Assessment of Ecological Footprint of Urban Squatter and Non-Squatter Settlements: A Case Study of Kathmandu Valley, Nepal

Pratistha Pyakurel[1], Ramesh Raj Pant[1*], Sadhana Pradhanang[1], Kiran Bishwakarma[2], and Archana Ghimire[3]

[1] Central Department of Environmental Science, Institute of Science & Technology, Tribhuvan University Nepal

[2] Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China

[3]Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, China

***CORRESPONDING AUTHOR:**

Ramesh Raj Pant
Email: rpant@cdes.edu.np

ISSN : 2382-5359(Online), 1994-1412(Print)

DOI:
https://doi.org/10.3126/njst.v21i2.62359

Date of Submission: 12/10/2021
Date of Acceptance: 31/01/2023

ABSTRACT

This research attempted to understand the variation in the ecological footprint of squatter and non-squatter households in terms of the cumulative environmental behavior index (CEBI). A hybrid footprint measurement tool was built considering the principal factors affecting ecological footprint (EF). The correlation between settlement type (squatter and non-squatter) and the EF (as measured by the mean CEBI) was tested using the Pearson product-moment correlation coefficient. Knowledge, attitude and behavior of people regarding the environment sustainability were studied through questionnaires and field observation. The average CEBI of non-squatter settlements was found to be significantly more than that of squatter settlements. Squatter households in the sample had a statistically significantly lower environmental impact (in terms of energy and water consumption) than non-squatter households ($p<0.01$). The highest contribution to the total CEBI was from the food sector, followed by waste production. People's attitudes towards the environmental sustanability varied and most of the squatter households had no clear opinion. Knowledge of environment-friendly practices were found comparatively more in non-squatter households. A majority of the respondents were ignorant about renewable energy. Identification of factors mainly responsible for increasing footprint is needed to design interventions for promoting sustainable development. The findings from this research will be useful for urban planners and other concerned professionals to make amends in sector policies for the sustainable development.

Keywords: Environmental Behavior Index, Ecological footprint, Correlation coefficient, Environment-friendly practices, Settlement type

1. INTRODUCTION

The science of Ecological Footprint (EF) is a comparatively new and emerging topic of concern. The United Nations Conference on the Human Environment in 1972 stressed the need to preserve the environment, and the report "Our Common Future" published in 1987 introduced the concept of sustainable development. The need for a tool that measures humanity's consumption against nature's supply was felt. This led the science of EF to flourish in the 1990s. The EF is "a means of comparing consumption and checking this against nature's ability to provide for this consumption" (Cui & Yu 2009). According to the Living Planet Report of 2012, we have been using 50 % more resources than the Earth can provide, and unless we change the course that number will grow very fast by 2030. Nepal's Status Paper presented at United Nations Conference on Sustainable Development (Rio+20) explains that Nepal's EF has already crossed its biocapacity despite its low carbon emission (National Planning Commission 2011).

Environmental footprint indicators track emissions as well as the usage of natural resources. These are pertinent for evaluating regional dynamics since they concentrate on the use of resources and pollutants brought on by human activity. For a thorough understanding of environmental challenges, policy formulation, and the evaluation of trade-offs between various environmental concerns, it is crucial to integrate various ecological footprints such as water footprint, energy footprint, built-up land footprint, etc, into a cogent framework (Vanham *et al*. 2019). The amount of water utilized in relation to human consumption is termed as the "water footprint." The four main direct elements that affect a country's water footprint are its consumption pattern, amount of consumption, climate, and agricultural practices (Hoekstra & Chapagain 2006). Understanding how various human activities and goods contribute to water scarcity, pollution, and related effects, as well as what can be done to ensure that activities and products do not contribute to the unsustainable use of freshwater, is made easier by assessing the water footprint (Hoekstra *et al*. 2011). The infrastructure for housing, transportation, and industrial output, as well as hydroelectric power projects, is included in the built-up land footprint (Holden 2004a). Planning for housing and land use is crucial for attaining sustainable consumption and lowering the ecological impact of private consumption (Høyer & Holden 2003).

