A Survey-based approach to minimize energy consumption in urban cities

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Abstract:

The energy sector is responsible for releasing immense amounts of greenhouse gases worldwide. In India, the primary energy demand is expected to increase due to rising living standards, which necessitates increased demand for energy services such as electricity, cooking, transportation, etc. Sustainable living reduces an individual's ecological footprint, making it can an effective response to mitigating greenhouse gases and conserving resources. Through our project, we focus on understanding the willingness of urban families to make lifestyle changes that will benefit the environment. It also entails understanding how money influences an individual's behaviour towards the environment and whether financial benefits can encourage them to reduce their energy consumption and carbon footprint at home. The results showed that although most people were less willing to adopt an entirely sustainable lifestyle, they were ready to conserve energy at home, provided monetary investments were not involved. Therefore, by making individuals aware that energy conservation can save money, they can be encouraged to minimize their carbon footprint and live more sustainably.

Key Words: Energy Conservation, Carbon Footprint, Sustainable Living

Introduction:

The energy sector involves extracting, processing, and distributing fossil fuels, thereby releasing immense amounts of greenhouse gases. These emissions are steadily raising global temperatures, which have adverse effects like climate change and biodiversity loss (Kappelle et al., 1999; United States Environmental Protection Agency, 2022). In India, the primary energy demand is expected to increase to about 1250 million toe (Tonne of oil equivalent) by 2030. This rise will most likely be driven by an increase in the standard of living, which requires a greater demand for energy services such as electricity, cooking, transport, etc. (IEA, 2021; Government of India Ministry of Power, 2022). GHG inventory analysis of Mumbai showed that the energy sector contributes the most to the city's GHG emissions, given its high domestic power demand and the fact that 95% of its electricity is generated from coal (The Hindustan Times, 2021; Times of India, 2021).Increasing consumption and diminishing resources are the primary causes of the World energy crisis that affects most parts of the World (Forbes, 2021; IEA, 2022).

Sustainable living minimizes an individual's ecological footprint; therefore, it can be an effective response to mitigating greenhouse gases and conserving resources. Reducing personal ecological footprints has recently become popular in various communities; however, the lack of social programs and policies promoting this idea negatively impacts many

people's attitudes toward the environment. In the absence of incentives or effective protocols, people may find it challenging to monitor or engage in practices that can result in environmental conservation. Studies find that financial incentives have been successful at changing specific actions, which can influence pro-environmental behavior among individuals (Maki et al., 2016; Kaiser et al. 2020).

Our daily commute, the food we eat, and everything we waste, all contribute to our footprint. The larger the footprint, the heavier the strain on the environment. This forms the basis of our project where we focus on understanding the willingness of urban families to inculcate lifestyle changes that will benefit the environment. It also involves understanding how money influences the behavior of individuals and whether financial benefits can encourage them to reduce their energy consumption and carbon footprint at home. Therefore, this project is structured in a way to motivate people to shift towards more environmentally responsible behavior while also reaping monetary benefits.

Materials and Methodology:

The study included two sequential surveys conducted with families residing in and around the Mumbai metropolitan region. Both questionnaires were generated using Google Forms and incorporated multiple-choice, nominal, Likert's scale (5-point scale), and open-ended long-answer questions. The questionnaire was divided into sections, each of which had a brief description of terms related to the questions. This served as a medium for raising awareness while assisting participants in understanding the questions better. The first survey assessed the general population's views on the overall concept of sustainable living while focusing on three factors: energy conservation, water conservation, and waste management. A total of 260 families participated in this survey. Of the 260 families, 104 families who agreed to continue with the project participated in the second survey. The questions in this survey focused on the world energy crisis, renewable energy, and carbon footprint.

Result and Discussion:

Survey 1

Sustainable Living:

According to Figure 1, individuals believed that their household activities had a greater impact on their health and well-being (4.24 ± 0.062 on a 5-point Likert Scale) than the global environment (4.07 ± 0.061 on a 5-point Likert Scale). A P-value of 0.042 ($P < 0.05$) indicates that the difference between the two means is statistically significant.

