It clearly indicates the status of energy used in rural areas of Nepal. The higher number of use of firewood significantly contributes in the negative impact on environment and health. As we see the data of LPG, higher number of urban people (56.7%) were using whereas only 18.9% households were using LPG in rural areas. There is an increased dependency on imported LPG for cooking in urban areas. The cost of LPG is not affordable for all as well as it is not accessible in the all areas of Nepal; basically in rural areas. Nepal government is promoting the use of electricity for cooking; especially induction stove to reduce the burden of LPG as well as to save the environment but the use of electricity is less than 1% (only 0.5% HHs) in Nepal.

Nepal's Biomass Energy Strategy 2017 aims to increase the access to biomass energy and hence contributing to the environment conservation by transforming traditional biomass energy use into modern, sustainable and clean energy. It had target to make indoor air pollution free Nepal by 2022 through the promotion of clean cooking technologies in all households; and by 2030, to ensure the availability of modern clean energy in all the households using solid biomass (Ministry of Population and Environment, 2017). But still there are challenges to access on improved cooking technologies in rural areas. Still people are using the firewood and cow dung with traditional stove. The use of cow dung is still high (5.8% HHs) in Tarai belt due to lack of access on firewood and other means of energy.

Table 1: Number of households by type of fuel usually used for cooking, NPHC 2021

Area	Total HHs	Type of fuel						
		Wood/ firewood	Liquefied Petroleum gas	Electricity	Cow dung	Bio gas	Kerosene	Other
Nepal	**6660841**	**3398316**	**2949995**	**32574**	**191531**	**78406**	**3297**	**6722**
%	100.0	51.0	44.3	0.5	2.9	1.2	0.0	0.1
Urban/Rural								
Urban Municipalities	4474699	1759331	2536623	24724	93262	54435	1849	4475
%	100.0	39.3	56.7	0.6	2.1	1.2	0.0	0.1
Rural Municipalities	2186142	1638985	413372	7850	98269	23971	1448	2247
%	100.0	75.0	18.9	0.4	4.5	1.1	0.1	0.1

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Area	Total HHs	Type of fuel						
		Wood/ firewood	Liquefied Petroleum gas	Electricity	Cow dung	Bio gas	Kerosene	Other
Ecological Belt								
Mountain	409260	349746	55411	709	558	2141	497	198
%	100.0	85.5	13.5	0.2	0.1	0.5	0.1	0.0
Hill	2945030	1528000	1387213	10701	364	15615	1991	1146
%	100.0	51.9	47.1	0.4	0.0	0.5	0.1	0.0
Tarai	3306551	1520570	1507371	21164	190609	60650	809	5378
%	100.0	46.0	45.6	0.6	5.8	1.8	0.0	0.2
Province								
Koshi	1190755	635672	490297	6177	40207	15682	468	2252
%	100.0	53.4	41.2	0.5	3.4	1.3	0.0	0.2
Madhesh	1156383	677732	331992	9468	126273	8252	303	2363
%	100.0	58.6	28.7	0.8	10.9	0.7	0.0	0.2
Bagmati	1567917	453987	1094195	8887	185	9342	755	566
%	100.0	29.0	69.8	0.6	0.0	0.6	0.0	0.0
Gandaki	661632	311925	341017	1390	225	6548	315	212
%	100.0	47.1	51.5	0.2	0.0	1.0	0.0	0.0
Lumbini	1141345	612698	481748	4692	23686	17230	574	717
%	100.0	53.7	42.2	0.4	2.1	1.5	0.1	0.1
Karnali	366037	300962	61727	353	510	1623	648	214
%	100.0	82.2	16.9	0.1	0.1	0.4	0.2	0.1
Sudur Paschim	576772	405340	149019	1607	445	19729	234	398
%	100.0	70.3	25.8	0.3	0.1	3.4	0.0	0.1

Source: Census Report of Nepal 2021

In comparison of provinces, the use of firewood for cooking is higher in Karnali province (82.2%) followed by Suder Paschim province (70.3%), Madhesh (58.6%), Lumbini (53.7%), Koshi (53.4%), Gandaki (47.1%), and Bagmati province (29%). The use of LPG is lower in Karnali province (16.9%) than the other provinces which indicate the low economic status of Karnali province. Use of electricity is less than 1% in all provinces which indicates that the effort of promoting the induction stove by Nepal government is still back. The utilization of traditional cooking stoves in Nepal consumes excessive firewood, the emission of harmful smoke, and time-consuming cooking processes, often burdening women. To address this issue, the Government of Nepal, in collaboration with AEPC, has prioritized the advancement and wider adoption of clean energy technologies such as improved cooking stoves (ICS), biogas, and solar cookers/dryers. However, the adoption of these practices remains limited in Nepal. Studies conducted by AEPC in 2009 and 2010 indicated that the adoption of improved cooking stoves (ICS) led to a 62% reduction in indoor air pollution. Furthermore, there was an average 43% decrease in firewood consumption, accompanied by a notable reduction in the amount of time women spent in the kitchen when ICS were used in rural areas.