Few studies have been done regarding people's lifestyle and their accountability for the environment in Kathmandu, the capital city of Nepal. The city constitutes well built-up settlement areas as well as squatter settlements. Since lifestyle varies with settlement type, EF may vary accordingly. Identification of factors mainly responsible for increasing footprint is needed to design interventions for promoting sustainable development. Controlling and managing the expanding EF is not possible without an in-depth study of the subject. But due to limited study, the dynamics of EF, particularly the key factors inbuilt core urban and squatter settlements, is not clearly understood.

The broad objective of this research is to assess the ecological footprint of urban squatter and non-squatter settlements in ward number 29 of Kathmandu Metropolitan City. The research focuses on understanding the factors that weigh down the ecological footprint in general and in each type of settlement; finding out the comparision between Cumulative Environmental Behavior Index (CEBI) of urban squatter and non-squatter settlements and identifying the gaps in local knowledge, attitude and practice that influence ecological footprint.

2. MATERIALS AND METHODS

2.1 Study Area

It is argued that the EF concept, in general, does not focus on the possibilities at the regional/local level, with studies concentrating on national or city footprints (Ryan, 2004; Aall & Norland 2005). This study was conducted in 2014 and concentrates more on community-level analysis. The chosen study area is ward no. 29 of Kathmandu which represents a stratified society and offers a good prospect to study the difference in environmental performances. It has an area of 218.6 ha (Ward Profile, Ward No. 29, Now Ward No. 26 of the Kathmandu Metropolitan City). The map of the study area is given in Fig.1.

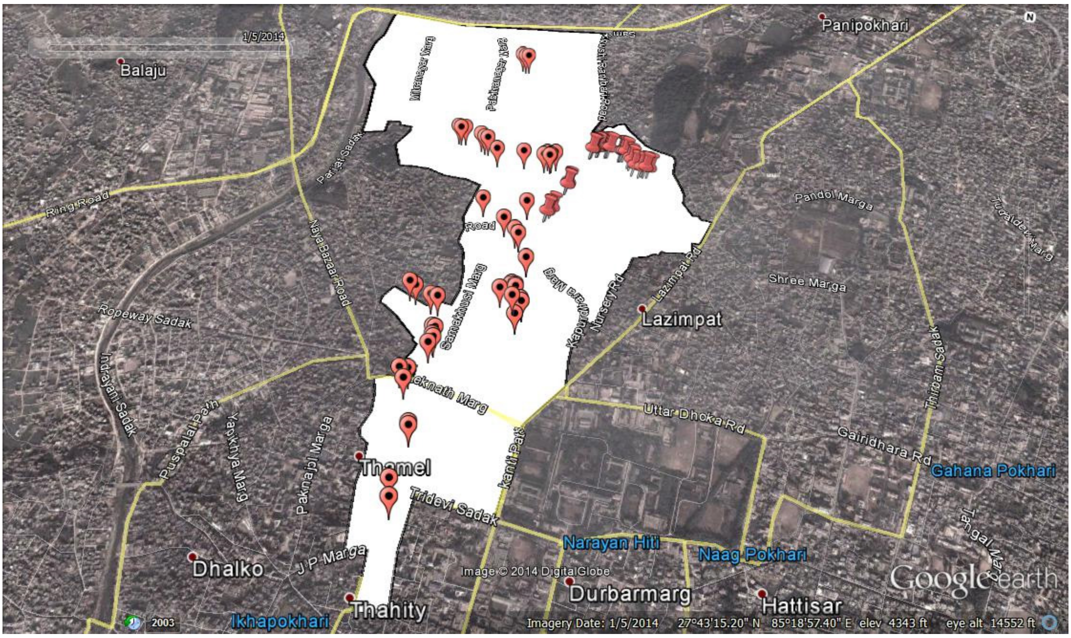

Fig.1. Map showing study area and sampled households, Kathmandu, Nepal

The ward has some scattered squatter settlements, mostly in Ranibari. The total population of squatters is 227 living in 45 households with an average household size of 5 (Lumanti 2008). Communities are considered "squatter settlements" because of a fundamental lack of land rights (Little 2012).

2.2 Data Collection

For the household survey, the study area has been divided into squatter and non-squatter settlements. The samples were divided proportionately among the settlements. A total of 77 samples were taken for household survey with 95% confidence level and 5.0% sampling error as prescribed by de Arkin and Colten (1963) of which 29 were squatter households. The household questionnaire survey was the main tool for gathering primary data to fill the CEBI form and to gather information about people's knowledge, attitude and practice regarding the environment. A preliminary study was carried at the end of November 2013. CEBI table formed the basis for the household survey. The passive observation was used mostly for photographs and understanding the study area settings.

