Household transitions to clean energy from traditional biomass in Nepal: Challenges and opportunities

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Abstract

In recent years, the Nepal government has recognized and prioritized several clean energy initiatives in its national plans and policies. Despite this, more than two-thirds of households still rely on traditional biomass, as their primary source of energy, for cooking and heating, making the household fuelwood consumption per person in Nepal among the highest in the world. However, why households' transitions to clean energy for cooking is slow has been poorly understood. Using energy-specific information from the World Bank's Multi-Tier Framework (MTF) survey and the Nepal government's Multiple Indicator Cluster Survey (MICS), the cooking and heating energy consumption situation of households across the provinces by rural and urban areas is analyzed briefly. Also, a simple levelized cost of cooking is estimated using different fuel-technology combinations. The main findings of this paper are: limited availability, unreliable supply and high costs are hindering households' transitions to clean energy from traditional biomass; the combination of fuelwood, liquified petroleum gas and other clean energy sources (multiple fuel stacking) are common within the same household; and, the use of biogas, and to some extent, solar power, for cooking is limited to scale and geographical location. It is expected that electricity will be the most economic and common primary clean cooking energy option for households in the future provided that the government has the policy to address the reliability concerns of electricity and that it is affordable for low-income households.

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1. Introduction

Traditional solid biomass[1] is the largest energy source in Nepal's total final energy consumption. Currently, fuelwood accounts for roughly 62% of the country's total final energy consumption (MOF, 2020b), considerably higher than most of the developing countries of the world [2] (IEA, 2020). Although its proportion in total final energy consumption has decreased by 16 percentage of points between fiscal year (FY) 2008/9 and 2018/19, the demand for fuelwood continues to rise in absolute terms. For example, fuelwood consumption has increased from 7.3 Mtoe in 2008/9 to 8.7 Mtoe in 2017/18, an increase of 19% (MOF, 2020b). As in many biomass-dependent developing countries, such as Sub-Saharan African countries (Congo, Ethiopia, Ghana, Tanzania, Namibia, Swaziland, and Mozambique) and South Asian countries (Bangladesh, Bhutan, Pakistan, Sri Lanka, and India), rural Nepalese households consume more fuelwood than urban households. The households in the mountains consume more fuelwood than the households in the hills, which consume more than those in the tarai.

Recognizing the heavy reliance on biomass and realizing the importance of clean energy as an input to the well-being and prosperity of people, the Nepal government has prioritized the United Nations-mandated energy initiatives, including Sustainable Development Goals (SDGs), especially goal 7, in its national plans and policies. Notable targets set by these initiatives at the household level include making all households free of indoor air pollution by 2022, ensuring the availability of electric cookstoves to all households by 2028, and providing access to modern and clean energy to all households by 2030 (ADB, 2017; MoEWRI, 2018; NPC, 2020a). Likewise, SDG7 specific targets include increasing access to electricity from 74% in 2015 to 99% in 2030, reducing the share of biomass for cooking from 75% in 2015 to 30% in 2030, limiting the use of liquified petroleum gas (LPG) to less than 40% in 2030, and increasing per capita energy consumption from 16 GJ in 2015 to 24 GJ in 2030 (NPC, 2017). Also, under the "Prosperous Nepal, Happy Nepali" plan, the electricity consumption per person is expected to reach 3500 kWh in the next 25 years, which is more than fourteen times the current per capita consumption of 245 kWh (NPC, 2020b).

Besides, there are several acts, strategies, plans and policies initiated by the Nepal government on energy-related issues, such as National Water Resources Policy, 2077 (2020), National Climate Change Policy, 2076 (2019), National Energy Efficiency Strategy, 2075 (2018), Electric Cooktop Standard, 2075 (2018), Biomass Energy Strategy 2074 (2017), Electricity Regulatory Commission Act, 2074 (2017), Renewable Energy Subsidy Policy 2073 (2016), Rural Energy Policy 2063 (2006), National Electricity Crisis Resolution Action Plan 2065 (2008), Hydropower Development Policies 2049 (1992) and 2058 (2001), National Water Plan 2062 (2005), Water Resource Strategy 2058 (2002), Water Resources Act 2049 (1992), Electricity Act 2049 (1992),

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1   Traditional solid biomass includes fuelwood, agriculture waste and animal dung. In this paper, fuelwood is focussed, as it dominates all available solid biomass.

2   For example, the share of biomass in total final energy consumption in 2017 is about 55% in Africa as a whole, 49% in Bangladesh, 46% in Pakistan, 33% in Sri Lanka, 29% in India, 25% in Asia (excluding India and China) as a whole, and 17% in China.

and Nepal Electricity Authority Act 2041 (1984) (MoEWRI, 2021; AEPC, 2021; MoFE, 2021). These initiatives, plans, and policies are critical for the country's future sustainable energy development and transitions to clean energy solutions for households. However, the lack of full understanding of why transitions to clean energy for households' cooking solutions is necessary may lead to misguided and ineffective implementation of energy plans and policies. There are several research studies on household energy use in Nepal. The focus areas of these existing studies vary widely from fuelwood use (Amacher et al., 1999; Baland et al., 2003; Baland et al. ,2018; Fox, 1984; Kandel et al., 2016; Soussan et al., 1991) to modern energy use (Acharya and Adhikari, 2021; Bhandari and Pandit, 2018; Clements et al., 2020; Gross et al., 2017; Lam et al., 2017; Malla, 2013; Paudel et al., 2021; Pokharel and Rijal, 2021; Shahi et al., 2020) by households either at the national or local levels, and other wide range of issues, such as socio-economic, behaviors, and cultural factors (Acharya and Marhold, 2019; Das et al., 2019; Joshi and Bohara, 2017; Pokharel, 2004; Shrestha et al., 2020) that influence household energy consumption. However, these existing studies do not comprehensively address the household transition from traditional biomass to clean energy, especially for cooking. Nor do they account sufficiently for households' transition from biomass to clean energy sources. The main purpose of this paper is to advance the understanding of the complexities and shortcomings of households' heavy reliance on biomass and the slow transition to clean energy in the country. An energy-specific dataset compiled from the World Bank's MTF survey (World Bank, 2019) and the government's MICS (CBS, 2020) is used to analyze households' cooking energy patterns by rural and urban areas across the provinces. Also, a simple levelized cost of cooking is estimated using different fuel-technology combinations. Finally, the paper addresses the challenges and opportunities surrounding the move to clean energy solutions for households.