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4.2 Use of Energy in household and business

In connection with the above Table 1, the next Table 2 also shows the use of energy like firewood, bio-mass, cow dung, petroleum oil, electricity, and renewable energy in various field of Nepal. Nepal is agricultural country and forests occupy roughly 44% of the country's landmass. On the other hand, according to the Economic Survey 2022/23, 15.1% of Nepal's population is under the poverty line — which means these populations live below $1.90 purchasing power parity/day. Firewood is freely accessible in forest so it is cost-effective for the rural and poor people (Ministry of Finance, 2023). The accessibility of forest and poverty might encourage the people to use the firewood. A household survey conducted in Dolakha district, Nepal, across six community forest user groups, revealed that the average daily fuel wood consumption per household was approximately 8.4 kg, resulting in an annual consumption of around 3,060 kg per household. On a per capita basis, the daily fuel wood consumption was calculated to be 1.7 kg. (Kandel, Chapagain, Sharma & Vetaas, 2016).

The data presented in the table 2 is used to analyze the distribution of different types of fuels for household and business energy consumption in Nepal, providing insights of last 11 years trend analysis. The data shows the annual increasing trend of traditional source of energy like firewood, agricultural residues, and cow dung. The average increasing trend of firewood is 2.54%, agricultural residues by 10.53%, and cow dung by -6.08% from 2013 to 2022. Similarly, the annual increasing trend of petroleum oils in last 10 years shows with 11.88%, electricity is with 15.98% and renewable energy with 11.10% in Nepal. The data shows the increasing use of energy in day to day household as well as business activities. The increasing use of firewood and petroleum oil negatively effect on the environment and human health. Air pollution is one of the major effects from smokes of firewood and petroleum vehicles.

The World Health Organization (WHO) defines air pollution as the introduction of any chemical, physical, or biological agent into the indoor or outdoor environment that disrupts its natural characteristics. Common sources of air pollution include household combustion devices, motor vehicles, industrial facilities, and wildfires (World Health Organization (WHO), 2017). Air pollution is a complex mixture comprised of numerous components, with the majority being airborne Particulate Matter (PM) and gaseous pollutants such as ozone (O3), nitrogen dioxide (NO2), volatile organic compounds (e.g., benzene), carbon monoxide (CO), sulfur dioxide (SO2), and so forth (Newby, et al., 2015).

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Table 2: Use of energy in different sectors

Source	Fiscal Year											Average Trend 2013 to 23
	BS 2069/70 (2013)	BS 2070/71 (2014)	2071/72 (2015)	2072/73 (2016)	2073/74 (2017)	2074/75 (2018)	2075/76 (2019)	2076/77 (2020)	2077/78 (2021)	2078/79 (2022)	* 2079/80 (2023)	
	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	ooo ToE	000 ToE
Traditional	8017	8983	9104	9227	9319	9473	9601	9624	9901	9928	6619	9317.70
%		12.05	1.35	1.35	1.00	1.65	1.35	0.24	2.88	0.27	-33.33	2.46
Firewood	7153	8154	8264	8376	8459	8604	8720	8762	9023	8905	5936	8442.00
%		13.99	1.35	1.36	0.99	1.71	1.35	0.48	2.98	-1.31	-33.34	2.54
Agricultural residues	353	403	408	414	418	425	431	436	449	762	508	449.90
%		14.16	1.24	1.47	0.97	1.67	1.41	1.16	2.98	69.71	-33.33	10.53
Cow dung	511	426	432	438	442	444	450	427	429	262	174	426.10
%		-16.63	1.41	1.39	0.91	0.45	1.35	-5.11	0.47	-38.93	-33.59	-6.08
Business	1854	1959	2331	2248	3253	3715	4115	4488	4719	3950	1750	3263.20
%		5.66	18.99	-3.56	44.71	14.20	10.77	9.06	5.15	-16.30	-55.70	9.85
Coal	415	320	465	536	664	762	970	1046	1436	1111	425	772.50
%		-22.89	45.31	15.27	23.88	14.76	27.30	7.84	37.28	-22.63	-61.75	14.01
Petroleum oils	1182	1264	1469	1275	2088	2388	2633	2895	2658	2839	1325	2069.10
%		6.94	16.22	-13.21	63.76	14.37	10.26	9.95	-8.19	6.81	-53.33	11.88
Electricity	257	375	397	427	501	565	512	547	626	892	595	509.90
%		45.91	5.87	7.56	17.33	12.77	-9.38	6.84	14.44	42.49	-33.30	15.98
Renewable Energy	166	291	292	292	294	296	299	352	307	359	363	294.80
%		75.30	0.34	0.00	0.68	0.68	1.01	17.73	-12.78	16.94	1.11	11.10
Grand Total	10037	11233	11728	11768	12866	13484	14014	14464	14927	15129	9327	12965.00
%		11.92	4.41	0.34	9.33	4.80	3.93	3.21	3.20	1.35	-38.35	4.72