A hybrid footprint measurement tool was built considering the principal factors affecting EF after a thorough review of existing established and published standard questionnaires for EF calculations (Bhattarai and Gurran, 2011, Brody and Ryu, 2006, Chambers *et al*. 2000). Components like agricultural land, water, waste, transportation, energy and built-up areas were considered for calculating ecological footprint (Ewing *et al*. 2010). The questionnaire was modified to suit the unique conditions of the study area. The parameters examined in the survey along with the scoring method for deriving an environmental behavior index are summarized in Table 1. Secondary data were collected from a review of relevant literature.

2.3 Methods of Results Presentation

Data were analyzed with the help of SPSS 26.0 software. Origin lab 2018 was used for preparing graphs. Google Earth was used for maps. In order to track the houses, Android OSMTracker was used. Shapiro-Wilk test for normality test (Razali & Wah 2011) and Pearson product-moment correlation coefficient for biological research (Puth *et al*. 2014) were used for statistical analysis.

Table 1. Cumulative Environmental Behavior Index (CEBI) calculation matrix

CEBI	EF Measure	Environmental Behavior Index Score				
		1	2	3	4	5
1	Building Type	Terrace Houses Apartment		Free Standing House		
2	Building Size (sq ft)	up to 250	251-500	501-1000	1001-1500	1501 and above
3	Electricity Usage (KWh)	Up to 50	51-100	101-150	151-200	201 and above
4	Water Usage (liters/month)	Up to 5000	5001-10000	10001- 15000	15001-20000	20001 and above
5	Meat and Meat products Con-sumption	Never	Once a week or less	Few times a Week	Often	Very Often/Every meal
6	Processed food	Very little	One quarter	Half	Three quarters	Most of the items
7	Self grown food	All	More than half	Half	Little	None
8	Waste (Kg/week)	Up to 5	6 to 10	11 to 15	16 to20	21 and above
9	Recycle Waste (%)	81-100	80 to 61	60 to 41	40 to 21	20 to 0
10	Public transport usage	All the time	Frequently	Half of the time	Rarely	Never
11	Flying	Never	Once a year	About once in 6 months	About once in 3 months	About once a months
		11	22	33	44	55

Source: Pyakurel (2013), derived from Bhattarai (2011), Brody-Ryu (2006), Høyer -Holden (2003), Klinsky *et al* (2009), Simmons *et al.* (2000), Wackernagel-Rees (1996)

3. RESULTS AND DISCUSSION

3.1 Comparison of CEBI in Terms of Settlements Type

Greater CEBI implies a higher ecological footprint. In this study, the average CEBI of urban built-up settlement in the study area was found to be 30.33 whereas the same for squatter settlement was 27.76. In both types of households (squatter and non-squatter), the same factors weigh down the EF, which suggests that these communities can benefit from the same interventions to reduce their EF. Pearson product-moment correlation coefficient analysis showed that the squatter households in the sample have a statistically significant lower environmental impact (in terms of their dietary patterns, energy and water consumption, waste generation, and patterns of transportation) than non-squatter households ($p<0.01$).

3.2 Factors That Weigh Down the EF in General

The highest contribution to the total CEBI was from the food sector – 16.86% of CEBI is attributed to the consumption of food bought from the market instead of growing it themselves and 13.80% to the consumption of processed food. The second factor responsible for increasing CEBI was waste. 16.66% of the total CEBI rise was because people did not recycle their wastes. Addressing these two issues can bring a significant change in footprint.

3.3 Factors That Weigh Down the EF in Each Type of Settlement

On average, non-squatter households has an excess score in building size by 24.44%, in electricity usage by 19.50%, in water usage by 19.50%, in waste produced per week by 17.33% and in total transport including flying, and in building type by 2.68%. On the other hand, squatter settlements scored 2.73% more on the recycling component which indicated that on average, they recycled less. They also scored slightly higher in the 'self-grown food' component (0.84% more) which showed they grow less food by themselves. The contribution by components in percentage is given in Fig. 2.

