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Examining the Relationship Between the Selected Demographic Parameters and Consumer Lighting Behavior in Energy Saving

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Abstract
Energy consumption in itself is not behavior, but rather a consequence of behaviors, such as turning the lights off or lowering thermostat levels. The consumer behavior is one of the key factor for determining the demand. The fact that residential sector is the largest consumer of energy, globally, is due to unnecessarily high demand because of inefficient infrastructures, leakage, building design and consumer behavior being the other main reason behind. [1] Consumers play a significant role for the quantity of energy use. People rarely act according to the standards because their needs and behavior differ widely. Ignorant behavior, lack of knowledge, social status, economic status being some of the reasons. Although several studies have been done related to energy efficiency and consumers behavior in modern urban settlements, there is limited knowledge available on the integrated studies on energy efficiency and consumer behavior focusing on traditional neighborhood. Such studies in the context of urban settlements in Nepal is given scant attention. Using correlation research strategy, this paper aims at making contribution to this knowledge gap by studying selected determining factors of consumers energy use behavior and its relation to energy efficiency in a traditional residential setting of Bramhatol one of old town of Kathmandu. A total of 25% HH (of around 300 total HH) was surveyed using structured questionnaire survey to measure the determining factors of consumers behavior based on the consumers behavior variables identified from literature review and the exploratory studies in the research area. The findings demonstrated that the users and their behavior are statistically significant to lighting use and efficiency.

Keywords
energy efficiency, consumer behavior, demographic variables

1. Background

Energy consumption in itself is not behavior, but rather a consequence of behaviors, such as turning the lights off or lowering thermostat levels [2]. The consumer behavior is one of the key factor for determining the demand. One of the key issues facing domestic energy consumption is the difficulty of making people aware that their behavior at home is linked to increased CO2 emissions and ultimately climate change [3]. The fact that residential sector is the largest consumer of energy, globally, is due to unnecessarily high demand because of inefficient infrastructures, leakage, building design and consumer behavior being the other main reason behind. The energy demand of Kathmandu in year 2017 was 7491.1GWh and the peak load was 1559.7MW [4]. Looking at the various lighting sources, electricity is the main source of lighting energy in Kathmandu. Out of the total demand, 98% household's demand is supplied from electricity [5]. Negligible households are utilizing biogas as source of lighting energy. Solar energy despite having the prospect isn't being utilized to its fullest. The population is dependent on non-renewable energy sources. Consumers play a significant role for the quantity of energy use. People rarely act according to the standards because their needs and behavior differ widely. Ignorant behavior, lack of knowledge, social status, economic status being some of the reasons.

Although several studies have been done related to energy efficiency and consumers behavior in modern urban settlements, there is limited knowledge available on the integrated studies on energy efficiency and consumer behavior focusing on traditional neighborhood. Such studies in the context

of urban settlements in Nepal is given scant attention. Using correlation research strategy, this paper aims at making contribution to this knowledge gap by studying the determining factors of consumers energy use behavior and its relation to energy efficiency in a traditional residential setting of Bramhatol one of old town of Kathmandu.

2. Literature study

Bibliometrics is a powerful quantitative tool to explore knowledge networks based on published literature and has been widely used for studying the structure and development of a research field [6]. A paper by Zhang, [7] applied bibliometrics to research of occupant behavior in buildings. The first related paper to be appeared was in 1978, authored by Socolow [8] in Princeton. It examined the role of residents and their behavior in energy consumption for space heating, which was based on a five-year field study of identical townhouses in Twin Rivers, New Jersey. The results of the experiments in the Twin Rivers program confirmed that the residents and their energy-related behavior in houses mattered with observed variation in energy consumption of identical houses with different occupants [8] (Socolow, 1978). In addition to Socolow‘s research Seligman, et al. (1978) and Sonderegger (1978) also highlighted the impact of occupant behavior on energy performance of residential buildings. Seligman, [9] concluded that the resident can play an important role in energy conservation that complements engineering solutions. Sonderegger [10] found that about 33% of the variation in gas consumption of 205 identical townhouses could be caused by occupant-related consumption patterns, of which persistent occupant-related patterns (‘lifestyle’) explained 18% of the variation and non-persistent patterns (‘change‘) 15% of it. Role of occupant behavior in building energy performance and energy conservation has been highlighted by some influential reports like the IPCC Fifth Assessment Report and the IIASA Global Energy Assessment.