ToE: Tons of Oil Equivalent

Source: Ministry of Power, Water Resources and Irrigation 2022 *First eight month's report through Economic Survey 2079/80, Govt. of Nepal, Ministry of Finance.

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The use of firewood can negatively effect on the forest, air and environment from the flowing manner:

Deforestation: Unsustainable harvesting of firewood can lead to deforestation, which has serious environmental consequences. Deforestation reduces biodiversity, disrupts ecosystems, and contributes to soil erosion.

Air Pollution: When firewood is burned in inefficient stoves or open fires, it can release harmful pollutants into the air, including particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs). Prolonged exposure to these pollutants can have adverse health effects, particularly respiratory problems.

Indoor Air Pollution: In many developing countries, where firewood is commonly used for cooking indoors, the combustion of firewood can lead to high levels of indoor air pollution. This can result in health issues such as respiratory infections, lung disease, and eye problems, especially among women and children who spend a significant amount of time near the stove.

Habitat Destruction: Harvesting firewood can disrupt natural habitats and negatively impact wildlife. The removal of dead wood and standing trees for firewood can reduce habitat availability for various species.

4.3 Number of households by usual source of lighting

Table 3 presents data on the sources of lighting in households in Nepal, categorized by various factors such as urban/rural areas, ecological belts, and provinces. The findings show that there are a total of 6,660,841 households (HHs) in Nepal, among them, the majority of households (92.2%) use electricity as their source of lighting. Similarly, solar lighting is used in 6.6% of households, while kerosene is the source for 0.6% of households. A very small percentage of households use biogas (0.0%) or other sources (0.6%) for lighting.

The data also shows the Urban/Rural Distribution of the source of lighting. As this table 2, in urban municipalities, a higher percentage of households (95.7%) use electricity for lighting, followed by solar lighting, which is used by 3.4% of urban households, while kerosene is used by 0.5%. Similarly, in rural municipalities, the use of electricity is lower (85.0%), with a higher reliance on kerosene (13.1%) and solar lighting (1.0%).

Other types of presentation of data are based on the ecological belt distribution. In the mountainous regions, a smaller percentage of households (78.4%) have access to electricity, and kerosene lighting is more common (19.9%). Similarly, in the hill regions, 88.9% of households have access to electricity, with a smaller reliance on kerosene (10.1%). The geographical belt is the Tarai region, which has the highest electricity usage (96.8%), with minimal reliance on kerosene (1.9%).

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Nepal is divided into seven provinces, so the data is also distributed based on these provinces. According to the data of the Census study 2021, the Koshi province has a relatively high usage of electricity (93.7%) and some reliance on kerosene (5.0%). The Madhesh province has the highest electricity usage (97.9%) among all provinces, whereas the Karnali province has the lowest percentage of households with electricity (49.6%), with a significant reliance on kerosene (47.9%). Sudur Paschim province also has a relatively low percentage of households with electricity (81.3%), with a significant percentage using solar lighting (16.3%).