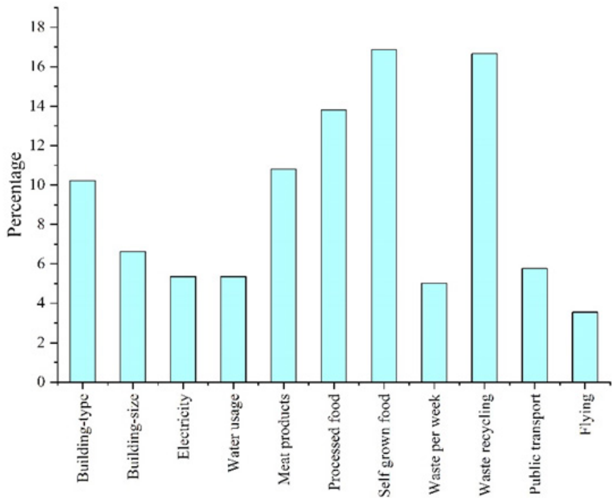

Fig. 2. Percentage of Ecological Footprint Components

3.4 Building Type and Size

In the non-squatter settlement, all houses were free-standing whereas in squatter settlement, the case was found in 96.55%. Families in the squatter settlement occupied only up to 250 sqft whereas,in non-squatter settlement, the majority of the family (39.58%) occupied 251 to 500 sqft. It is assumed that the built-up areas have replaced the croplands since human settlements are usually situated in the most fertile landscape areas (Hudeková *et al.* 2007). Because housing standards are rarely strictly adhered to in squatter communities, individuals live in unsafe and overcrowded situations. Squatters are extremely sensitive to occurrences and conditions that pose a threat to their lives because they frequently reside close to waste disposal sites (Bhattarai & Conway 2010). Housing that is concentrated and dense leaves fewer environmental footprints. This is because sparsely inhabited areas have enormous buildings that have a substantial impact on consumption patterns (Holden 2004a). According to Holden's (2004b) research, "green footprints" are 30% smaller than their "ordinary" counterparts. This is because green homes consume less energy and materials overall, leaving a smaller ecological impact than conventional homes.

3.5 Electricity Usage

The energy footprint is the largest and the average electricity consumption (50 kilowatt hour per month) was consumed by 79.31% of squatter households and 54.17% of non-squatter households. There is no much difference in electricity consumption which may be attributed to the power shortage problem in the country during the time of the survey. Although there is a virtual reduction in electricity footprint in the non-squatter settlement as a result of a power cut, some portion is added to the footprint of product consumption such as candles and generators which is not included in this study. Through energy conservation and efficiency initiatives, the energy footprint could be decreased. The ecological footprint would be further diminished by the use of more renewable energy sources, such as wind and solar (Klein-Banai & Theis 2011). The monthly electricity consumption in kW/h in both the settlements is given in Fig. 3.

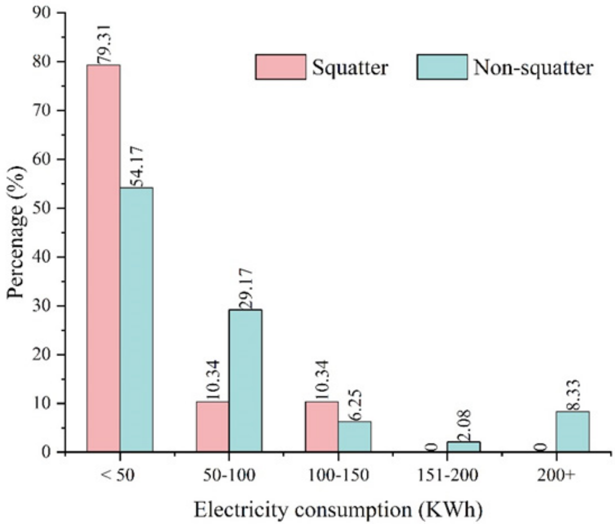

Fig. 3. Monthly electricity consumption in kW/h

3.6 Water Usage

Majority of the squatter households (89.66%) consumed water only up to 5000 liters/month. On the other hand, households using more than 20000 liters/month all belonged to the non-squatter community. For the most part, essential water supply and sanitation services have been ignored for squatters, and slum dwellers. The awareness level on water quality among the squatter dwellers is very poor (Phuyal *et al*. 2019). Also this divide is most probably due to the variation in sources of water. Non-squatter households are the highest users of groundwater. Since groundwater is free once a pump is installed, people are more inclined to use water extravagantly. In the absence of a monitoring mechanism, groundwater is being rapidly exploited. In addition, better income has allowed non-squatter households to buy water from private suppliers as well. Water Footprint (WF) analysis improves the knowledge of how scarce water is on a global, regional, and national scale. Investigating the application of WF tools enhances comprehension of the connections between water resource management and economic development planning (Chapagain & Tickner 2010). The water usage (liter/month) is given in the Fig. 4.