Energy consumption in itself is not behavior, but rather a consequence of behaviors, such as turning the lights off or lowering thermostat levels [2]. The consumer behavior is one of the key factor for determining the demand. One of the key issues facing domestic energy consumption is the difficulty of making people aware that their behavior at home is linked to increased CO^2 emissions [3] and ultimately climate change. Energy use is not visible and people often get detached from their domestic electricity use. Researchers have divided household energy saving behaviors to two different groups: efficiency behavior and curtailment behavior. These behaviors can be considered from an economics perspective, i.e. people’s energy consuming behaviors are linked to and have monetary impacts. Researchers have used both perspectives in analysing households’ energy consumption behaviors. Behavioral researchers who have analysed energy consumption behaviors have not been able to quantify whether curtailment or efficiency behaviors are more effective in domestic energy saving. Some researchers have argued that curtailment behaviors initiate actual behavioral changes and sustain them for long-term [11]. While some of the recent research has suggested that efficiency behaviors are in fact generally more effective in obtaining actual energy savings [12].

Several researchers [13, 14, 15] have identified six key parameters related to physiology, psychology, social and personal factors, contextual, natural environment, energy regulation and economic factors that influence the energy consumption behavior. Of these parameters, contextual factors involving architectural and interior design, and natural environmental factors involving day light and indoor comfort are important in case of traditional neighborhood.

2.1 Demographics related to behavioral change

Rothengatter and his team in a review articled have classified the factors which affect the patterns of households’ energy use into micro, meso and macro-level factors. The macro-level determinants comprise ‘technological developments, economic growth, social factors and cultural developments’ at the scale of a community or national level. The meso-level determinants are related to the socio-technical context constructed by the interaction of social factors [16] . The micro-level factors are at the scale of individual households and include ‘social–demographic attributes motivational factors, abilities and opportunities’ [17]. The micro-level determinants include personal attributes such as individual behavioral predisposition, consuming habits, and household constitution and energy routine activities on a household scale. The meso-level determinants affect energy behaviors in a local/societal scale including norms which influence

individuals' energy decisions, societal and class attitudes.

Taking into account the demographic parameters as well as attributes which contribute to individual energy behavior, Rothengatter (2005) proposed a comprehensive conceptual approach to categorize energy consuming behavior (see selected behavior in table1). The research [17] showed that the individual perception related to energy use or misperception from the consumers' perspective in respect to their efficient energy practices varied between individuals as it contains information gaps which influence habitual energy behavior. This energy perception gap is related to individuals' aware ness about how to consume efficiently or to their predisposition to be aware about the way to conserve energy.

Table 1: Demographic variables affecting energy consumption

Demographic variables	References
Type of family	Silverstone & Hirsch (1992)
Level of income	Zhang, Siebers, & Aickelin (2012)
Age	Sardianou (2007) Van den Bergh (2008)
Individuals' educational and professional elements	Sardianou (2007) Van den Bergh (2008)

Frederiks, Stenner† and Hobman (2005) have listed six demographic variables associated with energy consumption and conservation based on different literature review in their paper. From the literature study, four demographic variables related to family type and light use behavior, age and light use behavior, gender and light use behavior and income and light use behavior were selected for the present study.

Researchers [18, 19, 20, 21] have identified that total household energy consumption is positively related to family type or household size, and in contrast to this Frey and LaBay [22] suggested these two variables may have curvilinear relationship. Another studies ([18, 19, 23, 24]) have found positive associations between household income and residential energy consumption. At the same time, Sardianou [25] have mentioned higher-income households may be more willing and/or able to conserve energy because they can afford the financial costs of energy-saving investments. Researchers Frey and LaBay [22], Fritzsche [26] have concluded in their research that energy consumption peaks either, during the middle stages of the life cycle, perhaps with the larger households typical of mid-life having higher energy requirements. And in contrast to this studies, Tonn and Berry [27] have mentioned for younger and older households, both tend to live in smaller households with higher per capita consumption, and take fewer energy-saving actions than those in middle-age. The effects of gender on household energy usage seem to be inconsistent, minimal or statistically insignificant. Some research indicate that women exhibit more pro-environmental attitudes and behavior than men ([28, 29, 30, 31]), while others find no significant relationship ([18, 32, 19, 33, 25, 34]).