In the following section, a brief overview is provided of the country's current socio-economic and energy use profile at the provincial level. A brief description of data and methods is provided in Section 3. Results are discussed in Section 4 and the final section presents concludes.

2. Overview of province-level socio-economic and energy use

Administratively, Nepal is federalized into 7 provinces, 77 districts, and 753 local governments. The country has three ecological belts (mountain, hill, and tarai). The provinces have significantly different demographic, economic, and climate conditions that influence the energy use patterns of households (Table 1). About 42% of the population lives in two provinces (2 and 3). The number of households is the highest (27%) in province 3 that includes Kathmandu valley. In 2019, three provinces (1, 2, and 3) accounted for two-thirds of the country's GDP, while province 6 accounted for the lowest (4%). The forest area coverage, which is a proxy for the availability of fuelwood, also varies widely, from a low 3% in province 2 to a high 19% in province 6.

Table 1 Province-level socio-economic and energy use in Nepal (2019).

	Province									Nepal
	1	2	3	4	5	6	7	KTM[φ]		
Population* (%)	16.8	20.8	21.0	8.7	17.0	6.0	9.7	10.1		28.6 (million)
Household* (%)	17.4	19.4	22.6	9.8	17.5	5.6	7.7	10.5		6.3 (million)
Population density* (people/sq km)	175	559	272	112	202	56	131	3245		194
Contribution to GDP** (%)	16	14	36	9	14	4	7	-		3.5 (trillion NRs)
Forest area*** (%)	18.0	3.2	15.8	12.8	13.9	18.9	17.4	-		45
Grid-connected electrification rate[†] (%)	75.9	79.8	90.3	87.4	81.0	27.0	58.9	-		77.8
Electricity sales/household (kWh) [†]	402	409	758	390	493	93	242	-		472
Household electricity sales/total sales[†] (%)	41	34	52	55	37	68	54	-		44
Cooking with fuelwood/total fuels[§] (%)	63	54	25	50	61	89	79	5		54

*Notes: φ KTM is Kathmandu valley which is part of province 3. * Estimated figures for 2017 taken from (Malla, 2021). ** (CBS, 2021). *** 2018 value taken from (DoFRS, 2018). † (NEA, 2020). § (CBS, 2020).*

In terms of annual electricity consumption per household, province 6 has the lowest value (93 kWh) and province 3 has the highest value (758 kWh). Many factors contribute to the disparities in electricity consumption across provinces, including access to grid-connected electricity, economic conditions of households, and population density. Fuelwood is a source of primary fuel for cooking, and it remains significant in all provinces, ranging from a high 89% in province 6 to a low 25% in province 3. The actual quantity of fuelwood consumption varies across different climatic zones in the country, from warm tropical lowland in the south to the cold Himalayan mountain range in the north.

3. Data and methods

Household-specific energy consumption information is collected from the World Bank's MTF survey and the government's MICS. The MICS is supported by the United Nations Children's Fund (UNICEF) and conducted by the Central Bureau of Statistics (CBS). Information on annual household energy consumption is collected from the United Nations (UN) and the International Energy Agency (IEA).

The MTF survey data was collected between July and December 2017 from 6000 households and the MICS data was collected between April and May 2019 from 12800 households. The MTF collected data on a topic of energy-access needs in the country and the MICS data focused on a wide range of indicators about children and women in the country, including household energy use. National-level data on different types of energy used in households was

collected from the UN and the IEA. Every year, the UN and the IEA collect and publish energy statistics for Nepal.

Since the focus is on household's cooking and heating end-uses, relevant cooking and heating datasets were, first, extracted from the MTF survey and MICS. Some examples of the information collected from these variables include whether a household is connected to the grid, off-grid, or has no electricity; willingness to pay for grid-connected electricity; the main source of lighting for children for study; problems associated with grid and off-grid electricity connections, such as damage to electric appliances due to voltage fluctuations; and whether monthly electricity bill is a financial burden to the family. Second, based on these datasets, simple descriptive statistics on household energy use patterns at disaggregated levels (provinces and regions) are estimated using a statistical software tool. The MTF and MICS include both categorical variables and numerical variables. For categorical variables, the percentage of households that fall into each analytical region was calculated, and for numerical variables, summary statistics that include the mean, the standard deviation, and median values for each analytical region were calculated. The UN and IEA datasets were used to evaluate the current household energy consumption status of Nepal compared to other developing countries in the world.

A simple levelized cost of cooking (sLCOC) by households was then calculated using different fuel-technology combinations. To estimate the annual simple levelized cost of cooking (sLCOC), the following equation is used:

$$sLCOC(d) = \left(\frac{C_d + O\&M_d}{n}\right) + \left(\frac{F_f}{CV_f} \times \frac{UE}{\eta_d}\right)$$

where C_d is the capital cost of device d, $O\&M_d$ is O&M cost of device d, n is the device lifetime, f_i is the fuel cost of fuel type f, CV_f the calorific value of fuel f, UE is the annual useful energy requirement for cooking, and η_d is the thermal efficiency of device d. A levelized cost of cooking estimates the average annual cost of cooking using different fuel-technology combinations.

A very basic approach to calculating sLCOC is used, an approach in which the sum of capital and O&M costs (without discounting), and fuel costs (fixed) over the lifetime of cooking technologies (varying thermal efficiency) to meet the specific amount of useful energy requirements for preparing meals of a typical household is calculated. Also, several assumptions are made on the capital and O&M costs of cooking devices, their thermal efficiencies, and fuel prices (see Table 2 notes).

