JOURNAL OF GENDER AND POWER

Vol. 15, No. 1, 2021

DOI: 10.2478/jgp-2021-0002

Bindu Shrestha
Tribhuvan University (Nepal)

Sudarshan Raj Tiwari
Asian Institute of Technology Management (AITM) (Nepal)

Sushil Bahadur Bajracharya
Tribhuvan University (Nepal)

Martina M. Keitsch
Norwegian University of Science and Technology (Norway)

Gender Roles on Energy Consumption for Sustainability: A Case of Kathmandu Urban Households

ABSTRACT. Sustainability has become a global topic and is pursued in all countries along South Asia—Nepal, that it has become part of the political agenda, specifically visible in Kathmandu, the country's capital. Household is one of the highest energy-consuming sectors, and women have a higher responsibility for household chores in most cases. However, women are still lagged in the energy sector. The energy studies are more focused on technical policy with limitations of the gender lens. This study analyzes energy, gender, and sustainability interlinkage as a common goal and identifies the economic, environmental, and social sustainability of energy consumption from a gender perspective in Kathmandu's. The findings show that female participation in energy decisions is likely to increase in female-headed families. Kathmandu urban women still have lack of knowledge, the right information, and affordability. The overall sustainability study indicates that the energy policy needs to be a gender-neutral policy. Conclusively, innovative technical interventions can be combined with the subsidy, increase women's participation to reduce inequality, encourage efficient cooking technology to reduce the nation's financial burden.

KEYWORDS: sustainability, energy, gender, household, quality of life, Kathmandu

Introduction

Energy and gender integration are still in policy debates for the last two decades. Most studies acknowledge that women's participation in

JGP 15(1), 2021: 23–54 © The Author(s), Adam Mickiewicz University Press, 2021.

the energy sector contributes significantly to achieving global energy efficiency goals for sustainable development (Oparaocha & Dutta, 2011; Clancy et al., 2016; Habtezion, 2016). Habtezion (2016) accentuates that energy acts as a blood vein in economic development and is considered crucial in accomplishing sustainable development goals (SDGs). The energy consumption pattern depends on diverse practices in everyday culture and settings (Barr & Prillwitz, 2013). Men and women have different roles and control over the resources within households. Household energy consumption in the world accounts for a 35% share of total energy, and household has proved the most gendered spheres of society in most cultures (Barr & Prillwitz, 2013; IEA, 2020). WHO's (2006) study identifies that women's low participation is a significant barrier in development. It denotes that women have a pivotal role in the transition towards sustainable energy practices as they are the primary energy users in the households (Milne, 2003). However, women are mostly ignored in energy-related decisions and industries, ignoring women's productive activities (Ceceiski, 1995; UNDP, 2014). It indicates the limitations of real energy users' information in energy-related activities generating the information gap between users and policymakers. It claims that gender information in energy decisions plays an essential role in sustainable energy; however, it has scant studies of gender relations and roles on economic, social, and environmental aspects related to energy consumption. This study attempted to highlight this stance and develop sustainable indicators at the contextual level with references to a global vision that identifies the actual Kathmandu context from a gender lens on the sustainable energy path.

Statement of Problem

In most societies of most countries, such as Nepal, household chores are taken as women's primary responsibilities. Numerous studies (Clancy et al., 2016; Habtezion, 2016; Oberhauser, 2017) have proved that modern energy services used in households have improved women's socio-economic status and improved health consequences. Recognizing the importance of the gender dimension in energy policies, the seventh SDG has prioritized proper access to clean and affordable energy as universal rights (United Nations, 2016). The fifth goal emphasized gender as an inseparable entity in energy justice for sustainability. Additional-

ly, it highlights that expanding energy access must go beyond meeting basic needs: improving economic take-off conditions. It emphasizes on innovation, sustainable consumption, and justice (Habtezion, 2016). Development research shows that increasing women's management participation can achieve a win-win situation for both women and policy management (Köhlin et al., 2011). It advises that women should have an equal role in energy decisions and accessibility in all development activities.

Nepal is one of the least energy-consuming countries globally; however, it has the highest energy intensity in South Asia—4.5 times higher than the world average, which is 1.8 times higher than India or China (ADB, 2013; IEA, 2019). In Nepal, the residential sector accounts for the largest energy consumption by 80%, and cooking holds the 60% energy use of total energy share (Nakarmi, 2018). Kathmandu city—Nepal's capital holds 22% of its total urban population (CBS, 2015) and is an ethnically diverse city. The city is accompanied by the complex urban problems of severe demand on resources that resulted in a frequent energy crisis, inequitable distribution, and environmental degradation. However, Kathmandu households have been managing the energy crisis by fuel stacking, and multiple fuel uses by women. Ultimately, it has added financial burden, the use of more space, and resulted in a low quality of life. In most parts of Nepal, energy is substituted using human muscles (somatic energy), particularly in household chores, such as washing clothes, cleaning, and grinding by women. Traditionally, men are considered the breadwinner, and women are managers of the house; when women also started to earn and work outside, still household chores are managed by women in most cases. Women must extend their skills in three different production areas: household work, child-rearing, and the economic sector. In those conditions, modern energy and technology can help them manage three production zones competitively and confidently in such a globalization context.

Historically, both men and women are considered as sources of empowerment as a representation of Shakti—male (power) and Prakriti—female (nature) in Hindu philosophy. Similarly, the equality concept can be acknowledged through the example of *Ardhanareshowr* in Hindu doctrine. However, the concept is rarely translated into energy-related decisions at the household and policy level. The Nepalese society is driven by patriarchy that is reflected in women's decision power.

Even after the three decades of Rio summit and Beijing conference of gender advocacy have accomplished, still, women are hardly seen in an equal position in the energy sector.

Half of the population are women in Kathmandu (CBS, 2015), and they are still lagging in exercising their rights, particularly in the energy decision-making sector. A gap of unequal voices on energy needs (ADB, 2015) and low participation in energy decisions may hinder the SDGs goal achievement. Gender has been aligned with sustainability; mainly, social sustainability demands gender equality in every activity (Dempsey et al., 2011; Shrestha et al., 2020). Keeping the gender lens in the energy policy can make it easier to succeed in a sustainable development goal of 5 and 7. Gender integration in the energy sector plays an essential role in the sustainability pathway. However, it has not been adequately combined in the energy policy of Kathmandu.

Research objective

The objective of this study was to examine economic, social, and environmental contexts of energy consumption in urban households from a gender perspective. It establishes the energy sustainability indicators placing gender views and investigates the actual level of energy sustainability while integrating gender and power role in sustainability. This study will help policymakers, the appliances industry, researchers, and gender experts to improvise and develop gender-neutral policy showing contextual SDG scenarios and showing the importance of gender role in energy policy.

Literature Review

Gender Perspective on Energy Sustainability and Indicators

The Brundtland Commission report in 1987 has introduced the term sustainability, highlighting resources consumption for present and future needs. More than 70 definitions and 500 concepts about sustainability exist (Carrera & Mack, 2010). However, the most popular category refers to the three-pillar ideas that define sustainability as a combination of economic, environmental, and social domains. It emphasizes that every ho-

usehold is accountable to the sustainability challenges for the conscious use of natural resources, maintain diversity, gender equality, reduce energy poverty and institutional inequities. The ultimate goal of sustainability is often defined in terms of human well-being or quality of life, limiting energy use.

According to Gatersleben energy use is a valid indicator to monitor human behavior on environmental impact (Gatersleben, 2001). The study shows that people worldwide used 1.5 kW of energy per capita or 36 kWh per day. However, sustainability does not mean to live below the comfort and facilities but should maintain quality of life with 30 GJ, which advises a balance of social and environmental consumption. People need to pay attention to their comfort, freedom, and entertainment to maintain quality of life, reducing environmental degradation. Despite a dependency of energy consumption on different socio-economic, demographic factors, such as household income, family composition, residence type, and location, numerous studies (Harris, 2003; Bentley & Leeuw, 2009; Santoyo-Castelazo & Azapagic, 2014) have recognized that the three significant bottom line of sustainability measures to the energy use pattern. Different constituencies have drafted the sustainability indicators, but none of them has presented appropriate contextual indicators for Kathmandu household energy consumption from a gender perspective. The sustainability condition of the energy consumption of Kathmandu urban households' actual scenario is explored here in three bottom-lined contexts. The indicators are identified with gender in central place are defined below.