Table 3: Number of households by usual source of lighting, NPHC 2021

Area	Total HHs	Usual source of lighting				
		Electricity	Solar	Kerosene	Bio gas	Other
Nepal	**6660841**	**6139141**	**439282**	**38907**	**2032**	**41479**
%	100.0	92.2	6.6	0.6	0.0	0.6
Urban/Rural						
Urban Municipalities	4474699	4280136	153974	20440	1051	19098
%	100.0	95.7	3.4	0.5	0.0	0.4
Rural Municipalities	2186142	1859005	285308	18467	981	22381
%	100.0	85.0	13.1	0.8	0.0	1.0
Ecological Belt						
Mountain	409260	321058	81401	1572	186	5043
%	100.0	78.4	19.9	0.4	0.0	1.2
Hill	2945030	2617298	296449	8996	497	21790
%	100.0	88.9	10.1	0.3	0.0	0.7
Tarai	3306551	3200785	61432	28339	1349	14646
%	100.0	96.8	1.9	0.9	0.0	0.4
Province						
Koshi	1190755	1115686	59864	9765	295	5145
%	100.0	93.7	5.0	0.8	0.0	0.4
Madhesh	1156383	1132078	9511	10645	613	3536
%	100.0	97.9	0.8	0.9	0.1	0.3
Bagmati	1567917	1526035	36537	2203	115	3027
%	100.0	97.3	2.3	0.1	0.0	0.2
Gandaki	661632	645780	12633	1505	105	1609
%	100.0	97.6	1.9	0.2	0.0	0.2
Lumbini	1141345	1069081	51425	11368	549	8922
%	100.0	93.7	4.5	1.0	0.0	0.8
Karnali	366037	181676	175306	1775	145	7135
%	100.0	49.6	47.9	0.5	0.0	1.9
Sudur Paschim	576772	468805	94006	1646	210	12105
%	100.0	81.3	16.3	0.3	0.0	2.1

Source: Census Report of Nepal 2021

In summary, this table provides insights into the sources of lighting in Nepalese households based on various geographical and ecological factors. It shows variations in the use of electricity, solar, kerosene, and other sources across different regions of Nepal.

Nepal is abundantly endowed with water resources, including snow cover, rivers, springs, lakes, and groundwater. The potential for harnessing hydropower in Nepal is remarkable, with estimated technical and economically viable capacities of 83,000 and 42,000 megawatts (MW), respectively (Gunatilake, Wijayatunga, & Roland-Holst, 2020). However, despite initiating

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hydropower development as early as 1911, progress has been sluggish. As of 2005, Nepal had managed to generate only 557 MW of hydropower. This slow progress can be attributed to factors such as limited private-sector involvement, political considerations, and heavy reliance on external financing (Nepal Electricity Authority, 2021). Nepal has cheap, abundant solar energy. Every Nepali has access to more than enough solar power to consume the same amount of energy as those in wealthy nations while avoiding the use of fossil fuels. The use of solar energy contributes in reduction of climate change impact, so such green energy should be promoted in Nepal.

Practicing GSCM at the household level involves making conscious choices that prioritize sustainability, resource conservation, and reduced environmental impact in your daily life. Small changes can add up to make a significant difference in reducing your household's ecological footprint. 92% household was using electricity from hydropower, and 6.6% were using solar for lighting. Solar power, wind power, hydropower, and biomass are green energy or renewable energy which are considered environmentally friendly because they produce little to no greenhouse gas emissions during electricity generation, reducing the contribution to global warming and air pollution. These energy sources also have the advantage of being more sustainable in the long term, as they do not deplete finite fossil fuel reserves and can help reduce dependence on fossil fuels, which are subject to price volatility and supply issues. According to the data of the census study, the use of electricity from hydropower is higher in urban municipalities compared with rural municipalities, whereas the use of solar power is higher in rural municipalities compared with urban municipalities. Less than one present household are using kerosene, where there is either no access to electricity or it was very poor household who could not afford the installation of electricity or other means of energy sources.

4.4 Number of transportation

Table 4 provides data on the number of registered vehicles of various types for fiscal years from FY BS 2046/47 (1990) to FY BS 2079/80 (2023). According to this data, the number of registered buses increased from 36,651 in FY 2046/47 to 22, 46 in FY 2079/80, with some fluctuations over the years. Similarly, the number of registered minibuses/minitrucks increased from 16,989 in FY 2046/47 to 3,239 in FY 2079/80, also with fluctuations. Regarding the Crane/dozer/escalator/truck, this category saw significant fluctuations but generally increased from 57,217 in FY 2046/47 to 3,239 in FY 2079/80. Another type of vehicle is Car/jeep/van; the data shows the number of registered cars, jeeps, and vans increased steadily over the years, reaching 9,849 in FY 2079/80 from 163,667 in FY 2046/47. Similarly, the number of registered pickups showed fluctuations, ending at 2,518 in FY 2079/80 from 29,896 in FY 2046/47.