4. Results and discussion

4.1 Household fuelwood consumption per person in Nepal is among the highest in the world.

Nepal has one the highest fuelwood consumption per person in the world and has continued to increase over the past three decades. For example, in 2018, household fuelwood consumed by each person was about 1.43 m³, an increase of more than two-folds from the 1990 level (0.64 m³). Nepal is ranked second in terms of per capita household fuelwood consumption in Asia (Figure 1) after Bhutan. Almost all fuelwood available in the country is consumed by households for their cooking and heating needs.
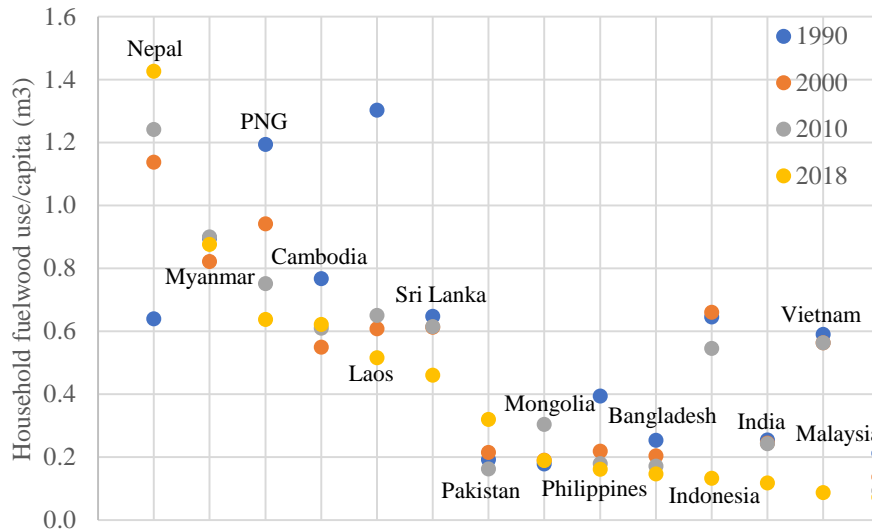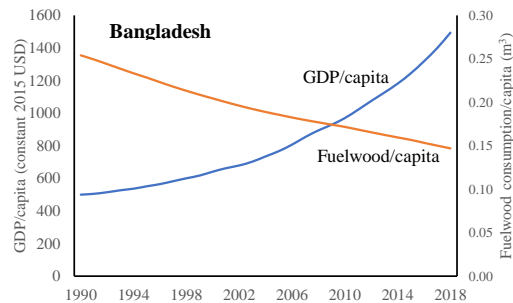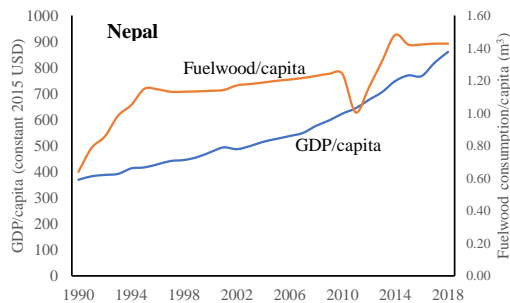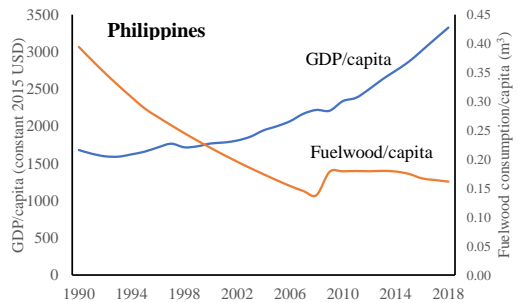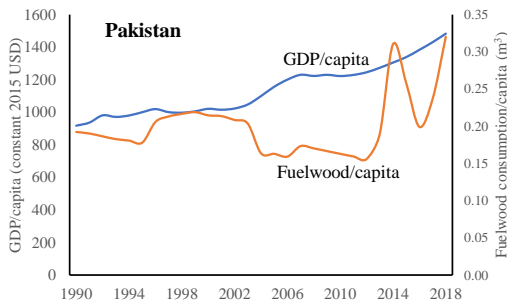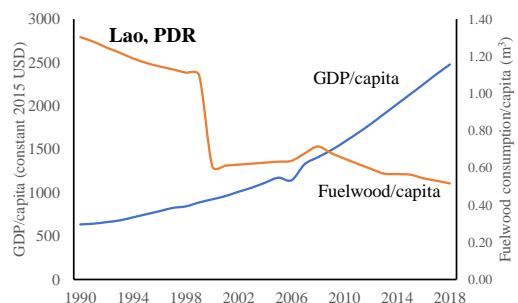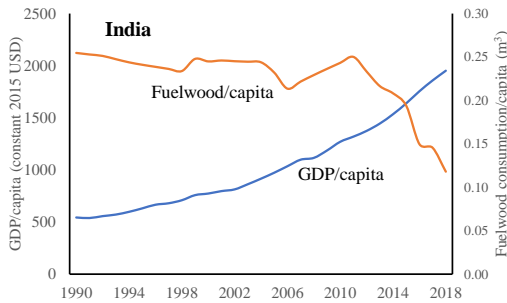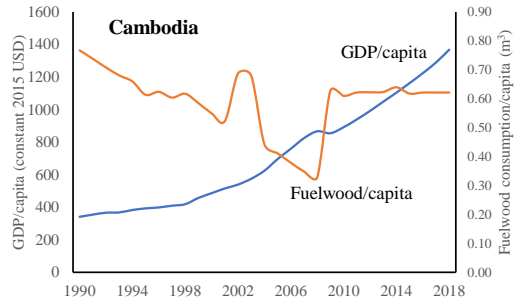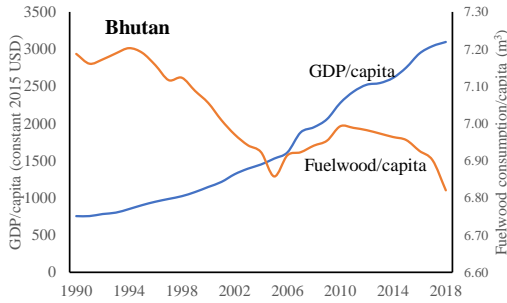
Notes: Bhutan, excluded for the clarity of the graph, has the highest fuelwood consumption per person in the world, ranging from 7.2 m³ in 1990 to 6.8 m³ in 2018.
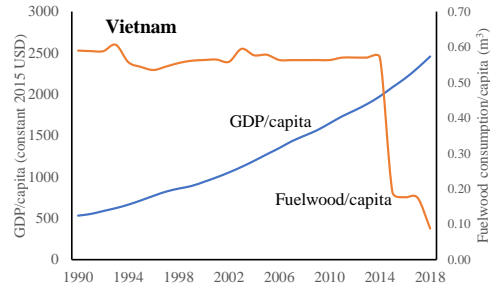
Source: (UNSD, 2021)

Fig. 1. Household fuelwood consumption per person in top 15 Asian countries from 1990 to 2018.