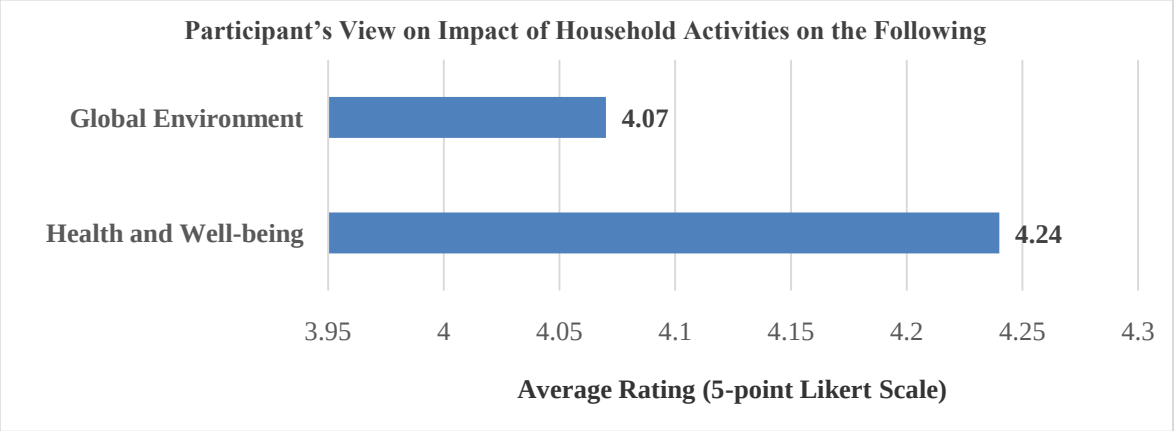

Figure 1: Impact of Household Activities

As per participant responses in Figure 2, the principal characteristic features of sustainable living and eco-homes included reusing and recycling waste (79.23%), usage of eco-friendly products (73.85%), and minimal carbon footprint (72.69%). However, little importance has been given to aspects like indoor air quality (36.54%) and reduced exposure to pollution (41.15%). Further, Figure 3 shows that while participants strongly believed sustainable living could lead to environmental sustainability (92.31%) and a reduction in ecological footprint (71.92%), they were less optimistic about its ability to promote economic growth (33.85%).