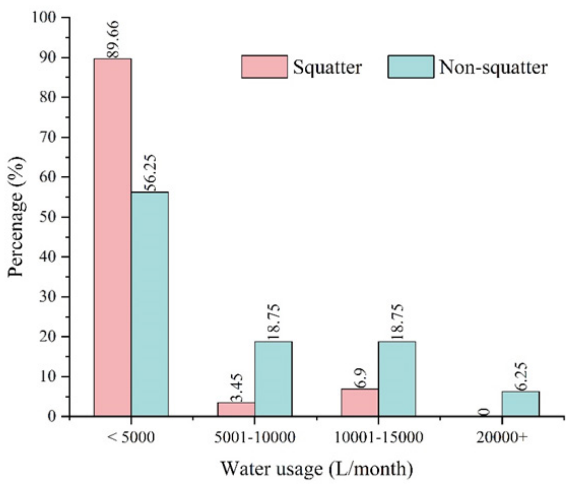

Fig. 4.Water usage in liter/month

3.7 Food

The impact of dietary habits on the environment as a whole is significant (Hoekstara 2015). Even though studies have been done focusing at the influence of diet type and meat consumption, but there is a need to look into the trend of diets' effects on the environment (da Silva *et al*. 2021). Eating meat and meat products once a week was the most common trend in both types of settlements. Interestingly, many squatter households ate meat more than once a week, as most of them were involved in meat and liquor selling business. Since the animal based food contributes more to the food footprint, so it is important for analyzing the variation in the amount of animal based food consumed by the people (Ryan 2004). An American study showed that "the meat-based food system requires more energy, land, and water resources than the lacto-ovo-vegetarian diet" (Pimentel & Pimentel 2003). A large portion of the food footprint is contained in imported goods, but still cities can undertake designs and policy interventions such as increased nutrient recycling and food waste reduction to reduce the food footprint (Goldstein *et al*. 2017). The trend of meat product consumption in both the settlemetns is given in the Fig. 5.

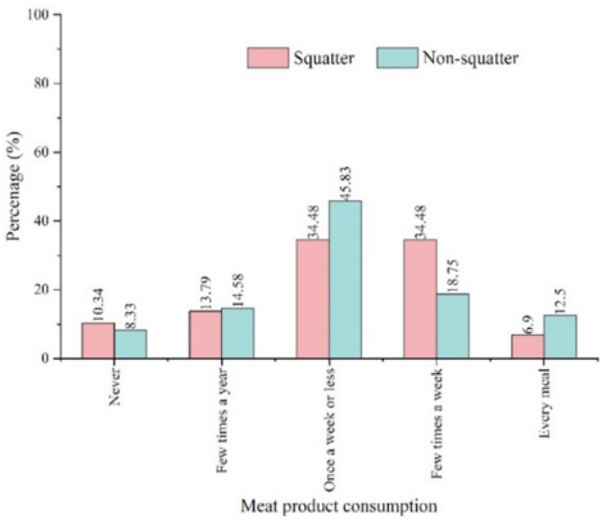

Fig. 5. Meat product consumption

On average, only a few households consumed self-grown food. This may stem from the fact that most houses do not have enough space for farming. However, people still can choose to grow some food on the rooftop or verandah and buy local produce to reduce EF. In the study area, agricultural land is being plotted and sold for building purpose. It is vital to preserve current agricultural plots from being converted into built-up land. The practice of importing "cheap" agricultural products from other countries may reward in short term but presses for conversion of local agricultural land into urban uses and "reduces both regional and global carrying capacity by facilitating the depletion of the total stock of natural capital" (Rees & Wackernagel 1996).