One of the key determinants of fuelwood consumption in households is income. In general, fuelwood consumption tends to decrease in proportion relative to modern fuel as household income increases. This is evident in many developing countries of Asia and other regions of the world. For instance, in per capita terms, residential fuelwood consumption declines or at least remains the same as the income rises, as Figures 2a and 2b show. This also indicates the evidence for the energy ladder hypothesis: households move towards modern energy sources as their income rises.
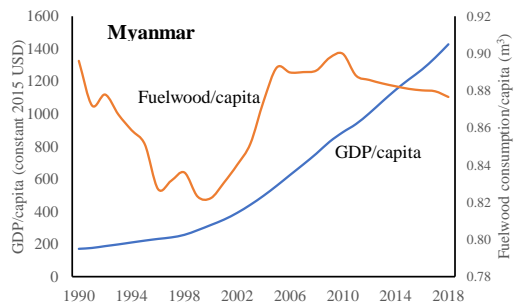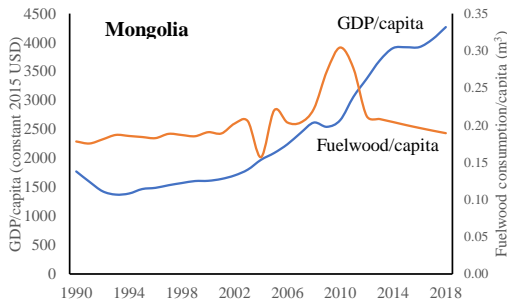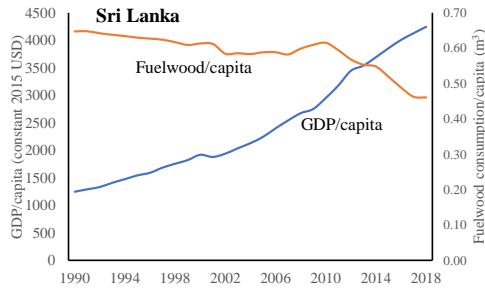
The page contains eight line charts, each plotting GDP/capita (constant 2015 USD) and Fuelwood consumption/capita (m³) from 1990 to 2018 for the following countries: Bhutan, Cambodia, India, Lao PDR, Mongolia, Myanmar, Pakistan, and Philippines.

Notes: Countries are selected based on the predominance of household fuelwood consumption, the GDP per capita is less than USD4,500, and data availability.

Sources: (IEA, 2020; UNSD, 2021; World Bank, 2021).