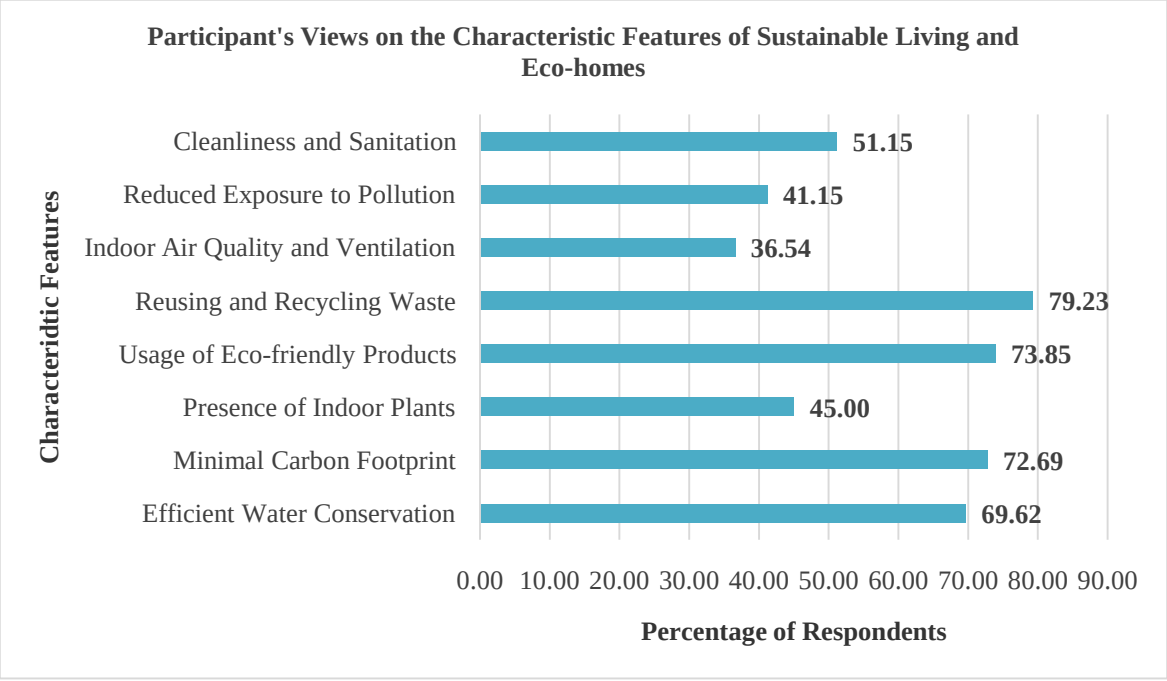

Figure 2: Characteristic Features of Sustainable Living and Eco-homes

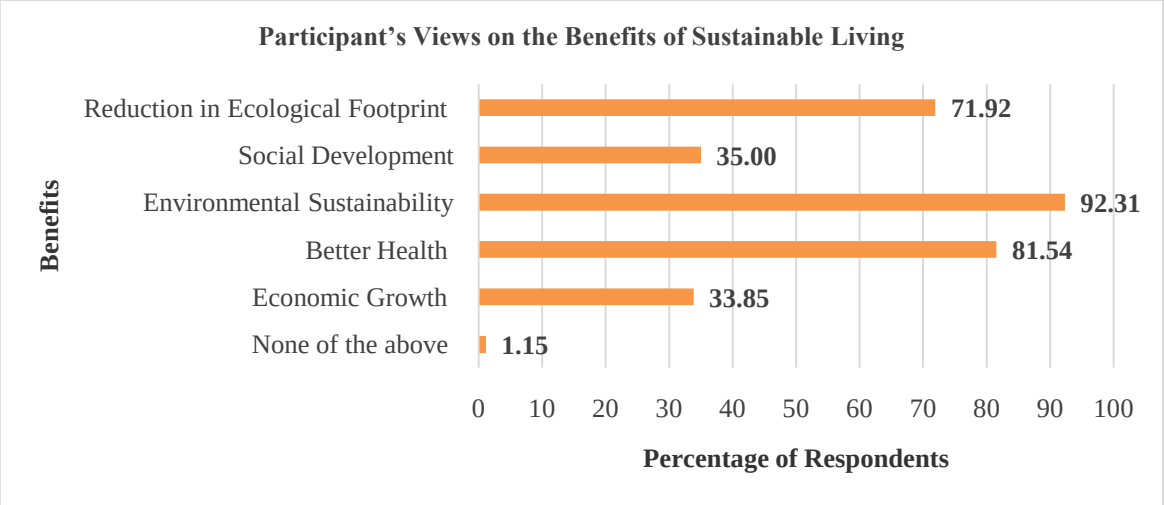

Figure 3: Participant's Views on the Benefits of Sustainable living

A mean of 4.23 ± 0.05 (On a 5-point Likert Scale) indicated that participants supported the concept of sustainable living. Yet, only 19.32% were not hesitant to work towards adopting sustainable living as seen in Figure 4. The hesitance of other participants could be attributed to a lack of proper awareness of sustainable living (53.85%) along with an unwillingness to spend money (40.00%). Moreover, 15% of the participants had a 'Why should I do it?' attitude, expressing a reluctance to accept responsibility for their actions (Figure 4).