Economic Sustainability and Indicators

Economic sustainability reflects an economic system that comprises inclusive institutions, gender-neutral policies, and functions to ensure a socially equitable society. The level of well-being is often reflected in per capita, gross domestic product (GDP) to uncover economic development. However, statisticians and economists argue that GDP does not represent the actual welfare level. Economic indicators of energy consumption levels link to welfare by the capacity of energy expenditure and household income (Gatersleben, 2001). It takes account of the financial condition and affordability of energy sources in households. Complying with Gatersleben' s concept, indicators are framed on a context basis. For instance, the energy intensity, use of renewable energy, and transformation of energy use are considered economic indicators because energy

use transformation results from income increment directly or indirectly. Previous studies highlight that the economic context implies clean energy's affordability in urban households (Harris, 2003; Bentley & Leeuw, 2009; Santoyo-Castelazo & Azapagic, 2014). Thus, it is crucial to increase electrical appliances and escalate the productivity of income generation. For instance, when women use higher electrical appliances instead of human muscles, they can use their time and effort in income-generating activities to support increasing their household and the nation's economic sustainability.

Environmental Sustainability and Indicators

Environmental sustainability in the household accounts significantly of direct energy used by end-users compared to indirect energy. Environmental sustainability considers natural capital supplemented by environment and conservation of energy; minimum resources use avoiding exploitation of it and maintaining a clean environment as human needs. This dimension ensures a healthy environment for dwellers within and outside buildings to elevate clean energy use for environmental balance. Environmental indicators criteria for household consumption are acquired from Spangenberg and Lorek's (2002) study, including energy use, source of energy, appliances use, and carbon emission (Fisk et al., 2013). The kitchen indoor air quality is a crucial aspect of environmental sustainability for women's health, which is investigated in this study.

Social and Gender Role in Sustainability Indicators

Social sustainability has a consideration of cultural aspects to value the social norms of society. It ensures fairness in the distribution of opportunities and gender participation within the household and policy level. It emphasizes that men and women are fundamental vehicles to increase equality using their different skills, knowledge, and experience. The previous studies have shown that substantial energy-efficiency could be achieved through technological and economic intervention without compromising the quality of life (Mills & Schleich, 2012; Cherp et al., 2018; Rosenthal et al., 2018). Levett (1998) has defined sustainability as the environment's limits, and the allocation of fair share is one of the measures in social sustainability. He suggests that instead of setting rules and options, innovative solutions can nurture social demands and needs. Gatersleben and Vlek (1998) have recognized that social indicator as com-

fort, health, safety, freedom, and social justice to maintain social and cultural values. The literature suggests that sustainability means the equality and essential role of gender participation in energy decisions that prioritize both men's and women's need to achieve the gender-neutral policy. It advises constructing indicators on a context basis to reveal the actual sustainability scenario. With this realization, the research framework has guided the exploration of sustainability in three-pillar aspects placing gender at a central place (Fig. 1). This study has explored the three pillars of sustainability in gender perspective in Kathmandu households' context and recognized the improvement sectors in the gender-inclusive concept of decision-making, skills, policy approach, and knowledge enhancement of energy, as shown in figure 1.

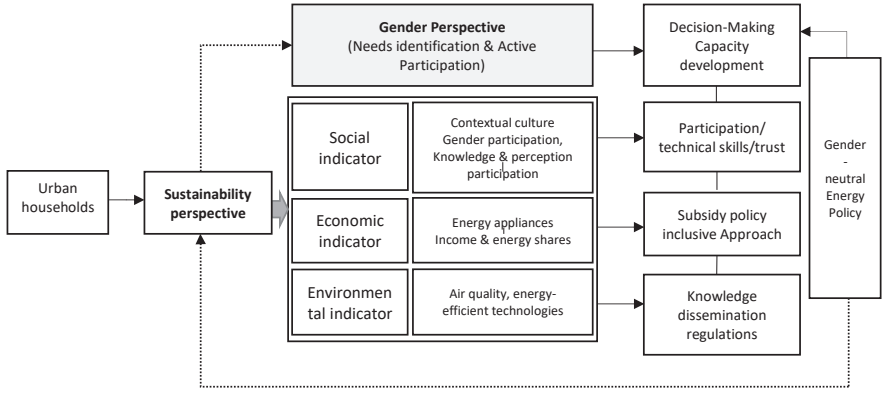

Figure 1. Research Framework on Sustainability from Gender Lens

Research design and methodology

This study is based on field observation, questionnaire surveys, and interviews about socio-economic demographics, household cooking culture, energy consumption, and the environment. The economic variables include energy-related appliances used in households, solar energy, and the relation between the householders' energy share and income. The social variables include gender participation in social events of local and neighborhood levels. Decision variables included purchasing decisions related to household basics, electrical appliances, and cooking fuel,

as shown in tables 3 & 4. The environmental variables include kitchen environment data: number of windows, exhaust fan, chimney air quality measurement, and comfort. The air quality test was done using Onset's HOBO MX1102 CO2 sensor in the cooking areas. It has a recording range: 0 to 5000 ppm and accuracy: ±50 ppm ±5% on a non-condensing environment. The 18 indicators were recognized from literature and contextual study: five in economic, twelve in social, and eight in environmental sustainability and explored in the three study layers (Annex A1). The cross-tabulation of those variables were employed in Statistical Package for Social Sciences (SPSS) to identify the percentage of sustainability indicators in three study areas. The results identified in percentage and counts were converted into a ten-point scale to obtain a sustainable level. The survey sample of 623 questionnaires was administered and analyzed from the SPSS in descriptive results. The qualitative analysis of interviews and observation was analyzed from ATLAS.ti, creating codes and network. The discussion and interpretation were obtained in a neutral voice relating to literature.

Selection of Study Area

Kathmandu city is the capital of Nepal—the world's 96th largest country by area. The study areas were identified in inner, middle, and outer-city as three layers based on urbanization and different socio-economic contexts for household surveys. The inner-city is mentioned as city layer 1, which history dates to 2000 years old, the primary domain of an indigenous group of Newar. The middle-city was urbanized highly between the 1980s and 2000s; inhabitants migrated from the nearby cities and moved from the inner-city.

As city layer 3—highly urbanized from the 2000s to the present and the primary domain of migrants from rural and nearby urban areas, the outer-city contained mixed ethnicities (Shrestha et al., 2020). The random stratified sampling survey was accomplished in 60 neighborhoods for diverse respondents, and air quality tests in the kitchen were done in six distinct households and fifteen for extended interviews. It is an ethnically diverse city that holds Newar as original ethnic group accounts—30%, Brahmin/Chhetri—28%, Rai/Limbu/Gurung accounts—21%, and other ethnicities are 14% of the population (GoN, 2019b).