Fig. 2a. Per capita relations between income and household fuelwood consumption in per capita for selected countries of Asia between 1990 and 2018.
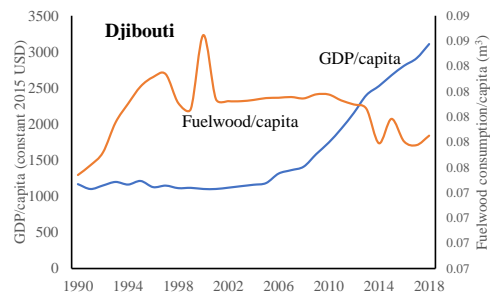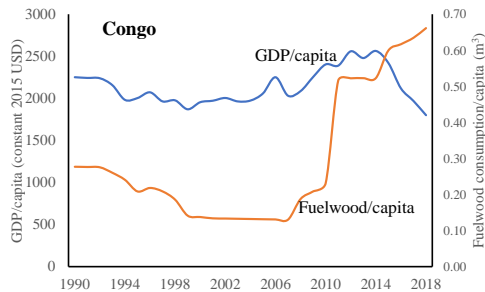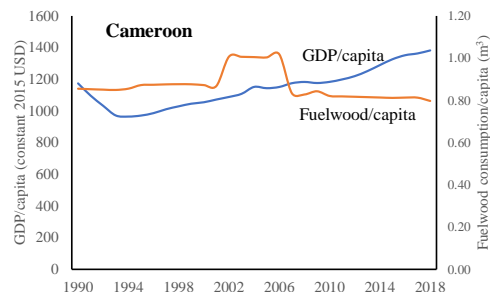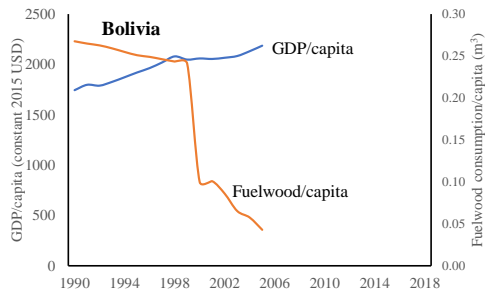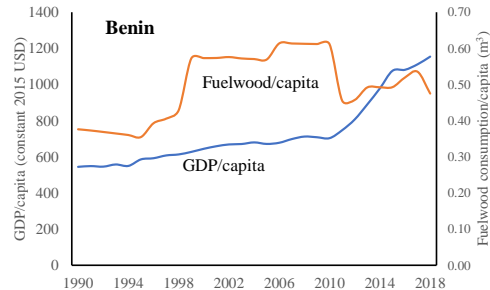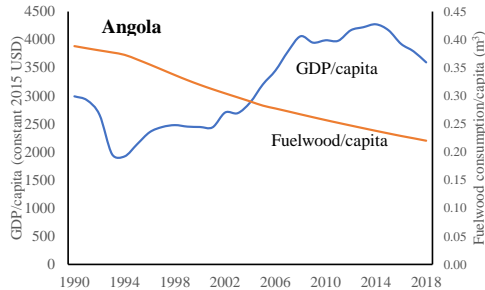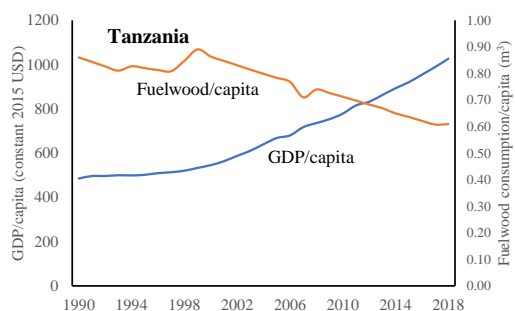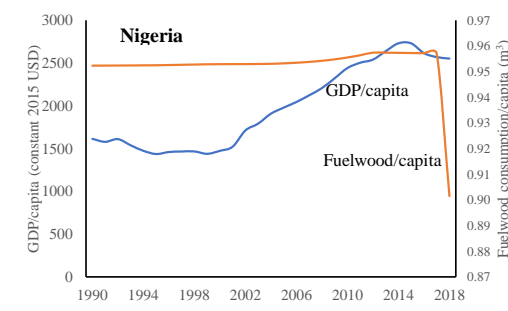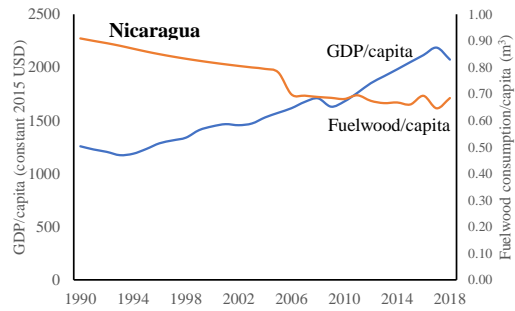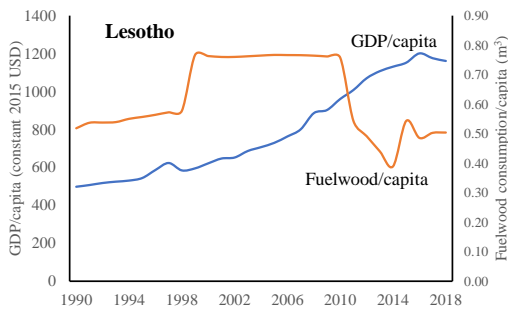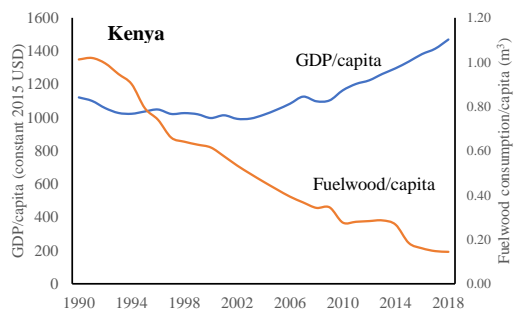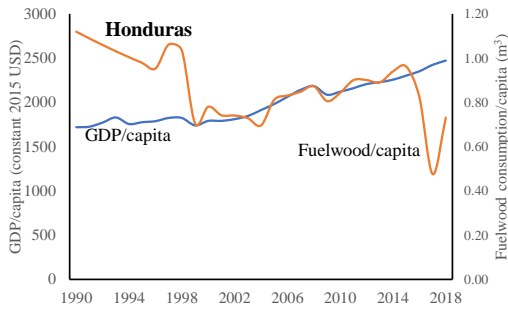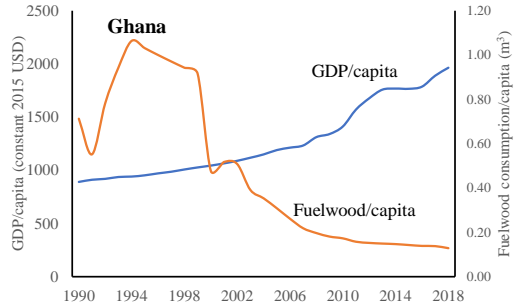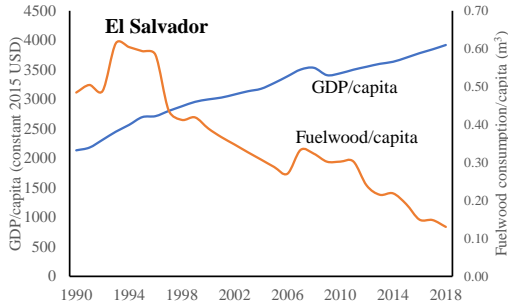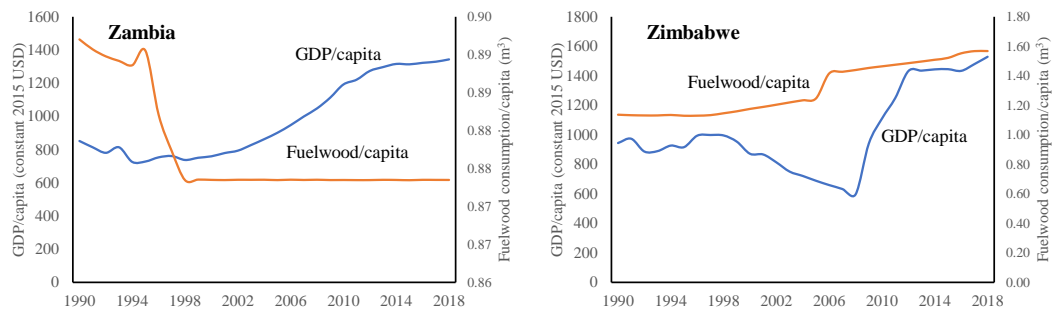
Notes: Countries are selected based on the predominance of household fuelwood consumption, the GDP per capita is less than USD4,500, and data availability.
Sources: (IEA, 2020; UNSD, 2021; World Bank, 2021).
Fig. 2b. Per capita relations between income and household fuelwood consumption of selected countries of Africa and Latin America between 1990 and 2018.