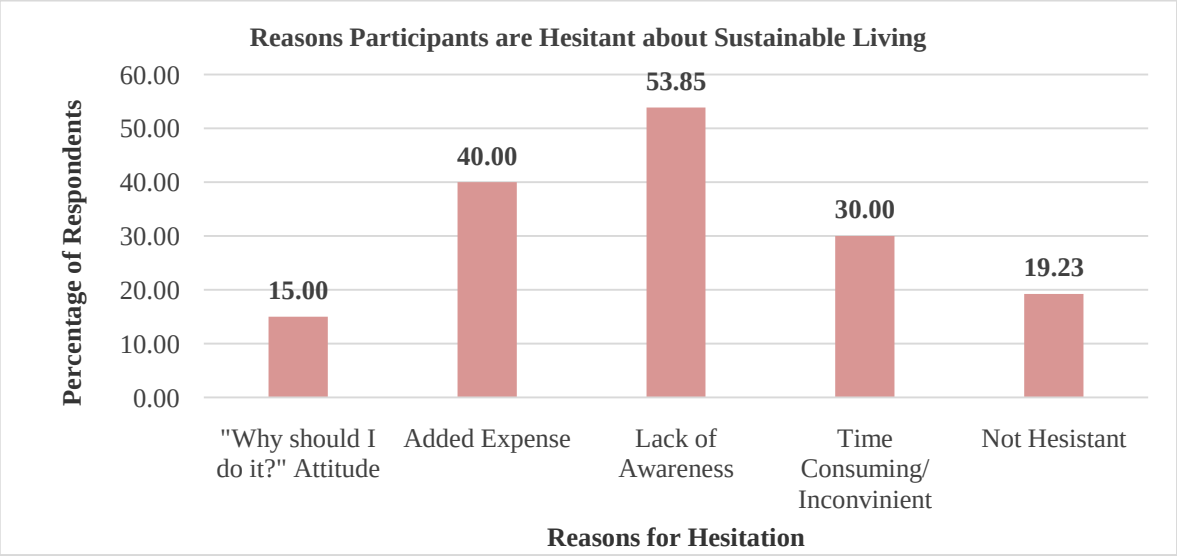

Figure 4: Reasons Participants are Hesitant about Sustainable living

Figure 5 represents the average willingness of participants (On a 5-point Likert Scale) to adopt sustainable living, conserve energy and water at home, manage waste and invest money into meeting these objectives. The results obtained after comparing these groups using

Tukey's test have been presented in Table 1. At P<0.0001, the willingness of participants to manage waste, and conserve energy and water differ significantly from their willingness to adopt sustainable living as a whole. The same difference in means can be observed in the case of their willingness to spend money. There is, however, no significant difference between their willingness to practice waste management, energy, and water conservation, indicating that participants do not have a preference among the three. Overall, this data shows that while participants are willing to conserve water and energy as well as manage their waste, they are less inclined towards the whole concept of sustainable living. Additionally, it emphasizes reluctance among people to invest money.