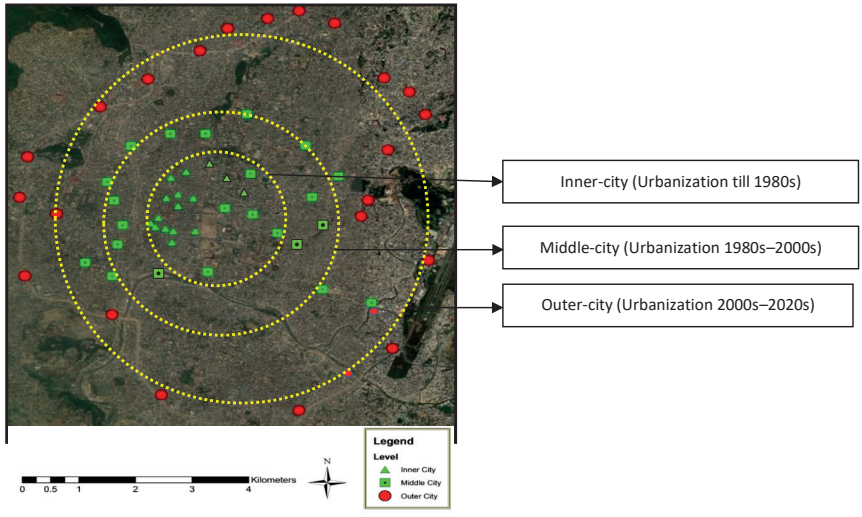

Figure 2. Selection of neighborhoods in three city layers

Air Quality Test Survey

HOBO sensor was placed in the cooking area at the height of 1.2 m from the floor level and 0.5-meter distance from the cooking area. The air quality test was done in rental and owner's households in three study layers to investigate scenarios of cooking culture, kitchen hoods, and design implications. Investigation in urban areas was challenging to take their time and access to their kitchen that took extended time and resulted in variation in data samples (Table 2). D2, D3, and D6 houses had 34, 9 & 31 sq. m, respectively, the area of spaces with two windows, exhaust fans, and chimneys (Table 1). It revealed that most of the self-owned household kitchens had ventilation, while rental spaces lacked ventilation and electric kitchen hoods. It illustrated that most of the rental kitchen did not have consideration of the cooking environment. Detailed of the indoor environment is listed in table 2.

Table 1. Detailed data of air quality tested households

Households	Area	Family members	Samples	Date	Temperature	Relative humidity	Air quality - CO2
D12	18 sq.m.	3	1428	1/31/19 to 02/15/2019	Temp. -10°C, -23°C	70%	Min. 367 ppm Max. 3683 ppm Avg. 603 ppm St. Dev. 241
D13	6 sq.m.	1	2344	02/15/19 to 02/23/19	Temp. -13°C, -18°C Avg. 14°C	77%	Min. 291 ppm Max. 2239 ppm Avg. 703 ppm St. Dev. 480
D8	22 sq.m.	3	2330	02/24/19 to 03/04/19	Temp. -15°C, -20°C Avg. 17°C	60%	Min. 343 ppm Max. 2521 ppm Avg. 519 ppm St. Dev. 314
D3	9 sq.m.	4	2890	4/10/2019 to 04/20/2019	Temp. Avg. 25°C	59%	Min. 340 ppm Max. 2266 ppm Avg. 623ppm St. Dev. 341
D2	34 sq.m.	5	7510	12/07/19 to 01/02/20	Temp. Avg. 13°C	68%	Min. 331 ppm Max. 1981 ppm Avg. 647 ppm St. Dev. 363
D6	31 sq.m.	5	4583	01/10/20 to 01/25/20	Temp. -11°C, 9°C, -16°C	75%	Min. 202 ppm Max. 1782 ppm Avg. 591 ppm St. Dev. 379

Results

Socio-economic Demographics

Table 3 represents the survey respondents' socio-economic and demographic data. In this study, the expenditure was considered to represent income groups because respondents expressed their expenditure transparently compared to income. (Assumption: the person who spends "x" amount of money means; he/she has "x" amount of income). Table 4, 5 & 6 display environmental, energy, and participation data based on a questionnaire survey.

Table 2. Urban household's profile

Socioeconomic and household variables		Counts (n)	Percentage (%)
Gender	Male	278	45
	Female	345	55
Age	18–35	205	33
	36–50	249	40
	Above 51	169	27
Education	Below 10 Grade	243	39
	10–12 grade	212	34
	Undergraduate	125	20
	Graduate and above	43	7
Expenditure groups	Below $200	119	19
	$200–$400	374	60
	Above $401	130	21
Property ownership	Male	326	52
	Female	172	28
	Joint	125	20
Family types	Joint	106	17
	Nuclear	485	78
	Single	32	5
Headship	Male	419	67
	Female	129	21
	Joint	75	12
Ethnicity groups	Brahmin/Chhetri	246	39
	Newars	260	42
	Rai/limbu/Tamang	60	10
	Others	57	9

Electric appliances users	1 to 5	100	16
	5 to 10	357	58
	11 to 15	146	23
	16 above	20	3
House type	Modern	527	85
	Traditional	39	6
	Mixed	57	9
Residence type	Own	364	58
	Rental	259	42

Table 3. Energy and environmental variables

Variables	Variables	Mean	Std. Deviation	Max.
Environmental	Number of hours in kitchen work	3.03	1.064	8
	Number of windows in a kitchen	0.87	0.801	5
	Number of appliances	9.12	3.767	26
Energy	Number of hours fan used.	2.23	2.160	12
	Electricity bill (Rs)*	1086	1215	18 000
	Cooking fuel (Rs)*	553	1138	5000
Participation	Social events	4.20	3.796	20
	Neighborhood/community events	2.38	4.117	48
	Ethnic/cultural events	1.50	1.533	8
	Friends gathering	2.49	3.104	24

* 1 USD = Rs. 120 (Nepalese rupees)

Table 4. Energy and environmental variables

Variables	Male (%)	Female (%)	Joint (%)
Minor Household	22	39	40
Health issues	22	24	54
Social involvement	27	27	46
Cooking fuel	25	33	42
Electrical appliances	25	15	60
Furniture/clothes	23	16	61
Property – Land/House	28	13	59

Table 5. Correlation of variables

Dependent variables with income	Correlation value (r)
Nos. of electric appliances Vs income	.48**
Monthly electricity bills	.35**
Monthly water bills	.32**
Total cooking hours	.31**
Monthly cooking fuel	0.43
Nos. of hours heating appliances used	.22**
Nos of hours cooling appliances used	.21**
Neighborhood events	0.068
Ethnic events	0.12**
Friends gathering	.088*

* $p < 0.05$
** $p < 0.01$

Economic Context and Energy Consumption

In this section, the economic condition was studied in terms of heating and cooling appliances uses and energy share of the household income.

Electrical heating and cooling appliances in the income group

The heating system's data in different expenditure groups demonstrated that the highest use of a heating system of electric and gas heater was found in the high-income group of outer-city dwellers by 68%. The lowest use of electric and gas heater was used in a low-income group of inner-city dwellers by 15%, as shown in figure 3. The dissimilarity trend was noticeable in the use of electric/gas heater among the high-income group of inner-city used by only 22% that was comparatively lower with middle-and outer-city layers (63% and 68%). The reason might be that the compact settlement pattern in the inner-city resulted in a warm environment and culture of clothing adjustment.

The data of space cooling appliances showed that electric fans were used extensively in all income groups in three city layers (Fig. 3). The highest percentage of electric fans were used (66%) by middle-income respondents of outer-city. The lowest use of electric fans was found in the low-income group of outer-city by 12%. The surprising trend of using

electric cooling appliances was noticeable, with a low correlation between using cooling appliances and income (r = .22) (Table 5). The high-income group of the inner and outer city used moderately less use of electric fans by 16% and 22%. Because of the lifestyle trend, they started to live in modern buildings with enough ventilations. The results showed that higher income had more significant use of heating appliances and less natural ventilation. The result revealed that income and heating appliances have a moderate positive correlation (r = .48, p < 0.01). The higher the income and broader use of appliances.

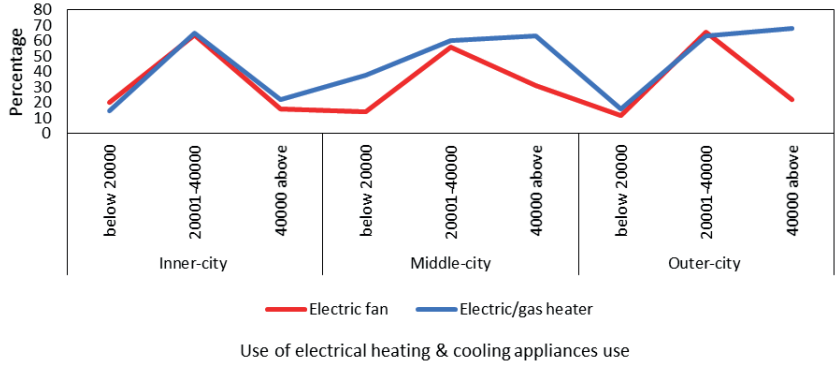

Figure 3. The relation between Heating and Cooling Appliances and Income

The data showed that the rental people used 6–7 number of electrical appliances, and people who had owned houses used more than 7 to 20 numbers of appliances (Table 1). The overall results demonstrated that the number of electrical appliances uses moderately correlated with the income group (r = .48, p < 0.01) that exhibited that lower the income, the use of electric appliances is lesser.