3.8 Waste Production

The ecological footprint's next major contributor is materials and waste. Ecological footprint of waste is important for evaluating the waste produced and managed at a particular place (Vološinová & Ansorge 2021). Waste produced ranged from 5 to 10 kg per week. While 75.9 % squatter households produced wastes no more than 5 kg per week, 66.70 % non-squatter households produced wastes ranging from 6 to 10 kg per week. This result shows that the majority of squatter and non-squatter households recycle hardly 0 to 20% of waste. Interestingly, a greater number of households in the non-squatter settlements were engaged in waste recycling. In non-squatter settlement, 96.6% households recycled 0-20% of wastes while 3.4% recycled

61-80% of wastes. In squatter settlement, households recycling 0-20, 21-40 and 41-60% of wastes were 87.50, 4.17 and 8.33%, respectively. Since using more recycled materials would reduce the amount of garbage produced, less raw materials would require more energy and area to produce, and less land would need to be used for landfilling (Ryan 2004). The data obtained from the study also suggest that people are (i) unaware of the benefits of "reduce, reuse, and recycle" (ii) confused about is achieved iii) not motivated enough. Whatever be the case, the reduction of the waste can be realized through household efforts like composting of organic fraction, waste recovery and so on (Dangi *et al*. 2011).

3.9 Public Transport Usage and Flying

Ecological footprint can be considered effective tool for calculating the overall effects of various activities, such as transportation, caused by diverse vehicle traffic (Shayesteh *et al*. 2014). In both types of settlements, the majority of the people used public transport all the time. This trend was more pronounced in squatter settlements where 69% of households used public transport all the time. 10.42% of households from the non-squatter community used public transport half of the time. When services are available close by, people are not forced to travel long distances to get their work done which significantly reduces transport footprint. It was found that the use of cycle was mostly limited to parents teaching their children to cycle. Since there are issues regarding road safety, so very fewer people tend to use cycle as their means of transportation. People were mindful of the benefits of sustainable transportation and the issues with traffic, but their awareness had little bearing on whether or not they chose to buy a vehicle (Flamm 2006). Nepal needs to come up with an integrated framework on pedestrian road safety, urban planning and transport infrastructures that will promote sustainable urban modes of transport in the country (Clean Air Network Nepal 2010). None of the households in squatter settlement reported flying. Planning for land use and transportation is made easier by examining the ecological footprint of transportation (Chi & Stone 2005). The use of public transport (%) is given in Fig. 6.

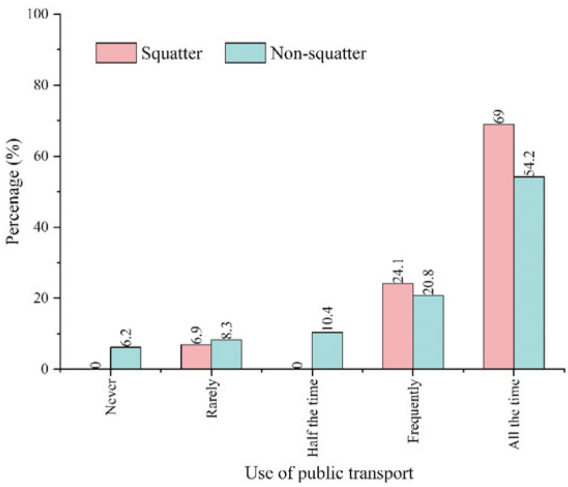

Fig. 6. Use of public transport

3.10 Knowledge, Attitude and Practice Regarding the Environment

The study showed a positive correlation between education and CEBI. The prerequisite for working to reduce EF is adequate awareness regarding environmental conservation. 66.7% of squatter respondents and 79.3% of the non-squatter respondents were not clear about the term renewable energy. Interestingly, some respondents claimed to know it but when asked, they came up with wrong examples or definitions. A part of the problem may be that our education system does not emphasize enough environment-friendly behavior and are more problem-centric than solution-centric. Effective environmental education may aid students in connecting with and focusing on environmentally friendly behavior by incorporating ecological footprint activities into the curriculum (Cordero *et al*. 2008). Also people's travel habits, acceptance of transportation policy initiatives, and discoveries about important indications of people's intention to minimize their use of private vehicles are all influenced by people's demographic traits and attitudes. There is the need of raising public knowledge of traffic issues and the perceived advantages of sustainable transportation as a viable strategy for lowering the usage of private vehicles (Xia *et al*. 2017).