However, this may not be the case in Nepal. Over the past three decades, fuelwood consumption by Nepalese households increased with a rising income with some variation (Figure 2a). Many factors might have influenced the evidence against the energy ladder hypothesis in Nepal as compared to opposite cases in other developing countries in Asia and other regions of the world. First, the hill and mountain regions of Nepal, where most of the fuelwood use is concentrated, differ from many other developing countries. Fuelwood is used by Nepalese households both for cooking and heating. Also, the forest conditions in the country, measured by forest cover and biomass, remain steady in the past two decades so. For example, MoFE (2018) reported an overall increase in forest coverage in the country based on the forest resource assessment from 2010 to 2014, despite a declining rate of forest loss in the tarai, about 0.44% per year during 2001-2010. Likewise, Hurni et. al. (2019) find forest cover in Nepal expanded from 26.2% in 1992 to 44.9% in 2016. This makes Nepal different from the global trend of deforestation in other developing countries. Second, Community Forest User Groups (CFUGs) in the country helped protect, own, and manage forest resources and contributed to improving forest conditions. A study by Oldekop et al. (2019) finds community-based forest management has contributed to forest resurgence in most areas of the country. These conditions may have induced easy availability and collection of fuelwood for free in a controlled environment.

Fuelwood is also readily available for free from non-community forests and it does not require any processing before use. Further, fuelwood yields charcoal that is commonly used for some commercial purposes, such as by goldsmiths, hotels, and restaurants. This might have encouraged households to use more fuelwood than its modern substitute for charcoal and sell it in the informal market for financial gain. Third, the growing population combined with a lack of affordable, reliable, and sufficient supply of alternative, modern household energy resources, together with the successful promotion of improved cookstoves, likely have contributed to the country's heavy and continued reliance on fuelwood. For example, between 2008/09 and 2018/19, more than 1.1 million improved cookstoves that use fuelwood as their main fuel source were installed across the country (MoF, 2020b). Fourth, although common in other developing countries as well, smoke from burning fuelwood makes thatched roofs

insect- and water-repellent while helping preserve food stored in the rafters (Wood and Baldwin, 1985). These factors might have increasingly continued Nepal's reliance on fuelwood (in per capita terms) as compared to other developing countries.

This heavy reliance on fuelwood is also evident from its share in the country's total energy supply (TES). For example, over the past 40 years, the share of fuelwood in TES only slightly declined, from 74% in 1981 to about 62% in 2019 (MOF, 2011, 2020b). However, the supply of fuelwood, in absolute values, increased by almost three-fold, from 3.4 Mtoe in 1981 to about 8.7 Mtoe in 2019. This increasing trend of fuelwood use over the years is alarming. Without any targeted policy initiatives, this trend is likely to continue in the future that would negatively affect the country's forest resources and climate, and the health of those who have been exposed to household air pollution, especially, women and children.

4.2 Electricity is likely the most economical cooking energy solution for Nepal.

A levelized cost of cooking estimates the average annual cost of cooking using different fuel-technology combinations. Excluding a 3-stone fuelwood cookstove, our initial assessment indicates that biogas is the most economical cooking energy solution for households, followed by fuelwood, LPG, electricity, and kerosene cookstoves (Table 2). Of course, many strong assumptions are made in ranking cooking energy solutions for households. For example, discounts or interest rates for the cost of capital of cooking devices are not accounted. Likewise, if fuelwood is collected for free, it would be the most economical cooking solution. In contrast, if all the fuelwood used is purchased, then it would become the least economical cooking solution.

Table 2 Simple levelized cost of cooking using different fuel−technology combinations for Nepal (NRs/year)

	Capital cost[a]	O&M Cost[b]	Device Life[b]	Device Efficiency[c]	Fuel Cost[d]	Simplified LCOC
	(NRs)	(%)	(Year)	(%)	(NRs/unit)	(NRs/year)
Fuelwood						
3-stone cookstove	0	0	1	10	0	0
Traditional cook-stove (mud)	0	0	1	15	7.5	13165
Improved cookstove (two-pothole)	150−200	10	4	25−30	7.5	7222−7731
Metallic cookstove (*Bayupankhi*)	600−1650	5	5	25−30	7.5	7303−9161
Kerosene pressure stove	1000	5	5	45−55	100	23324−24356
LPG stove	3500−4000	5	10	60−70	1350	13069−15102

Biogas stove	3500−4000	5	10	60−70	0	4.4[e]
Electricity						
Coil	400−500	20	5	60	10	19113−21117
Hot plate	3500−4500	10	10	75	10	15598−20163
Induction	4000−5500	5	10	90	10	13098−15978

Notes: a) The value for fuelwood cookstoves is from (Thapa & Subba, 2015). Others are from authors' assumptions based on online market data and local news articles. b) Jain et al., 2015 and authors' assumption. c) Malla & Timilsina, 2014. d) The unit for fuelwood is in kg, kerosene is in a liter, LPG is in cylinder and electricity is in kWh. The fuel prices for kerosene and LPG are from (NOC, 2021), fuelwood is from local news articles, which is NRs 15 per kg in 2015 (it is assumed that half is collected free and half is purchased, i.e., NRs 7.5 per kg) and electricity is from (NEA, 2020). The calorific values (GJ/ton) used are 15.6 for fuelwood, 43.8 for kerosene, and 47.3 for LPG taken from (UN, 2018). It is assumed that 1 ton of kerosene is equivalent to 1.236 kl and 1 cylinder of LPG is equivalent to 14.2 kg. It is estimated that UE per person using 4.55 GJ for cooking meals (Pokharel, 2004) and 1.375GJ for snacks per household, with a household size of 6.2. To reflect the current household size, 4.3 is used (CBS, 2020) to estimate the annual useful energy required per household, which is 4.1 GJ (or 1140 kWh). The average value for the fuel cost to estimate sLCOC is used. e To estimate sLCOC for biogas, NRs 80,798 is used for 6 m³ capacity of a biogas plant with lifetimes of 20 years (AEPC, 2015), which is NRs 4000 per year plus the Levelized cost of biogas.