Clean Energy Use—Solar Energy

Solar Energy as a photovoltaic (PV) panels started to use in the last two decades in Kathmandu for lighting and bathing purposes due to the electricity crisis. The data showed that the higher use of solar panels was by the middle-income group of middle-and outer-city by 3.7% and 3.5% of total respondents (Fig. 4). of total respondents. It was due to higher installation costs that resulted in incredibly less acceptance in urban households.

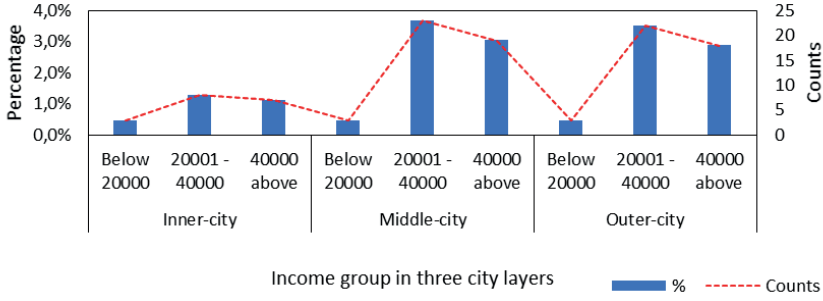

Figure 4. Use of solar use in different income groups

The data showed that 8% of Newar, 11% of male-headed families, 16% of modern households, and 15% of respondents who lived in their own house used solar Energy (Fig. 5). It represented that middle-income dwellers' Newar ethnicity demonstrated renewable energy knowledge and practiced with a quality of life even in the energy crisis. It implies that renewable energy as solar is influenced by headship, ethnicity, building types, and ownership variables. Simultaneously, female-headed families have low affordability for solar energy.

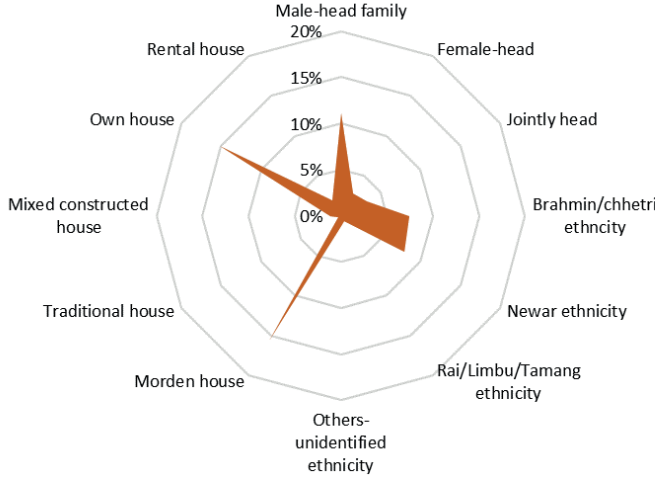

Figure 5. Solar Energy uses in different variables

Income and Energy Share in Urban Households

Figure 8 shows that energy use is an economic indicator from household expenditure on fuel and electricity in urban households. The indicator demonstrated that the affordability of energy uses that amplified disparity in the city. It illustrated the share of income spent associated with energy services at each level of income. The low-income group spent 13%, middle-income by 6%, and high-income group by 3% of their total share of income on household energy expenditure (Fig. 6). The results indicated that society segments with lower income used a larger share of their monthly income for household energy needs. The overall results showed that low-income women suffered from energy scarcity and spent more time in income generation activities. They had limited appliances and used human muscles instead of appliances.

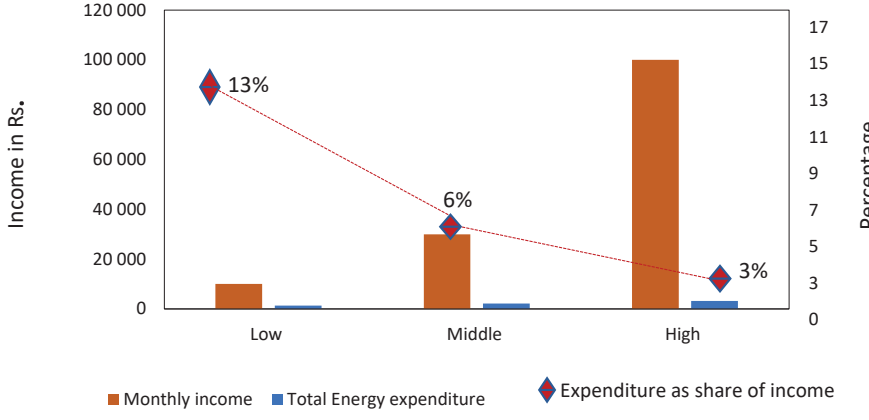

Figure 6. Average income and monthly household energy cost share

The Social Context of Energy Consumption

In this section, social sustainability indicators elaborate on a contextual way of life, customs, values, aspirations, knowledge, and participation of men and women in energy decisions. The twelve different micro indicators are analyzed under four categorized social indicators.

Contextual Culture of Energy Use

The social phenomena in terms of celebration of festivals, cultural activities have a crucial role in energy consumption. The data showed that Newars had higher energy-intensive activities of celebrating festivals and gatherings in-home; for instance, eight significant events—local, ethnic, and friends' gatherings occurred monthly at home compared to other ethnicities, as shown in figure 7. Additionally, Newars had a tradition of serving cooked food in social events, which usually ranged from five to fifteen items. It displayed that social gatherings and cultural festivals were the energy-intensive activities that had influenced the energy use pattern. It demonstrated that inner-city's Newars spent 20–25% more cooking hours per month than the average food culture. Rai/Limbu/Tamang ethnicity had low social events. The findings exhibited that the monthly energy bill of Newars was 18% higher than Brahmin/Chhetri of inner-city, 24% higher than Rai/Limbu/Tamang, and 13% than other groups.

Similarly, Newars of the middle-city spent 20% higher than Brahmin/Chettri and Rai/Limbu, and other groups. Simultaneously, Newars of the outer-city spent 1% lesser than other unidentified ethnicities; however, higher than the remaining groups (Table 2). In Newar culture, women were highly responsible for cooking foods. Newari women are highly involved in energy-intensive activities.

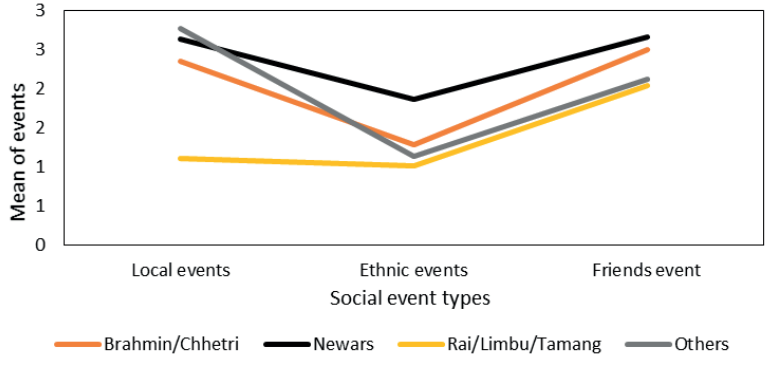

Figure 7. Average monthly social activities number at home

Gender Participation in Social Activities

The participation of men and women in different social activities varied in different ethnicities. The result showed that 42% of females from Brahmin/Chhetri, 33% of females from other unidentified ethnicities, were involved in social activities compared to males of the same group (Fig. 8). In contrast, 51% of males from Newars and 27% of males from Rai/Limbu/Tamang had higher participation than females of the same group in the social events. It also resembled that Newari women were less involved in outdoor social activities but busier on internal household activities.