3. Research context

The research study is based around the social and economic context of ward no.12, representing urban population of Kathmandu valley. It is one of the oldest as well as densely populated traditional settlement area of Kathmandu core. The ward has total of 3173 household and population of 13,262 where 6812 are male and 6450 are female. The inhabitants are overwhelmingly Newar. Ward No. 12 is like an open-air museum of cultural history with many remarkable religious and artistic treasures. This settlement area have many cultural and social significances. It is also a route for many Jatras and festivals in valley. The survey sample is done particularly in Brahmatole area. The main features of this settlement area is number of squares (N;chowks) and private courts (N;nanis) interconnected to one other. Also the population density is high in these area. Buildings are built just next to each other attached on two sides and in some cases on three sides, the front façade being only the access point of natural lighting. Here maximum houses are rented to middle income group people who have migrated to Kathmandu for occupation and higher education. It is home to people of different social group, different economic group and different age group.

4. Methodology

The research uses quantitative research method. Using Cochran's method for definite population, a sample size of 75 households was determined. For the calculation, confidence level was taken as 95 %, i.e. margin of error as 5% and taking estimated portion of attribute that is present in population as 10%.

The sample was distributed spatially using the researchers experience and judgment based on existing demographic situation of the research setting. According to which, research area was divided into four cluster namely courtyard with two sides attached, courtyard with three sides attached, inner courtyard with two sides attached and inner courtyard with three sides attached. In each cluster, samples were selected randomly. Then four demographic variables related to family type and light use behavior, age and light use behavior, gender and light use behavior and income and light use behavior were selected for the present study.

Table 2: Distribution of Households by Family Type

Family Type	No. of Households Surveyed
Single	19
Nuclear	45
Joint	11
Total	**75**

Table 3: Distribution of Households by Income

Income Group	No. of Households Surveyed
Below 25K	-
25K – 50K	53
50K – 100K	18
Above 100K	4
Total	**75**

Table 4: Distribution of Respondents by Gender

Gender	No. of Respondents
Male	107
Female	107
	214

Table 5: Distribution of Respondents by Age Group

Age Group	No. of Respondents
10 – 20	25
20 – 40	127
Above 40	63
Total	**214**

Among the total of 75 household surveyed, 48% respondent belonged to category of courtyard with two sides attached, 37% respondent belonged to category of inner courtyard with two sides attached and 15% respondent belonged to category of inner courtyard with three sides attached. Out of 75 household, only 29 families owned the house whereas 46 families were temporary tenants. The following table 2 and 3 represents the frequency of total household surveyed and the total respondents surveyed according to family type, income, gender and age distribution.

5. Data analysis and discussion

The following chart demonstrate the type of various light fixtures used in the sample area. Maximum percentage were still using the conventional light. The use of tungsten bulb have already been obsolete. 6% of the total fixtures were incandescent lamp and the maximum number of 43% were the conventional tube light. Main reasons for still using these light were trusted quality brand and using it from many years. About 21% of light fixtures were CFL bulbs, 26% were LED bulbs and only 4% were LED tube light.

Different types of bulbs use in different time throughout a day was also surveyed. The time was divided into four slot, morning (5 am to 10 am), day (10am to 5 pm), evening (5pm to 8 pm) and night (8pm to 5 am). This gave the idea of the preference of light fixtures use according to the type of activity people perform. People rarely used incandescent bulbs during day, maximum used it at evenings only. For early morning activities and evening activities tube light and LED bulb were mostly used. The data shows tube light were not used during day time. Instead people preferred to use LED bulbs during day time where natural light was not sufficient.