Even if fuelwood is collected for free, adding health-related costs associated with air pollution from its use and the opportunity cost of time spent collecting it, the fuelwood would most likely be the least economical cooking solution. Also, any costs related to the lack of availability, affordability, and reliability of cooking with biogas, LPG, and electricity are not considered. Further, biogas may not be feasible in some regions in the country, while the supply of LPG is frequently disrupted due to economic blockade and political instability. However, one interesting finding is that kerosene is the least economical cooking solution. With subsidies removed in 2014, the use of kerosene has dramatically declined in the country. Indeed, the recent MTF and CBS surveys find that households no longer use kerosene for cooking. Although biogas is the most economical option, it might have many limitations. For example, its initial investment is huge, and it requires 36−45 kg dung, an equivalent of 4 cows, to produce 1.6 m³ of biogas per day, which is good for cooking meals for a household with 5 people (AEPC, 2015). In the case of LPG, if the subsidy is removed, it will be less economical than electricity for cooking. Considering all these issues, our sLCOC analysis indicates that cooking with electricity is likely to be a promising clean cooking option.

4.3 High level of accessibility but low level of reliability and affordability of electricity use.

In recent years, Nepal has made excellent progress in improving access to electricity for its people. In just the last eight years, the percent of the country's population with access to electricity (grid and off-grid) increased from just over 28% 2000 to 94% 2018 (World Bank, 2020), and it is expected to reach 100% by 2024 (NPC, 2020b). Despite this improvement, Nepal's average household sector electricity consumption per person is one of the lowest in Asia. For example, in 2018, Nepal's per capita household electricity consumption (101 kWh) was less than half of India's consumption (207 kWh) and only about one-seventh of China's

consumption (704 kWh) (UNSD, 2021). Further, the electricity access is disproportionate across the regions and provinces in the country (Table 3). For instance, in rural areas, electricity from the grid and off-grid connections is still limited, even more so in provinces 6 and 7, where about half of the population currently does not have access to electricity. Another notable concern is that a significant proportion of the children who are enrolled in school still use kerosene lamps as the main source of light for study and homework.

The reliability of electricity is a concern. Households reported damage to their electric appliances caused by voltage fluctuations and frequent supply disruptions from grid-connected electricity, ranging from low of 4% of households in rural province 5 to high of 54% of households in rural province 2. Voltage fluctuations of off-gird electricity are even more severe across all the regions and provinces. There are also contrasting issues of affordability of electricity. On the one hand, a high percentage of households who do not have access to grid electricity is willing to pay for electricity connection, while a significant proportion of the households with access to electricity, both in rural and urban areas across the provinces, feel that their monthly electricity bill is a financial burden to the family (Table 3). These observations suggest that focusing only on increasing the proportion of households with access to electricity, as highlighted under the SDG7 initiative, may lead to misguided program and policy formulations to achieve the "electricity for all" goal set by the government. Both reliability and affordability of electricity must be prioritized as well by the government, especially in the regions and provinces where electricity from the grid is expected to expand in the future.

Table 3 Accessibility, reliability, and affordability metrics of electricity use by region and province in Nepal (% of total household)

	Rural							Urban							KTM *
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	
Access to electricity															
Grid	57	92	79	86	75	11	48	90	96	93	94	94	38	86	98
Off-grid	25	2	14	11	9	32	12	2	2	3	5	1	14	4	2
No electricity	17	7	7	2	16	57	41	8	2	4	1	5	49	10	0
WTP** for grid electricity	90	78	86	88	89	92	82	69	91	67	100	79	88	83	na
Kerosene lamp for study	28	57	12	32	12	9	28	25	57	4	31	23	7	37	na
EA damage (grid)	17	54	31	14	4	..	14	11	14	38	11	12	32	27	10
Voltage variation (off-grid)	81	..	88	71	68	25	61	53	..	..	..	100	38	44	na
Electricity bill burden***	24	34	11	21	19	25	53	31	47	15	17	17	15	46	27

*Notes: * KTM is Kathmandu valley, ** WTP is the willingness to pay, and *** Electricity bill burden is for grid-connected electricity. na is not applicable. Sources: (CBS, 2020; World Bank, 2019)*

4.4 Households' dilemma of fuel choice for their cooking and heating needs.

Unlike in many other countries, households in Nepal do not have many choices of energy sources for their cooking and heating needs. Solid biomass, mainly fuelwood, remains the main cooking fuel for most households. From more than two-thirds to as high as 90% of rural households in all provinces rely on fuelwood for cooking (Table 4). Even in urban households, cooking with fuelwood is significant, ranging from about 28% in province 3 to 82% in province 6. After fuelwood, LPG is ranked second for households' primary fuel choice for cooking, mainly in urban areas. Cooking with biogas and electricity is so far insignificant.

Table 4 Households' primary cooking fuels for cooking and heating by region and province in Nepal (% of total household)

	Rural							Urban							KTM*
	1	2	3	4	5	6	7	1	2	3	4	5	6	7	
Primary cooking fuels															
Fuelwood	79	63	77	76	80	96	90	54	50	28	36	48	82	71	5
LPG	13	16	20	22	15	2	5	40	40	68	59	45	17	22	94
Biogas	3	1	2	2	4	0	2	3	1	2	5	5	0	5	0
Electricity	0	1	1	0	1	0	1	0	1	0	0	1	0	2	1
Others*	5	19	1	1	2	1	3	4	8	1	0	1	1	0	0
Primary heating fuels															
Fuelwood	70	47	86	77	81	91	71	58	49	50	56	66	75	55	14
Others**	13	18	1	1	7	1	2	10	13	3	2	8	1	3	9
Electricity	1	2	1	3	1	0	0	3	4	8	4	2	1	1	23
None	17	32	12	20	11	8	27	29	35	40	38	25	23	41	54

*Notes: * Mainly agriculture waste and animal dung. ** Mainly agriculture waste, charcoal, lignite, and solar.*

Sources: (CBS, 2020; World Bank, 2019)

Households' reliance on fuelwood is likely to remain high unless collecting it for free from the forests declines and is available only for those who can purchase in the market. This will be challenging and even if households shift away from fuelwood, LPG and electricity are the only two fuel choices available for most households. LPG is a relatively clean and convenient fuel for cooking but it is not easily accessible and affordable for many rural households. Frequent supply disruptions and other risk factors, such as cylinder explosion and associated HAP, further complicate promoting LPG for cooking. Also, if subsidy for LPG is removed, it will less likely be used by households if alternative cheaper fuel choices are available. Since alternative fuel choices are limited, removing the LPG subsidy may push households back to using fuelwood unless electricity and biogas are available reliably and affordably. As for cooking fuel options, biogas and to some extent solar and bio-briquettes have limited expansion possibilities country-wide due to many geographical, technical, and financial constraints.