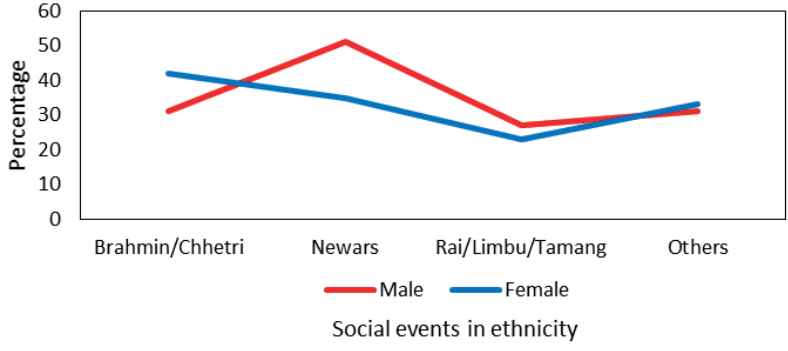

Figure 8. Gender Participation in Social Activities and Events in Different Ethnicities

The results of a higher percentage of Brahmin/Chhetri women in social activities demonstrated a broader social opportunity. Simultaneously, the observation findings showed that the venue of social activities had been changed. For instance, historically, all the festivals and gatherings occurred within the home, but later, the venues had been taken place to restaurants and party palaces. The results showed that the food vendors had gained a commercial market due to the celebration trend transformation. Besides, cleaner energy, for instance, LPG and electric cooking in households, reduced women's drudgery. However, only a limited number of women have gained this opportunity.

Knowledge and Perception

The knowledge of clean energy use and efficiency practice has a significant role in achieving social sustainability. The rainwater harvesting

trend was higher in the Newar group (13%), inner-city dwellers (8%), male-headed families (12%), modern houses (17%) living in their own house (16%) (Fig. 9). The lowest rainwater harvesting was found in rental dwellers (5%), traditional houses (2%), and other unidentified ethnicities. The reason for it might be that unidentified people were migrants living in rental spaces, did not have built a rainwater collection system in the building, and lived in a single room without a terrace. It revealed that residency type, headship, and building design construction method influenced the rainwater harvesting trend and behavior.

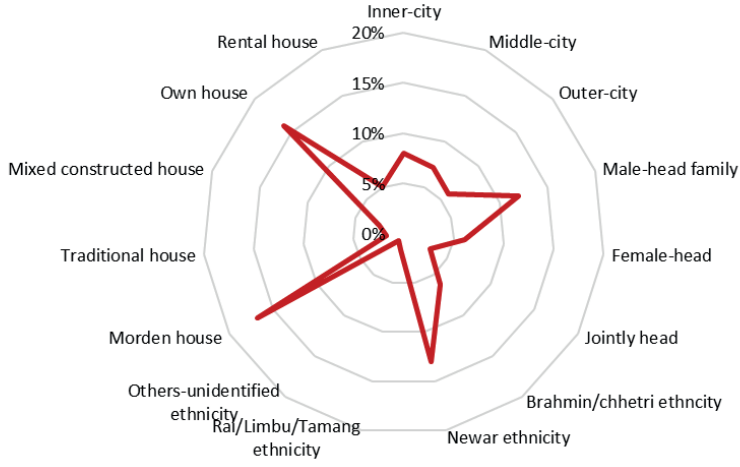

Figure 9. Rainwater harvesting in different variable

Women's Participation in Energy Decisions

In the participation of minor household decisions, joint decisions scored a higher percentage in inner-and middle-city by 41% and 44%, respectively. At the same time, female decisions were increased by 44% in middle-city households. The increased number of females in household decisions as jointly and singly reflected the indicators of social responsibility. The electrical appliances and cooking purchase decisions were increased in three city layers by 47% to 67% and 38% to 43% (Fig. 10). The results showed that urban households had a trend of joint decisions in most household decisions representing expanding social sustainability levels.

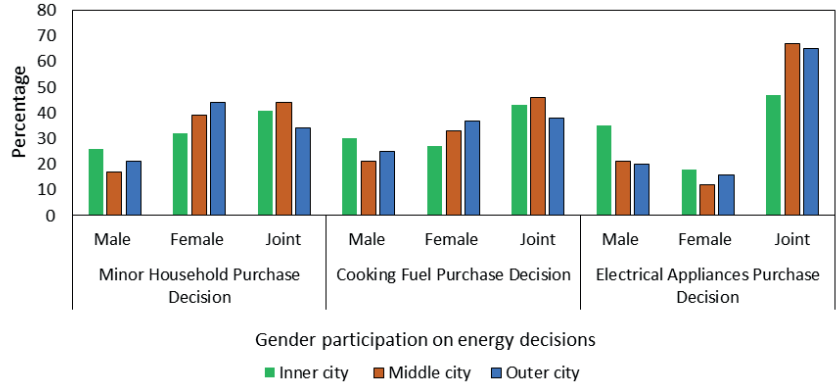

Figure 10. Decision participation in cooking fuel purchase—influences of various variables

Environmental Context of Energy Consumption

The environment context of urban households is described here as the kitchen environment in terms of ventilation and electric kitchen hoods to reveal space's air quality. The study showed that higher energy consumption in the households and women were highly involved in cooking activities. Thus, the kitchen was taken as a significant study place in the household in this paper.

Use of electric kitchen hoods and ventilation

The use of exhaust fans and chimneys were higher in modern buildings compared to traditional and mixed buildings. The data showed that 23% of modern buildings contained exhaust fans, and 22% consisted of chimneys, while the traditional building contained exhaust fans only by 0.3% and chimneys by 0.16%. Mixed buildings contained 2% of exhaust fans and 1% of chimneys (Fig. 11). The observation and findings indicated that most new buildings consisted of kitchen hoods and proper ventilation to achieve a healthy kitchen.

The inner-city respondents used exhaust fans by 5% and chimneys by 4%, respectively. The middle-city respondents used exhaust fans by 10% and chimneys by 11%, respectively. Similarly, outer-city respondents placed exhaust fans and chimneys by 10% and 11%, respectively (Fig. 11). Overall, the use of exhaust fan and chimney in the kitchen was found higher in the owned household by 20% and 21% compared to ren-

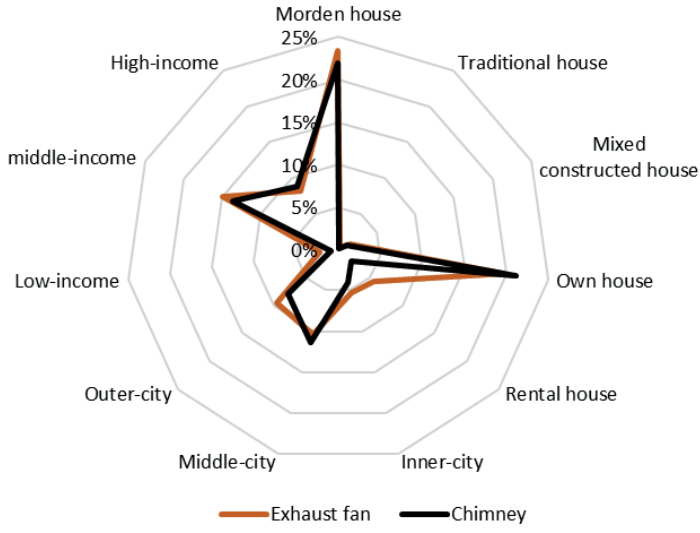

Figure 11. Use of exhaust fans and chimney in various building types

tal households' kitchens. Besides, natural ventilation is indispensable in cooking a person's comfort and maintaining hygiene. The results showed that urban kitchens without windows were found by 37%, in inner-city, and having a single-window by 71%. The results showed that women of inner-city neighborhoods were in unhealthy windowless kitchens. Only a single window contained cooking spaces that could ultimately result in health consequences in long-term effects.