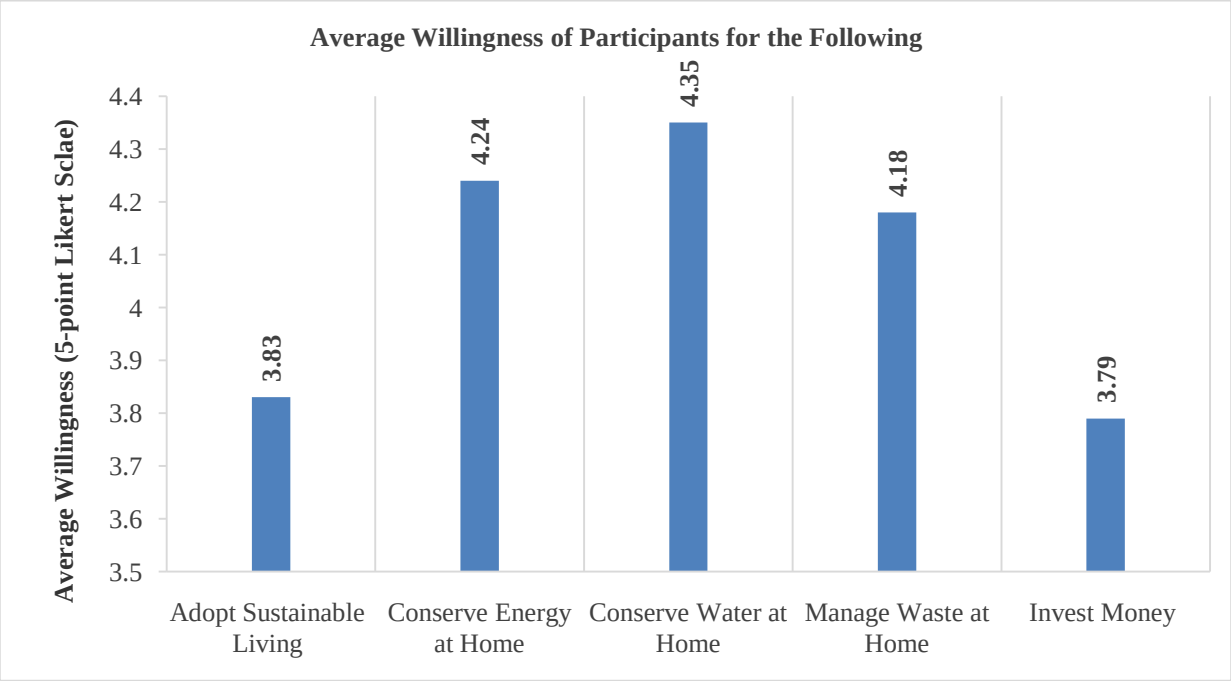

Figure 5: Average Willingness of Participants to Take Action

Table 1: Multiple Comparison of Groups (Sustainable Living) using Tukey's Test

*A – Adopt sustainable living, B – Conserve energy at home, C – Conserve water at home, D – Manage waste at home, E – Invest Money. Highly significant - **** & not significant – ns.*

	A	B	C	D
B	****			
	P<0.0001			
C	****	ns		
	P<0.0001	P>0.05		
D	****	ns	ns	
	P<0.0001	P>0.05	P>0.05	
E	ns	****	****	****
	P>0.05	P<0.0001	P<0.0001	P<0.0001

Energy Conservation: (In terms of Electricity, Cooking, and Travel):

When asked if their energy consumption had increased as a result of the COVID-19 pandemic, 59.23% of participants said yes (Figure 6), but only 31.00% stated that they were consuming more energy than necessary (Figure 7). Additionally, in comparison to water consumption and waste generation, household energy consumption increased the most during the pandemic.