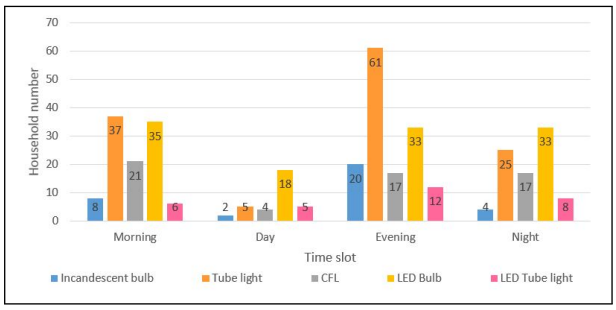

Figure 1: Type of light fixture use at different time

The survey data shows that people still preferred to use conventional lighting appliances because they have been using it for many years now and have gained trust over these appliances. The graph shows initial cheaper cost and easy availability and installation are other main reasons. But people are much aware that these appliances do not have longer life span compared to the efficient light appliances

and do not contribute in energy savings. The survey data reflects that respondents agrees the need to switch from using conventional appliances to efficient appliances as these appliances are low energy consuming also these illumination brighter and have longer life span. But few respondents were still hesitant to use these appliances because of the higher initial cost and incompatibility with the existing system, the family income being governing factor.

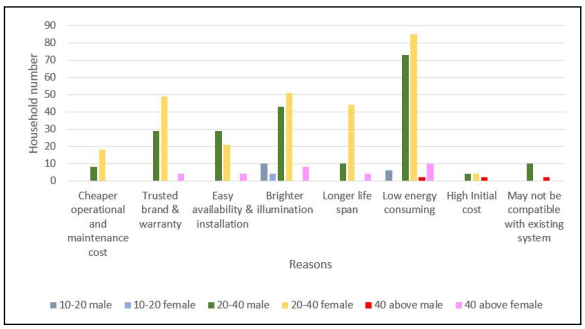

Figure 2: Type of light fixture use at different time

One of the behaviour pattern examined in survey was switching off the light when unnecessary like leaving rooms and sleeping. Of the total respndents, 59% usually turned off light when ever leaving a room. In this case female of working age group are more concious than male respondents. They do so beacause they wanted to help reduce the electricity bills. The rest of 41% have ignorant behavior of keeping the lights on. Mostly respondents of age group between 10 to 20 years behaved ignorant as they forget to turn off.

Table 6: Significance test values

Demographic variable	P value (sig value)	R value	Result
Family size	0.696	0.046	Weak relation, not significant
Age	0.001	0.303	Moderate relation, highly significant
Occupation	0.233	0.082	Weak relation, not significant
Education	0.9	0.008	Weak relation, not significant

The Chi square analysis between the family income and electricity unit consumption showed that there is negative relation between these two variables. The calculated F value was 0.164 and Sig value (P value) was 0.849 which shows that these two variables are not statistically significantly correlated. The plot graph also shows that the energy consumption increases with increase in family income to certain level but gradually decreases though income increases. The probable reason could be the use of efficient appliances by higher income group families.

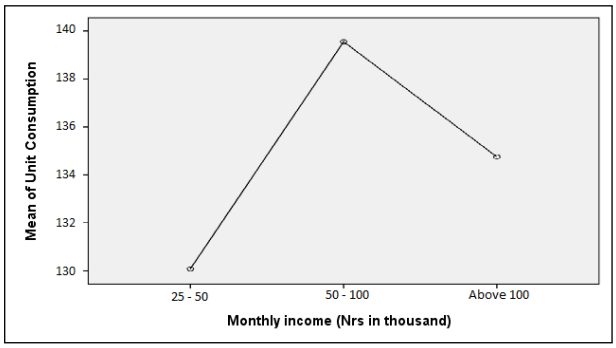

Figure 3: Income and energy consumption graph

6. Conclusion

Consumer's personal behavior has been growing as significant factor in lighting efficiency. This research provides evidence for the reviews from the literature. As age of people increases the awareness level regarding optimum use also increase. The research concludes that it is not necessarily true every time that with increase in income or economic status of any family the energy consumption should also increase. Family size has positive relation with light use. The curvilinear relation obtained from researchers validate this research that higher income households may be more willing and/or able to conserve energy as thaey can afford energy saving investments. The demographic parameters has significant contribution in the light use pattern and conservation, which the correlation analysis also verifies. This research also concludes that female exhibit more energy saving attitude and behavior compared to opposite gender. Besides these other parameters like social factors, physiological factor, natural factor, contextual factors and regulations also affects the light use pattern which has not been studied in this research.

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