Kitchen environment/air quality of cooking space

WHO standards and American Society of Conditioning Engineers (ASHRAE) has provided ventilation standards to maintain a level of CO2 and suggested to have windows open for fresh air flow and healthy air quality. Carbon dioxide level has potential health issues when it will be above 1000 ppm (Fisk et al., 2013) and impact human decision level.

The cooking culture and ventilation positions impact on air quality of the kitchen. The tested households had maximum air quality in terms of CO2 level above 1000 ppm, and the highest was 3683 ppm in D12 (Fig. 12). The average level was 603 ppm, as shown in Figure 17. However, this household had an average (2–3) cooking culture but showed a high CO2 level.

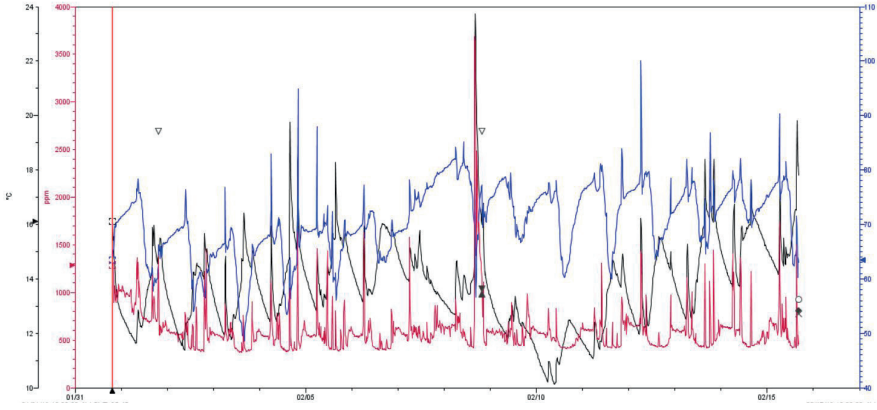

Figure 12. Indoor air quality in the kitchen of D12 household

It might be because of the cooking area's improper ventilation position, lacking kitchen hood, and exhaust fan. In comparison, the D6 household demonstrated a maximum of 1782 ppm and an average of 591 ppm. The lower value of CO2 resulted from cross ventilation of two windows and a modern chimney (Fig. 13).

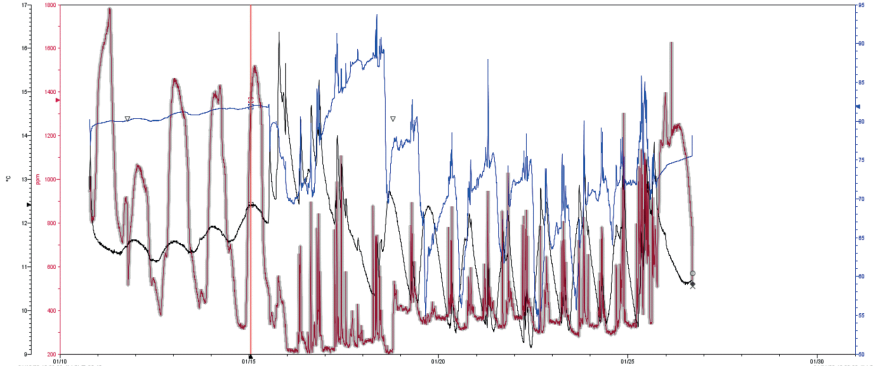

Figure 13. Indoor air quality in the kitchen of D6 household

The results demonstrated that cooking culture might impact increasing CO2, but the kitchen's air quality can be improved, placing modern chimneys and ventilation room design. It was found that the kitchen's air quality was poor with high CO2 in the windowless cooking area and lacking kitchen hoods. Women stated eye irritation and mild respiration

during cooking, but they considered normal during cooking. It showed that not only women, remaining family members, were less aware of the kitchen's air quality standards.

Sustainability Level

Comparing three study city-layers in three pillars of the sustainability concept of economic, social, and environmental with contextual indicators has been defined in the literature. The results showed that middle-city used higher energy use. The middle-and outer-city started using solar energy, and it had assisted in achieving a Sustainable Development (SD) value of 56 (Annex A1 & A2). Similarly, inner-city was prevalent in cultural activities and fuel stacking nature keeping extra cylinders. The female participation in EAP is higher compared to middle-and outer city layers. SD value of inner-city was 50. In contrast, joint participation in EAP and clean cooking were higher in the middle-city layer than in the rest of the study areas. Meanwhile, the awareness and knowledge of rainwater harvesting and female participation in CFP were higher in the outer city. It resulted in the middle-and outer city having gained social sustainability values of 56, and the inner-city achieved only 48 (Annex A1 & A2).

It was apparent that cooking culture influence the air quality of the kitchen in some context. The ventilated kitchen, use of exhaust fans/chimneys were extensive in the middle-city. While comfort feeling during cooking and clean energy use were expressed higher among outer-city dwellers, the presence of windowless kitchen. The sustainability values showed that the outer and middle-city households received the same SD of 70, and inner-city achieved 50 points (Annex A1 & A2). The low SD score of the inner-city was due to high cooking culture and a lack of ventilation and kitchen hoods. The overall score with additional values of economic, environmental, and social aspects of inner-city epitomize to low energy sustainability (49 points), outer-city (58), and middle-city (61) has ranked higher among three. The overall SD values of Kathmandu achieved 56 points combining three aspects in the gender lens. The middle-city achieved higher values. The reason for it underlined higher gender participation in energy decisions.

Discussions

As asserted by Gatersleben (2001), Masera et al. (2000), Bisu, Kuhe and Iortyer (2016), and Muller and Yan (2018), multiple fuel use does not always ensure awareness about energy-saving compelled to use mixed fuels and resulted in the fuel stacking model in three city layers. It created a social gap between rich and poor within the same neighborhood due to the corrupted market. This gap has a greater impact on women for daily basics. Consistency with Barr & Prillwitz (2013), Gatersleben (2001), and Lutzenhiser (1992), social sustainability is strongly based on culture and practice. In Kathmandu, electric appliances had been increasing extensively, particularly in the middle- and higher-income groups, for instance, electric heater and fans, but it was used consciously for limited hours only. The natural ventilation and wearing clothes in layers were practiced as an adaptation model in Kathmandu for extreme weather. It had demonstrated that culture and belief still entrenched in Kathmandu urban dwellers in energy use and saving practice.

Aligned with Davis (1998), Gatersleben and Vlek (1998), Levett (1998), and Nasir, Murtaza and Colbeck (2015), ownership demonstrated a significant role in energy uses and saving behaviors. The results showed that joint decisions were higher in all categories except in female-headed families. Female-headed and low expenditure households had higher involvement of females in energy purchase decisions. It revealed that when the women had financial power in hand, they could decide to buy what they wanted for the home. The urban households, women's power in decision-making is still low due to low ownership in the property.

In contrast to Mills and Schleich (2012) and Rosenthal et al. (2018), the use of clean technologies as solar energy could not establish as remarkable energy-saving behavior in the Kathmandu urban households. However, at least, it had facilitated to achieve a quality of life in fewer households. The electricity crisis had edified solar energy knowledge and practiced to some extent. However, the inhabitants were found less eager to continue it. Rental and low-income respondents could not afford it because of the higher cost and inaccessibility to the sunspaces. Solar energy use remains only for the high-and middle-income group.

Clancy et al. (2016), Gatersleben (2001), Habtezion (2016), and Oberhauser (2017) claim that modern energy services with electric appliances use have improved women's socio-economic status by reducing the time and effort involved in households' chore and this is also perceived same

in Kathmandu. The increasing use of electric appliances was reinforced to reduce urban drudgery and enhance new kitchen culinary recipes in a limited time. Besides, men also started to help with the kitchen chores. Besides, environmentally, kitchen design and culture had been improved due to electric kitchen hoods for better air quality. In contrast, the air quality results showed the inner-city kitchen environment, especially in the rental spaces lacking ventilation, exhaust fans, and chimneys. Simultaneously, few studies showed that poor air quality of the rooms or increased CO2 concentrations adversely impacts decision making performance. Fisk et al. (2013) study showed that people who stayed below 600 ppm have higher decision-making capacities. People living with less ventilation demonstrated health problems frequently with low decision capacity.