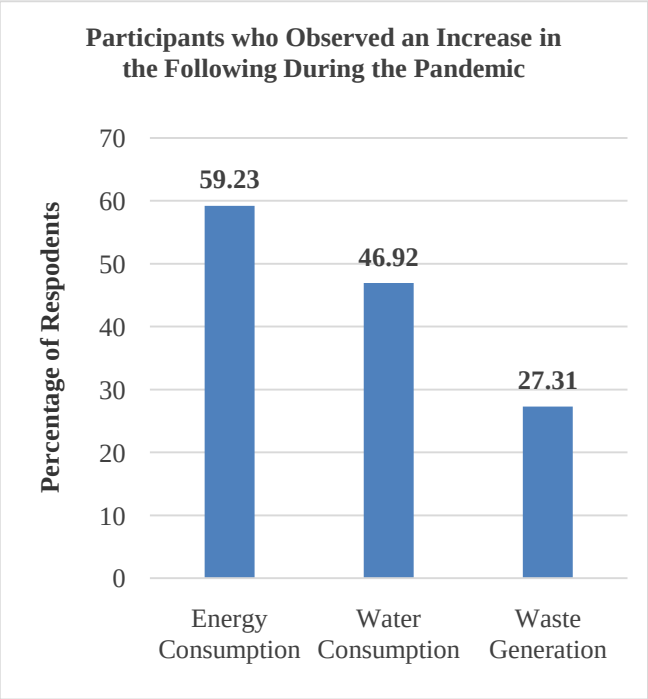

Figure 6: Impact of Pandemic on Energy, Water & Waste

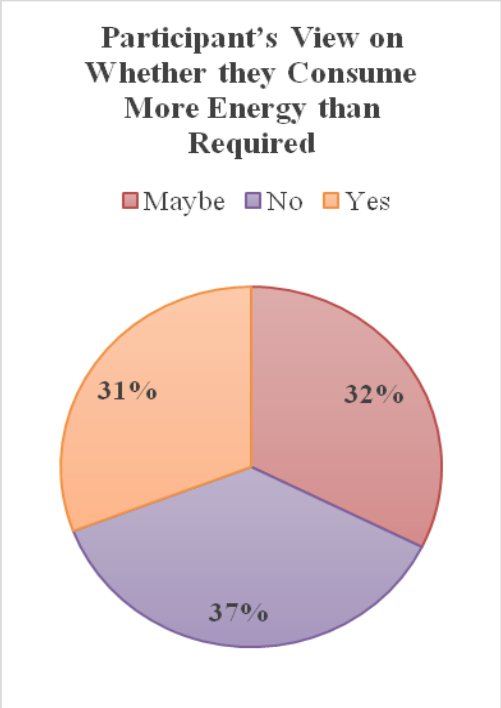

Figure 7: Views on Energy Consumption

According to Figure 8, 3.46% of the participants were unwilling to reduce their energy consumption, expressing a negligent approach toward the environment. Further, 69.23% of participants stated they would be encouraged to conserve energy if it lowered expenses and saved money. Even though 69.62% of the respondents saw energy conservation as an opportunity to use alternative energy sources (Figure 8), when it came to purchasing appliances, a majority of the participants preferred to focus on other factors. These included the appliance's life expectancy, energy efficiency, brand reviews, and available discounts rather than dependence on renewable energy sources (Figure 9).