One interesting observation is the opposing trends of kerosene and LPG sales over the past 15 years (Figure 3). Kerosene subsidy reform in 2008 and the automatic petroleum products pricing mechanism in 2014 led to a sharp decline in kerosene consumption. This is evident from the MTF and MICS surveys that find households no longer using kerosene for cooking barring a few exceptions. Despite a steady rise in its retail price, LPG sales have increased at an average annual rate of 13% in the past 15 years. This increase in LPG demand is mainly driven by urban households having easy access, affordability, and most importantly, lacking alternative modern cooking fuels.
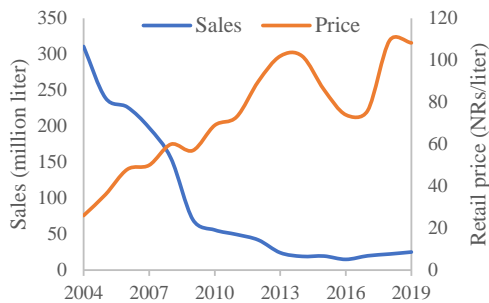

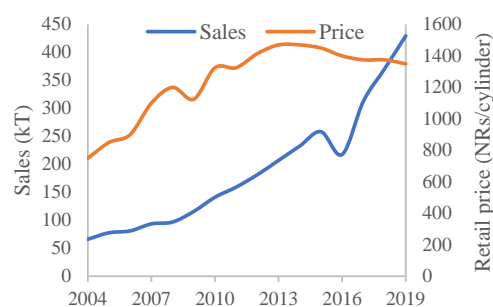Fig. 3a. Kerosene sales and retail prices   Fig. 3b. LPG sales and retail prices

Source: (NOC, 2021)
Fig. 3. Historical trends of kerosene and LPG sales and their retail prices (2004-2019).

There are some recent encouraging government steps towards making electricity accessible and affordable. Some of these steps include the allocation of NRs 4 billion for rural electrification under the "Bright Nepal" initiative in the budget speech of FY 2020/21 (MOF, 2020a). Further, under the alternative energy program, the government also allocated NRs 4.13 billion. One interesting and important step includes the provision for incentives for the use of electric appliances, including electric stoves. Also, the government has arranged to provide free electricity to households that consume up to 10 units per month, a 25% discount to those consuming up to 150 units per month, and a 15% discount to those consuming 250 units per month. This is an important step towards making electricity available for not only lighting but also for cooking.

4.5 Disaggregated energy consumption data and digitization is currently not available.

The Ministry of Energy, Water Resources and Irrigation (MoEWRI), the UN, and the IEA are the three primary sources of Nepal's energy consumption statistics. The official energy statistics are published through reports from three government institutions: the Water and Energy Commission Secretariat (Synopsis Report), the Ministry of Finance (Economic Survey), and the Central Bureau of Statistics (Statistical Yearbook). It is important to emphasize that these datasets should be available at the provincial level by urban and rural areas and by energy-consuming sectors to be more policy-relevant. The UN and the IEA also publish the country's annual energy consumption statistics. These data are available for different energy-

consuming sectors. The UN data is freely available, while the IEA data is available only for purchase.

Despite its importance in Nepal's energy system, the quality of available energy consumption statistics is poor and their geographical and sector coverage is limited. For instance, substantial differences and uncertainties exist in the country's fuelwood consumption statistics published by national (official) and international organizations. Depending upon the topography and the level of development of different regions of the country, there are wide variations in household fuelwood consumption ranging from 400 kg to 700 kg per person per year (Malla, 2021). Therefore, the concepts and definitions and the conversion factors used in estimating biomass energy consumption should be documented for meaningful comparison with other fuels. Energy data digitization is also lacking in the country. Most of the available energy data from government sources are in portable document formats which are very difficult and time-consuming for researchers, policymakers, and other end-users to dissect and process. These energy datasets must be made available by the government in a digital (computer-readable) format.

5. Policy recommendations

Nepalese households rely heavily on traditional biomass, mainly fuelwood, for their cooking and heating needs. It is a growing problem because using fuelwood for cooking is associated with many negative health and environmental impacts. Despite the government's efforts over the past two decades or so, households' transitions from biomass to clean energy have not picked up as expected. Many factors are attributed to such a slow transition to clean energy. The lack of alternative clean energy sources that are affordable and reliable is key among other factors. Fuelwood is still readily and freely available in many areas across the county and LPG use is mostly concentrated in urban areas with frequent supply disruptions. Other factors include unreliable grid and off-grid electricity supply due to frequent outages and voltage fluctuations and households' limited ability to pay for electricity bills, despite the percentage of people with access to electricity has improved in recent years. Also, cooking with biogas and solar is limited both in scale and geographic location.

As hydropower projects are expected to expand rapidly in the country, electricity will likely be the main clean energy cooking option in the future. However, the government will need to pursue decentralized and innovative clean energy policy efforts and initiatives that make electricity reliable and affordable for low-income households. Particularly, provinces 6 and 7 should be given top priorities, where the level of clean energy use by households is very low. Recent government initiatives, such as providing free electricity to low electricity-consuming households, and incentives for the use of electric cookstoves, are encouraging steps. Also important is the policy that targets awareness of clean cooking, including benefits related to health, gender, social, and time savings from moving away from fuelwood cooking. To measure the success of these efforts requires the availability of disaggregated good quality data of household energy use across all end-uses by region and province. The digitization data, which is currently lacking, is also necessary.

Funding

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