The data also shows the number of registered micro buses, which increased from 3,746 in FY 2046/47 to 286 in FY 2079/80. Likewise, the number of registered tempos increased from 9,068 in FY 2046/47 to 4,939 in FY 2079/80. Popular tempos in Nepal are called ‘Safa Tempos’, which are electric vehicle so due to increasing pressure of air pollution, the demand for Safe

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Tempos increased in urban cities. A motorcycle is a very common private vehicle. This category had a significant increase, going from 1,567,589 in FY 2046/47 to 183078 in FY 2079/80, making it the most registered vehicle type. The demand of Tractor/power tiller is also increased. As the data, the number of registered tractors/power tillers increased from 103,695 in FY 2046/47 to 2,519 in FY 2079/80. In the latter stage, another popular small-sized public transport is the E-rickshaw, which is found in almost every urban city. It provides services up to the access road of rural societies also. E-rickshaws were not registered until FY 2072/73 but showed steady growth, reaching 6,820 in FY 2079/80. There are others category which include various vehicle types, and the number of registrations remained relatively low, ending at 4 in FY 2079/80 from 6,886 in FY 2046/47.

Table 4: Number of Transportation

Types	Fiscal Year									
	FY 2046/47 to 2071/72	**2072/73 (2016)**	**2073/74 (2017)**	**2074/75 (2018)**	**2075/76 (2019)**	**2076/77 (2020)**	**2077/78 (2021)**	**2078/79 (2022)**	**2079/80 * (2023)**	**Total till**
Bus	36651	4353	5342	2972	3722	2282	3400	3679	2246	**64647**
Minibus/minitruck	16989	4625	2008	1973	2409	998	3078	2160	3239	**37479**
crane/dozer/ escalator/truck	57217	8328	12712	12154	13425	4112	6339	8235	3239	**125761**
car/jeep/van	163667	28361	21292	24338	23019	11211	19140	21242	9849	**322119**
pick up	29896	5060	10675	10342	9759	4347	9317	8598	2518	**90512**
micro bus	3746	1137	841	1934	2330	393	563	485	286	**11715**
Tempo	9068	2613	17782	16209	11025	5764	14944	10132	4939	**92476**
motorcycle	1567589	267439	354071	341623	282997	209671	556819	503279	183078	**4266566**
tractor/power tiller	103695	9786	17085	13396	12220	5160	11549	8872	2519	**184282**
e-rickshaw	0	11894	2247	12325	8952	1068	3512	8767	6820	**55585**
others	6886	169	204	348	380	216	678	134	4	**9019**
Total	1995404	343765	444259	437614	370238	245222	629339	575583	218737	**5260161**

*** till fiscal year BS 2079/80 Falgun last**

Source: Ministry of Physical Infrastructure and Transport 2079 through Economic Survey 2079/80, Govt. of Nepal, Ministry of Finance.

In total, the number of registered vehicles across all types increased significantly over the years, going from 1,995,404 in FY 2046/47 to 218,737 in FY 2079/80. It's worth noting that there are some fluctuations in the data, and the growth trends vary for different vehicle types. The data can be used for analyzing the changing landscape of vehicle registrations in the given region over the specified fiscal years. With the increasing demand for vehicles, it also increased the demand for petroleum oils and LPG, which need to be imported from other country so it

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expensive for Nepalese societies. The increased demand for vehicles and petroleum oils increased the economic burden as well as negatively affected the environment and human health by creating sound and air pollution.