Sustainable development 2019 report showed that Nepal was ranked in 103 positions with 68 SD scores (Bertelsmann Stiftung & SDSN, 2019). In comparison, this study of Kathmandu city obtained 56 scores. This difference in scores might be because this analysis had combined only 5 and 7 SDGs goals in the integration approach rather than considering seventeen goals. The findings indicated that energy accessibility and gender equality are still challenging for both the city and national contexts. Most researchers' studies (Pokharel, 2004; Shahi, Rijal & Shukuya, 2020) showed that Nepalese households used electricity, only 50 MJ/household/monthly or 90–100 kWh that is relatively lower than in developing and developed countries. It is worthy of using less energy. However, social sustainability suggested that it is equally critical to achieving the standard of quality of life, as discussed by Gatersleben and Vlek (1998), Carrera and Mack (2010), and Santoyo-Castelazo and Azapagic (2014). It is essential to balance quality of life using energy-efficient appliances in households holding habitual saving behavior. Women, particularly, have a lower quality of life, and it implies improving overall comfort to women, and they can participate in economic development.

Economic sustainability showed that high-income group spent more than low-income groups, but shares were low due to high-income affordability power. These conditions are perceived in most developing and in-lined with research by Harris (2003), Santoyo-Castelazo and Azapagic (2014), and Van der Kroon et al. (2013). It increased a disparity in society when there was no subsidy for low-income that continues a vicious cycle, creating a rich and poor gap. However, the use of appliances has been increasing compared to the last decades, but women are still lagged in technical knowledge, capacity development, and quality of life.

Conclusions

This study shows a strong relation of economic sustainability to energy use representing a moderately positive correlation (r = .48) between energy consumption and income. The lower-income group uses a larger share of their monthly income for household energy needs and use unclean cooking fuel. The most urban kitchen lacks a chimney, exhaust fan, and ventilation that directly impact women who used to cook every day. Female participation has been increasing in the form of joint energy decisions. However, females are still less vocalized in technology-related decisions, even in urban households. Environmental indicators demonstrate that lower-income groups' females suffer from unhealthy cooking space due to unawareness and unaffordability for the electric kitchen hoods. Kathmandu's overall score is quite low (56 points) and resembles that the city still so far to go on the sustainability goal on energy and gender integration concept. It suggests that women should be encouraged to participate in the technology movement. Proper information dissemination is essential for integrated energy policy to reduce gender inequality, maximizing clean energy to achieve a better quality of life. Gender-blind energy policies have resulted in women's low social positions and hinder sustainability goals. Women are still ignored for new technology awareness for upscaling household chores and capacity development and have a low voice in energy decision due to cultural and gender identity with different socio-economic conditions. Kathmandu urban women still subordinate status in society. Conclusively, gender and energy have a broader impact on sustainability than current research has shown so far, and it should be further investigated in different related variables.

REFERENCES

ADB (2013) *Energy Outlook*. Manila.

ADB (2015) *Gender review of national energy policies and programmes in Nepal*. [Online] Available from: https://energia.org/assets/2016/05/Gender-Review-NEPAL.pdf. [Accessed: 15 January 2021].

BARR, S. & PRILLWITZ, J. (2013) Household analysis: researching "green" lifestyle a survey approach. In: *Methods of sustainability research in social sciences*. 1st ed. London: Sage. Pp. 29–47.

BENTLEY, M. D. & LEEUW, B. de (2009) Sustainable consumption indicator. In: Bawa, K. S. & Seidler, R. (eds.) *Dimesions of sustainable devlopment*. UK. Pp. 339–366.

BERTELSMANN STIFTUNG & SDSN (2019) *Sutainable Development Report 2019: Tranformations to achieve the SDGs*. New York.

BIGGART, N. W. & LUTZENHISER, L. (2007) Economic sociology and the social problem of energy inefficiency. *American Behavioral Scientist*. 50(8). Pp. 1070–1087. DOI: 10.1177/0002764207299355.

BISU, D. Y., KUHE, A. & IORTYER, H. A. (2016) Urban household cooking energy choice: an example of Bauchi metropolis, Nigeria. *Energy, Sustainability and Society*. 6(1). Pp. 1–12. DOI: 10.1186/s13705-016-0080-1.

CARRERA, G. & MACK, A. (2010) Sustainability assessment of energy technologies via social indicators: Results of a survey among European energy experts. *Energy Policy*. Elsevier. 38(2). Pp. 1030–1039. DOI: 10.1016/j.enpol.2009.10.055.

CBS (2015) *Population Atlas of Nepal*. Kathmandu. [Online] Available from: http://repositorio.unan.edu.ni/2986/1/5624.pdf. [Accessed: 15 June 2020].

CECEISKI, E. W. (1995) From Rio to Beijing. Engendering the energy debate. New perspectives on energy. *Energy Policy*. 23(6). Pp. 561–575.

CHERP, A. et al. (2018) Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework. *Energy Research and Social Science*. Elsevier. 37 (November). Pp. 175–190. DOI: 10.1016/j.erss.2017.09.015.

CLANCY, J. et al. (2016) *Mainstreaming gender in energy sector practice and policy: lesson from the ENERGIA international network*. UK. Department for International Development.

DAVIS, M. (1998) Rural household energy consumption: the effects of access to electricity, *Energy Policy*. 26(3). Pp. 207–217.

DEMPSEY, N. et al. (2011) The social dimension of sustainable development: Defining urban social sustainability. *Sustainable Development*. 19(5). Pp. 289–300. DOI: 10.1002/sd.417.

FISK, W. J. et al. (2013) Is CO2 an indoor pollutant?: Higher levels of CO2 may diminish decision making performance. *REHVA Journal*. (October). Pp. 63.

GATERSLEBEN, B. (2001) Sustainable household consumption and quality of life: the acceptability of sustainable consumption patterns and consumer policy strategies. *International Journal of Environment and Pollution*. 15(2). Pp. 200–216. DOI: 10.1504/IJEP.2001.000596.

GATERSLEBEN, B. & VLEK, CH. (1998) *Green Households: Domestic Consumers, the Environment and Sustainability*. 1st ed. ed. K. J. Noorman & T. S. Uiterkamp. New York.

GoN (2019) *Nepal's Profile*, *Ministry of Foreign Affairs*. [Online] Available from: https://mofa.gov.np/about-nepal/nepal-profile/. [Accessed: 15 June 2020].

HABTEZION, S. (2016) *Gender and sustainable energy: training module 4*. New York. [Online] Available from: https://www.undp.org/content/dam/undp/library/gender/Gender and Environment/Training Modules/Gender_Climate_Change_Training Module 4 Sustainable Energy.pdf [Accessed: 15 June 2020].

HARRIS, J. M. (2003) Sustainability and Sustainable Development. *International Society for Ecological Economics* (February). Pp. 213–233. DOI: 10.4324/9781315442044-11.

HUEBNER, G. M. et al. (2015) Explaining domestic energy consumption—The comparative contribution of building factors, socio-demographics, behaviors and at-

titudes. *Applied Energy*. Elsevier Ltd. 159. Pp. 589–600. DOI: 10.1016/j.apenergy.2015.09.028.

IEA (2019) *The Energy Progress Report*. Washington. [Online] Available from: https://trackingsdg7.esmap.org/. [Accessed: 15 June 2020].

IEA (2020) *Energy and gender*, *International Energy Association*. [Online] Available from: https://www.iea.org/topics/energy-and-gender. [Accessed: 1 June 2020].

KÖHLIN, G. et al. (2011) Energy, Gender and Development. What are the Linkages? Where is the evidence? *World Bank Policy Research Working Paper*. (125). Pp. 1–63. DOI: 10.1596/1813-9450-5800.

VAN DER KROON, B. et al. (2013) The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and Sustainable Energy Reviews*. Elsevier. 20. Pp. 504–513. DOI: 10.1016/j.rser.2012.11.045.

LEVETT, R. (1998) Sustainability indicators—Integrating quality of life and environmental protection. *Journal of the Royal Statistical Society. Series A: Statistics in Society*. 161(3). Pp. 291–302. DOI: 10.1111/1467-985X.00109.