Upon being enquired whether industrial development and protection can go hand in hand if planned properly, a surprising majority of the respondents (58.62%) in squatter settlement were neutral about it whereas 56.20% in non-squatter settlement choose to agree. A staggering 77.10% of non-squatter settlements and 62.10% of squatter settlements did not harvest rainwater in terms of environmentally friendly practices. Human consumption and water use, as well as global trade and the management of water resources, have hidden connections. To demonstrate the significance of human consumption and global aspects in sound water management, the idea of water footprint is required (Galli *et al*. 2012). Due to their economic and social status, non-squatter households are able to purchase water. Low-income households assist in reducing energy use, whereas middle- and high-income households experience a different situation. In high-income households, consumption-related environmental challenges predominate (Poumanyvong & Kaneko 2010). Hydropower for lighting and solar power for heating were the two most popular uses of renewable energy. The level of knowledge of renewable energy in both the settlements is given in Fig. 7.

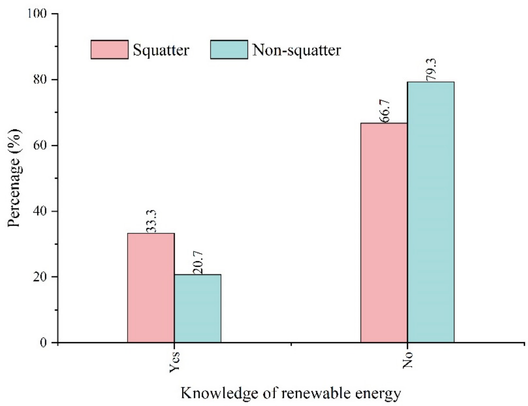

Fig. 7. Knowledge of renewable energy

Currently, known methodologies of footprint calculation at the local/urban level do not include sufficient size of green areas as one of the basic indicators of ecological stability of territory (Hudeková *et al.* 2007). In this study, households with the green patch were recorded and found to be miserably less i.e., 12.5 for non-squatter and 10.34 for squatter settlement. Interestingly, households with green patches were found in clusters. This hints that establishing green patch in a house encourages the neighboring houses to do the same, like a fashion or a competition. Urban areas not only destabilize the ecosystems they are a part of but also unbalance the sustainability of the entire globe (Rees & Wackernage 1996). Comparing the footprint of a given population in a discrete area with the amount of biologically productive space available to that population provides a way to estimate whether or not a population's consumption is sustainable (Venetoulis & Talberth 2010). It was noted that the agricultural land in the study area were being rapidly plotted and sold for building construction. First and foremost, local government must implement a proactive policy to safeguard the existing agricultural land plots. A country's economic efficiency also depends on appropriate land use planning since it lessens reliance on transportation. The goal of urban planning should be to promote diversified land use and avoid sprawl (Labib *et al*. 2014). To achieve global sustainability, the appropriate initiatives must be taken because environmental challenges are largely driven by population expansion, modernization, and changes in land use (York *et al*. 2003; Wu 2008).

4. CONCLUSION

This study showed the relationship between settlement type (squatter or non-squatter) and people's environmental behavior or EF expressed as Cumulative Environmental Behavior Index (CEBI) of ward number 29 of Kathmandu metropolitan city. In terms of CEBI, squatter households have lower EF (27.76) compared to non-squatter households (30.33). The findings showed considerable variations in the consumption patterns amongst different households implying that both types of households need to be studied to identify environment-friendly practices. At the government level, developing a mechanism for regular EF and CEBI analysis, creating awareness for a sustainable lifestyle and developing a sustainable certification system could help check the EF of households. At the household level, being informed and consuming sustainably, adopting the "reduce, reuse and recycle" principle and gardening to produce certain food at home could be beneficial in reducing EF.

ACKNOWLEDGMENTS

The authors are thankful to the Central Department of Environmental Science, Institute of Science and Technology, Tribhuvan University (TU) for providing the necessary facilities. Thanks to the Second Higher Education Project (SHEP), TU for financial support. Our thoughtful appreciation goes to Mr. Amit Bhattarai and the organization Lumanti for their cooperation. I am thankful to the respondents and everyone who helped in fieldwork.

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