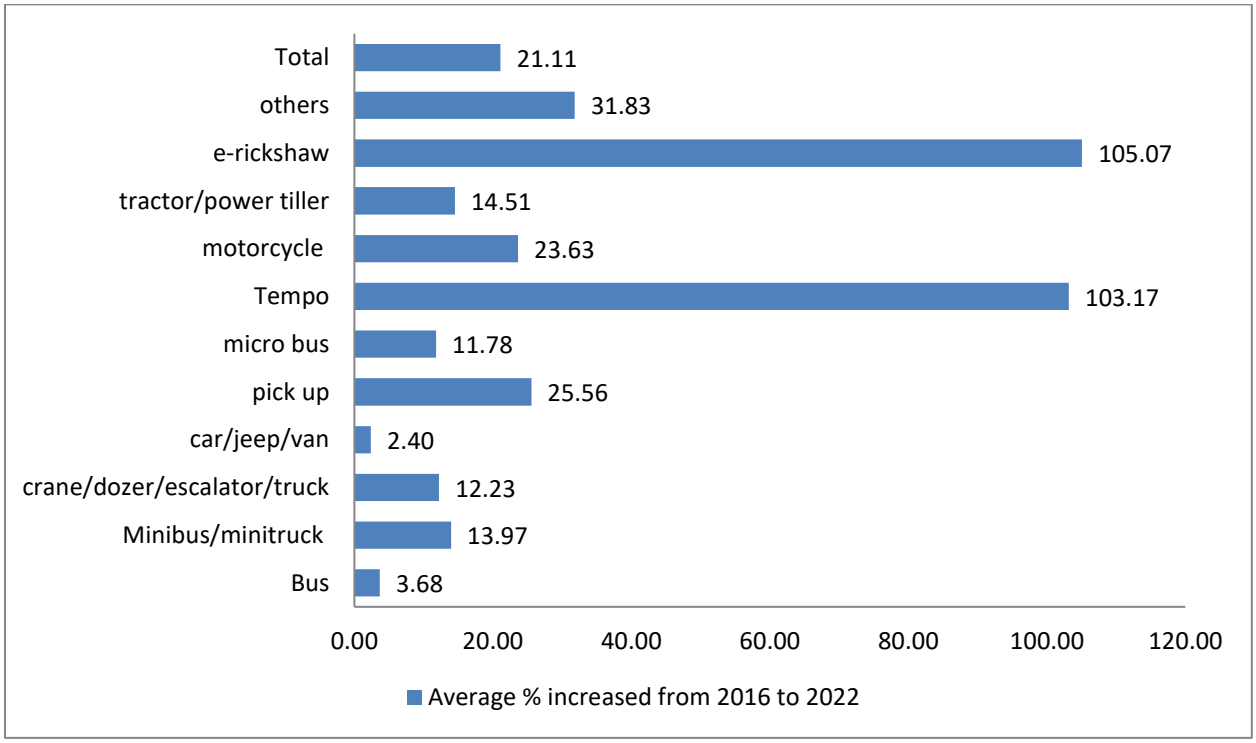

Figure 1: Average increasing trend of transportation

Source: Ministry of Physical Infrastructure and Transport 2079 through Economic Survey 2079/80, Govt. of Nepal, Ministry of Finance.

The above Figure 1 shows the average percentage increase in the number of registered vehicles of various types from the year 2016 to the year 2022. The data shows the increased presence of each category of transportation.

From 2016 to 2022, we saw some pretty interesting shifts in how many vehicles were registered in different lineups, with some growing a lot more than others. Buses grew at a pretty good pace, seeing about a 3% bump each year.68% of them, and then things like cars, jeeps, and vans went up a little slower, at 2.Just 40%.But pickups? They really shot up, growing by 25% each year on average. That's 56%, which really shows how quickly people are preferring these kinds of cars. Even smaller trucks and vans, the kind businesses and utility companies use, saw a good jump in sales. Minibuses and mini-trucks went up by 13.97% each year, and microbuses increased by 11. Seventy-eight percent, and if you look at cranes, dozers, escalators, and trucks all together, that group went up by twelve percent. It's 23 percent each year. Tractors and power tillers grew by 14 percent, which was a lot.51% of them, which just goes to show how big they're getting in farming and building.

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Electric vehicles and two-wheelers really took off, showing the biggest jump in growth. Motorcycles clocked in a solid 23. An astounding 63% increase happened every year, and tempos and e-rickshaws absolutely blew up with 103% growth.17% and 105. It looks like things are really changing fast, with folks preferring quick, local ways to get around, as shown by that 0.07% shift. And yeah, the "Others" group, which covers all the random vehicle types, really shot up, growing about 31% each year on average.83%. That just goes to show how much more varied the vehicles on the road became over these years.

Regarding the total number of registered vehicles across all categories increased by an average of 21.11% annually from 2016 and 2022, indicating significant overall growth in the sector. Among the various types of vehicles, the data shows that the annual growth of number of e-rickshaw and tempo were significantly increased in last 7 years in comparison of other types of vehicles. These are the eco-friendly transportation which contributes in the reduction of carbon emission. This trend shows the significant improvement in promotion of EV in Nepalese market. Though, the trend of other types of petroleum oil based vehicles is also increasing which increase the cost and pollution. There is need to promote the Eco-friendly Transportation; use public transportation, carpool, bike, or walk whenever possible to reduce carbon emissions.

4.5 Use of petroleum products

Petroleum products are a significant source of energy, and their consumption has increased over time (Table 5).Every year, consumption of gasoline, diesel, LPG, and aviation fuel has increased, while kerosene consumption has decreased. This is due to the adoption of LPG as a substitute. Over a number of years, the consumption of LPG increased by 11 to 12% annually. The table provides data on the quantities of various petroleum products (excluding LPG) for the fiscal year 2078/79 (corresponding to 2021-22 AD) and previous years, along with their percentage changes.