LUTZENHISER, L. (1992) A cultural model of household energy consumption. *Energy*. 17(1). Pp. 47–60. DOI: 10.1016/0360-5442(92)90032-U.

MASERA, O. R. et al. (2000) From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model. *World Development*. 28(12). Pp. 2083–2103. DOI: 10.1016/S0305-750X(00)00076-0.

MILLS, B. & SCHLEICH, J. (2012) Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries. *Energy Policy*. Elsevier. 49. Pp. 616–628. DOI: 10.1016/j.enpol.2012.07.008.

MILNE, W. (2003) Women, Energy and Sustainability: Making Links, Taking Action. *Canadian Woman Studies*. 23(1). Pp. 55–60.

MULLER, C. & YAN, H. (2018) Household fuel use in developing countries: Review of theory and evidence. *Energy Economics*. Elsevier BV. 70. Pp. 429–439. DOI: 10.1016/j.eneco.2018.01.024.

NAKARMI, A. M. (2018) 'Energy Scenarios: Harnessing Renewable Energy for Sustainable Development and Energy Security in Nepal'.

NASIR, Z. A., MURTAZA, F. & COLBECK, I. (2015) Role of poverty in fuel choice and exposure to indoor air pollution in Pakistan. *Journal of Integrative Environmental Sciences*. 12(2). Pp. 107–117. DOI: 10.1080/1943815X.2015.1005105.

OBERHAUSER, A. M. (2017) Gender and development. *Gender and Development*. Pp. 1–157. DOI: 10.4324/9781315870878.

OPARAOCHA, S. & DUTTA, S. (2011) Gender and energy for sustainable development. *Current Opinion in Environmental Sustainability*. Elsevier BV. 3(4). Pp. 265–271. DOI: 10.1016/j.cosust.2011.07.003.

POKHAREL, S. (2004) Energy economics of cooking in households in Nepal. *Energy*. 29(4). Pp. 547–559. DOI: 10.1016/j.energy.2003.10.015.

ROSENTHAL, J. et al. (2018) Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals. *Energy for Sustainable Development*. Elsevier Inc. 42. Pp. 152–159. DOI: 10.1016/j.esd.2017.11.003.

SANTOYO-CASTELAZO, E. & AZAPAGIC, A. (2014) Sustainability assessment of energy systems: Integrating environmental, economic and social aspects. *Journal of Cleaner Production*. Elsevier Ltd. 80. Pp. 119–138. DOI: 10.1016/j.jclepro.2014.05.061.

SHAHI, D. K., RIJAL, H. B. & SHUKUYA, M. (2020) A study on household energy-use patterns in rural, semi-urban and urban areas of Nepal based on field survey. *Energy and Buildings*. Elsevier BV. 223, 110095. DOI: 10.1016/j.enbuild.2020.110095.

SHRESTHA, B. et al. (2020) Gender differences in household energy decision-making and impacts in energy saving to achieve sustainability: A case of Kathmandu. *Sustainable Development*. DOI: 10.1002/sd.2055.

SPANGENBERG, J. H. & LOREK, S. (2002) Environmentally sustainable household consumption: From aggregate environmental pressures to priority fields of action. *Ecological Economics*. 43(2–3). Pp. 127–140. DOI: 10.1016/S0921-8009(02)00212-4.

UNDP (2014) UNDP Gender Equality Strategy 2014–2017. The Future We Want: Rights and Empowerment. *United Nations Development Programme*. Pp. 36.

United Nations (2016) *Sustainable development goals: Metadata*, *Sustainable Development Goals*. [Online] Available from: http://www.un.org/sustainabledevelopment/poverty/. [Accessed: 15 June 2020].

WHO (2006) *Fuel for life: Household Energy and Health*, *Energy*. Switzerland. [Online] Available from: http://www.who.int/indoorair/publications/fuelforlife.pdf. [Accessed: 15 June 2020].

Annex

A1: Energy sustainability indicators checklist in three city layers

Economic aspects of energy consumption

SN.	Description	Inner-city	Middle-city	Outer-city
1	Proportion of income and electrical appliances use	Low-income – 7 (24%) Middle-income – 10 (61%) High-income – 11 (15%)	Low-income – 7 (17%) Middle-income – 9 (59%) High-income – 12 (25%)	Low-income – 6 (18%) Middle-income – 9 (60%) High-income – 11 (22%)
2	Electric fan	68%	61%	53%
3	Electric/gas heater	27%	39%	39%
4	Vacuum cleaner	28%	41%	36%
5	Solar use	17%	42%	41%
6	Income and share of energy cost proportion	Low-income – 13% Middle-income – 7% High-income – 4%	Low-income – 14% Middle-income – 7% High-income – 4%	Low-income – 11% Middle-income – 6% High-income – 3%

Social aspects of energy consumption

SN.	Description	Inner-city (%)	Middle-city (%)	Outer-city (%)
1	Context – Energy-intensive activities	30 (Nos)	12 (Nos)	10 (Nos)
2	Aspiration of new technology – shifting	50	41	44
3	Crisis management (extra cylinders)	22	20	20
4	Crisis management (Induction)	6	5	5
5	Crisis management (LPG + induction)	2	4	3
6	Crisis management (Kerosene +LPG)	3	2	1
7	Crisis management (fuelwood)	4	5	5
8	Knowledge of Rainwater Harvesting	15	22	24
9	Female Participation in CFP	27	33	37
10	Female Participation in EAP	18	12	16
11	Joint Participation CFP	43	46	38
12	joint Participation EAP	47	67	65

Environmental aspects of energy consumption

SN.	Description Use of electric kitchen hoods	Inner-city (%)	Middle-city (%)	Outer-city (%)
1	Exhaust fan	21	41	38
2	Chimney	17	49	34
3	Energy use (LPG + induction)	3	5	7
4	Energy use (LPG)	82	85	82
5	Gender role in kitchen work (Joint)	25	39	36
6	Cooking culture	73	62	63
7	No. of Windows (two windows)	3	14	9
8	Air quality of kitchen (CO2) based on test -poor	50	30	20
9	Comfort feeling during cooking -gender	31	36	33
10	Kitchen design without window	24	33	37

A2: Sustainability score in three city-layers

Economic Sustainability Checklist

SN.	Description	Inner-city	Middle-city	Outer-city
1	Use of electrical appliances	6	6	5
2	Electric Cooling system use	4	4	5
3	Electric heating system	8	7	7
4	Vacuum cleaner	3	5	4
5	Solar use	2	5	5
6	Number of appliances	5	5	5
7	Income and share of energy cost proportion	7	7	8
	SD Values Obtained out of 100 score	**50**	**56**	**56**

Social Sustainability Checklist

SN.	Description	Inner-city	Middle-city	Outer-city
1	Culture – Energy-intensive activities	4	8	9
2	Aspiration of new technology – shifting	6	5	5
3	Crisis management (extra cylinders)	8	9	9

4	Crisis management (Induction)	6	5	5
5	Crisis management (LPG+ Induction)	2	4	3
6	Crisis management (Kerosene+ LPG)	8	9	2
7	Crisis management (fuelwood)	1	2	2
8	Knowledge of Rainwater Harvesting	8	7	6
9	Female Participation in CFP	2	3	3
10	Female Participation in EAP	2	2	2
11	Joint Participation CFP	5	6	4
12	joint Participation EAP	5	7	7
	SD Values Obtained	**48**	**56**	**48**

Environmental Sustainability checklist

SN.	Description	Inner-city	Middle-city	Outer-city
1	No. of Windows	5	9	8
2	Exhaust fan	3	5	4
3	Chimney	2	5	4
4	Gender role in kitchen work	3	5	4
5	Cooking culture	7	8	8
6	Energy use (fuel use)	6	7	8
7	Air quality of kitchen (CO2)	5	8	9
8	Air quality comfort feeling	5	8	9
9	Social events	7	9	10
10	Kitchen design problem	7	6	6
	SD Values Obtained	**50**	**70**	**70**