As the Table 5, the findings of the data shows that in the fiscal year 2078/79 (2021-22 AD), the quantity of petrol consumed was 736,276 KL, representing a 24.43% increase compared to the previous year. Over the 10-year period from 2012/2013 to 2021/22, petrol consumption showed an average annual growth rate of 14.64%. similarly, Diesel consumption in 2078/79 was 1,723,557 KL, with a relatively low annual growth of 1.61%. However, the average annual growth rate over the 10-year period was 11.03%.

Kerosene consumption in 2078/79 was 17,340 KL, which decreased by 26.48% compared to the previous year. Over the 10-year period, kerosene consumption decreased on average by 0.67% annually. Additionally, the consumption of aviation turbine fuel in 2078/79 was 157,128 KL, showing a significant increase of 117.44% from the previous year. The average annual growth rate over the 10-year period was 13.67%. finally, LPG consumption in 2078/79 was

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536,028 MT, indicating a 12.20% increase compared to the previous year. Over the 10-year period, LPG consumption had an average annual growth rate of 10.99%.

Table 5: Petroleum Products [in KL except LPG] for 2078/79 (2021-22AD)

Fiscal Year	Petrol		Diesel		Kerosene		Aviation Turbine Fuel		LPG	
	KL	%	KL	%	KL	%	KL	%	MT	%
2078/79 (2021-22AD)	736276	24.43	1723557	1.61	17340	-26.48	157128	117.44	536028	12.20
2077/78 (2020-21AD)	591700	15.54	1696202	15.11	23584	24.62	72264	-47.42	477752	6.39
2076/77 (2019-20AD)	512128	-9.65	1473536	-14.08	18924	-24.32	137424	-31.33	449063	4.53
2075/76 (2018-19AD)	566827	15.99	1714917	7.93	25004	11.94	200108	1.46	429609	15.94
2074/75 (2017-18AD)	488675	19.99	1588869	20.38	22337	13.92	197220	19.65	370560	18.42
2073/74(2016-17AD)	407270	69.42	1319873	67.99	19607	38.14	164836	96.66	312928	46.10
2072/73(2015-16AD)	240386	-16.38	785685	-14.76	14194	-27.78	83819	-40.72	214194	-17.08
2071/72 (2014-15AD)	287473	13.45	921714	13.99	19653	6.76	141404	12.51	258299	11.02
2070/71 (2013-14AD)	253381	13.58	808567	12.11	18409	-23.50	125678	8.44	232660	12.38
2069/2070 (2012/2013 AD)	223087	0	721203	0	24065	0	115896	0	207038	0
Average growth from 2012/013 to 2021/22	430720.30	14.64	1275412.30	11.03	20311.70	-0.67	139577.70	13.67	348813.10	10.99

Source: https://noc.org.np/import

Looking at the historical data, it's clear that there have been fluctuations in the consumption of petroleum products over the years, with some products experiencing significant annual growth in certain years and decreases in others. These fluctuations can be influenced by factors such as changes in demand, economic conditions, and government policies. The average annual growth rates over the 10-year period provide a longer-term perspective on the trends in petroleum product consumption, with some products consistently increasing over this period, while others have experienced more variable growth rates.

The utilization of fossil fuels achieves enormous natural expense as it is a monstrous supporter of the greenhouse gas impact (Rolim, Gonçalves, Farias, & Rodrigues, 2012). Starting at 2010, there are more than 1 billion engine vehicles all around (Sousanis, 2011). IEA report stated that the vehicle division is responsible for 23% of worldwide vitality related greenhouse gas emissions. The outflows decrease required to confine a dangerous atmospheric deviation to less

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than 2°C is extremely hard to accomplish if the vehicle segment doesn't coordinate. Hence, alternative vehicle technologies are sought after with intrigue (IEA, 2015). A green vehicle or environmentally friendly vehicle is a street engine vehicle that produces less harmful effects on the earth than practically identical ordinary inward burning motor vehicles running on gas or diesel, or one that utilizes certain alternative fuels. As climate change is recognized as one of the key challenges of the 21st Century (UNFCCC, 2010), limiting global warming and climate change by leaving fossil fuels in the ground is a key strategy to reduce such emissions (McGlade & Ekins, 2015).

These findings highlight the complex dynamics of petroleum product consumption, with some products experiencing consistent growth while others fluctuate. Several important implications can be drawn from these trends:

Environmental Impact: The high consumption of petrol and diesel suggests a significant contribution to greenhouse gas emissions. The transportation sector, in particular, is a major emitter of greenhouse gases, making it crucial to explore alternative vehicle technologies and fuels.

Need for Green Vehicles: Given the environmental concerns associated with fossil fuels, the findings underscore the importance of green and environmentally friendly vehicle technologies. Transitioning to electric vehicles (EVs) or other alternative fuels can help mitigate the environmental impact of the transportation sector.

Climate Change Mitigation: The findings align with the global imperative to limit global warming and combat climate change. Reducing the consumption of fossil fuels, especially in the transportation sector, is essential for achieving emission reduction targets and addressing climate change challenges.

Policy Implications: Government policies and incentives play a crucial role in shaping the consumption patterns of petroleum products. Policies that promote cleaner energy sources, energy efficiency, and sustainable transportation can contribute to a more environmentally sustainable future.

The data on petroleum product consumption highlights the urgent need to transition towards more sustainable and environmentally friendly energy sources and transportation methods. Addressing the environmental consequences of fossil fuel consumption is essential to combat climate change and ensure a sustainable future.

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5. Conclusion and Recommendation

5.1 Conclusion of the study

In conclusion, the study provides valuable insights into various aspects of energy usage and transportation in Nepal based on secondary data and time series data. Practicing GSCM at the household level involves making conscious choices that prioritize sustainability, resource conservation, and reduced environmental impact in your daily life. Small changes can add up to make a significant difference in reducing your household's ecological footprint.

The main conclusion and their implications are as follows:

Cooking Fuel Usage: The data reveals that a significant portion of households in Nepal, especially in rural areas, still rely on traditional sources of cooking fuel such as wood/firewood and cow dung. This reliance has adverse effects on the environment and human health. The government's efforts to promote cleaner cooking technologies, like LPG and electricity, have had limited success, particularly in rural areas. This suggests the need for more effective and accessible clean energy solutions in rural regions.

Energy Sources for Household and Business: The data also indicates a growing trend in the use of various energy sources for both household and business activities. While there is an increase in the adoption of modern energy sources like electricity, there is still a significant reliance on traditional sources such as firewood and petroleum oils. The increasing use of petroleum oils has adverse effects on air quality and contributes to air pollution. To address this, there is a need for policies and initiatives to promote cleaner and more sustainable energy sources.

Lighting Sources: The majority of households in Nepal use electricity for lighting, especially in urban areas, which is a positive sign. However, there is still a significant reliance on kerosene in rural areas. Promoting access to electricity in rural regions should remain a priority, as it not only improves living conditions but also reduces the reliance on kerosene, which is harmful to health and the environment.

Transportation Trends: The data shows a substantial increase in the number of registered vehicles of various types over the years. This growth has economic implications, including increased fuel consumption and importation of petroleum oils. Additionally, the rapid increase in the number of vehicles can contribute to traffic congestion, air pollution, and noise pollution in urban areas.

Green Energy Opportunities: Nepal has significant potential for harnessing green energy sources like hydropower and solar energy. These sources can contribute to reducing the environmental impact of energy consumption and transportation. Promoting renewable energy

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initiatives and the adoption of electric vehicles, such as e-rickshaws, can help mitigate the negative effects of increased vehicle usage.

Overall, addressing the environmental and health challenges associated with energy usage and transportation in Nepal requires a multi-faceted approach involving government policies, private sector engagement, and public awareness campaigns. By promoting cleaner and more sustainable energy sources and transportation options, Nepal can work towards a greener and healthier future. The findings of this study can help policymakers and researchers understand energy consumption patterns and make informed decisions regarding energy policies, sustainability, and environmental impact in different parts of the country.

5.2 Recommendations

The study has made following recommendation based on the above findings:

- **Promote Clean Cooking Technologies:** The government should intensify efforts to make clean cooking technologies more accessible and affordable, especially in rural areas. Subsidies or incentives for LPG and electric induction stoves can be considered to encourage adoption.
- **Increase Access to Electricity:** Expanding the electricity grid to reach remote and rural areas should be a priority. This will not only improve lighting sources but also reduce the reliance on traditional fuels for lighting and cooking.
- **Green Energy Promotion:** Invest in the development and promotion of green energy sources like hydropower and solar energy. Incentives for the adoption of solar panels in households and businesses can help reduce the carbon footprint.
- **Efficient Transportation:** Encourage the use of electric vehicles, especially in urban areas, to reduce air pollution and dependence on imported petroleum oils. The promotion of public transportation and the development of efficient transport systems can also help alleviate traffic congestion.
- **Environmental Awareness:** Raise awareness among the public about the environmental and health impacts of traditional cooking fuels and petroleum-based transportation. Education campaigns can encourage individuals to make more sustainable choices.
- **Regulation and Standards:** Implement and enforce emission standards for vehicles to reduce air pollution. Additionally, regulate the use of traditional cooking stoves to minimize indoor air pollution.

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