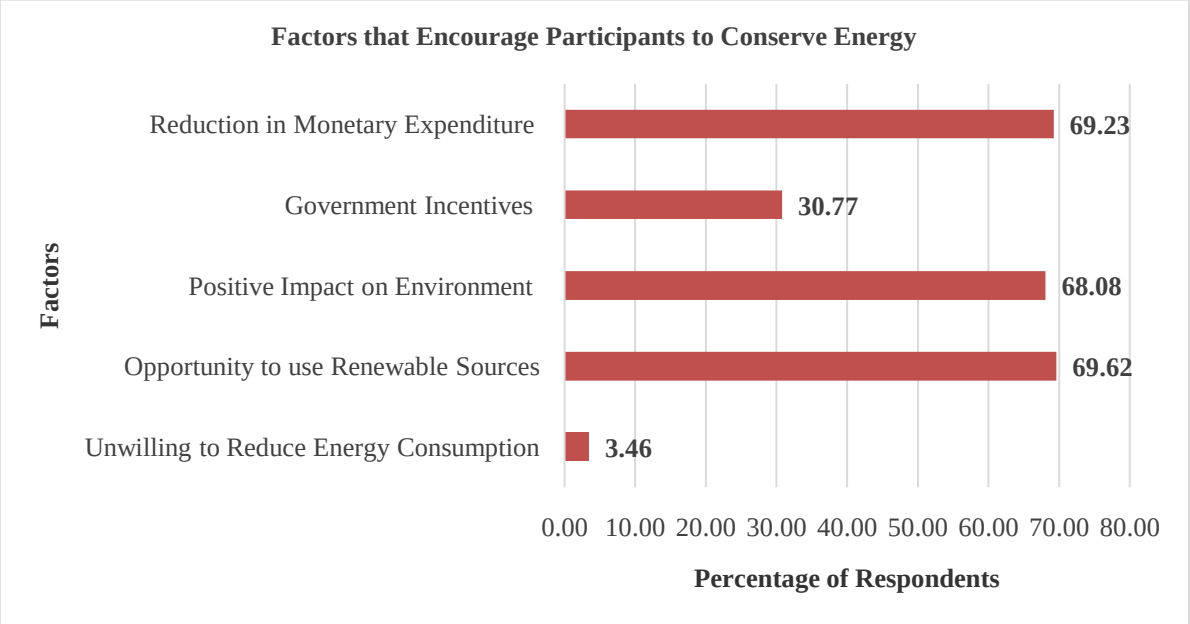

Figure 8: Factors that Encourage Participants to Conserve Energy

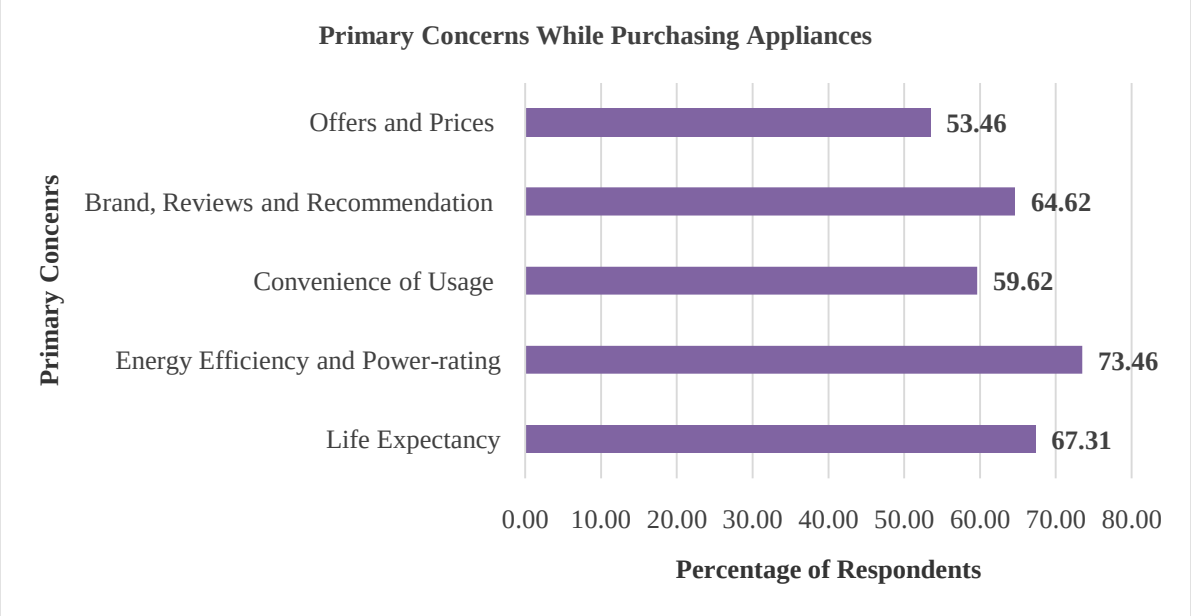

Figure 9: Primary Concerns While Purchasing Appliances

Water Conservation:

The survey found that 49% of the respondents felt they use only as much water as necessary, while 32% were uncertain of their consumption (Figure 10). Moreover, 53% always conserved water, 33% were not careful with their consumption, and 4% did not make any attempt to save water (Figure 11). Additionally, a majority of participants preferred simple conservative measures over those that would make a more impactful difference, such as rainwater harvesting or installing dual flushes (Figure 12). This highlights a need to create

awareness among the general population about effective measures to conserve and save water at a household level.

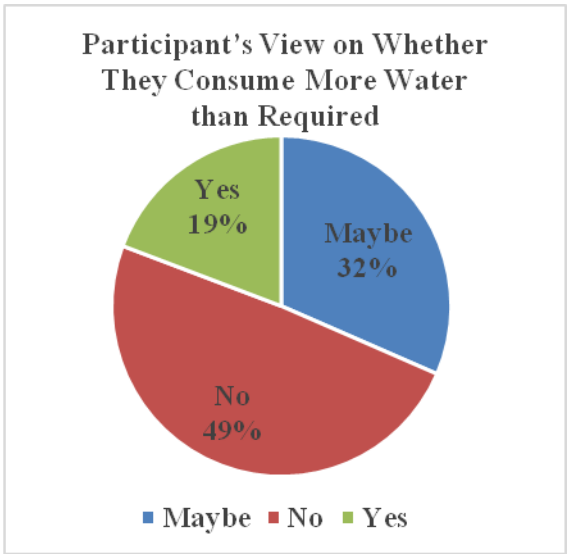

Figure 10: Views on Water Consumption

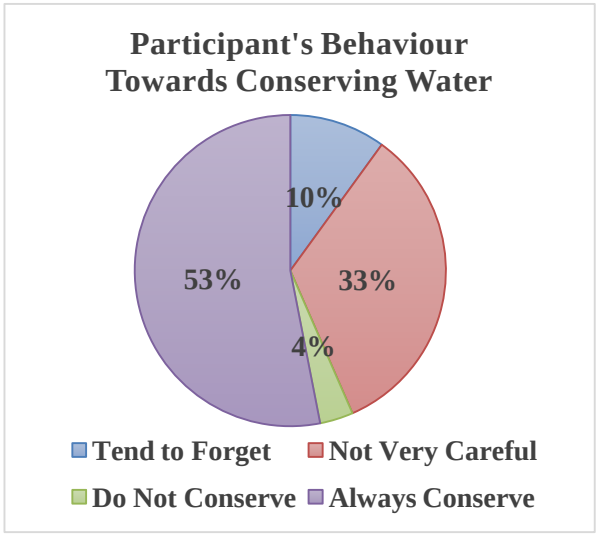

Figure 11: Behaviour towards Conserving Water

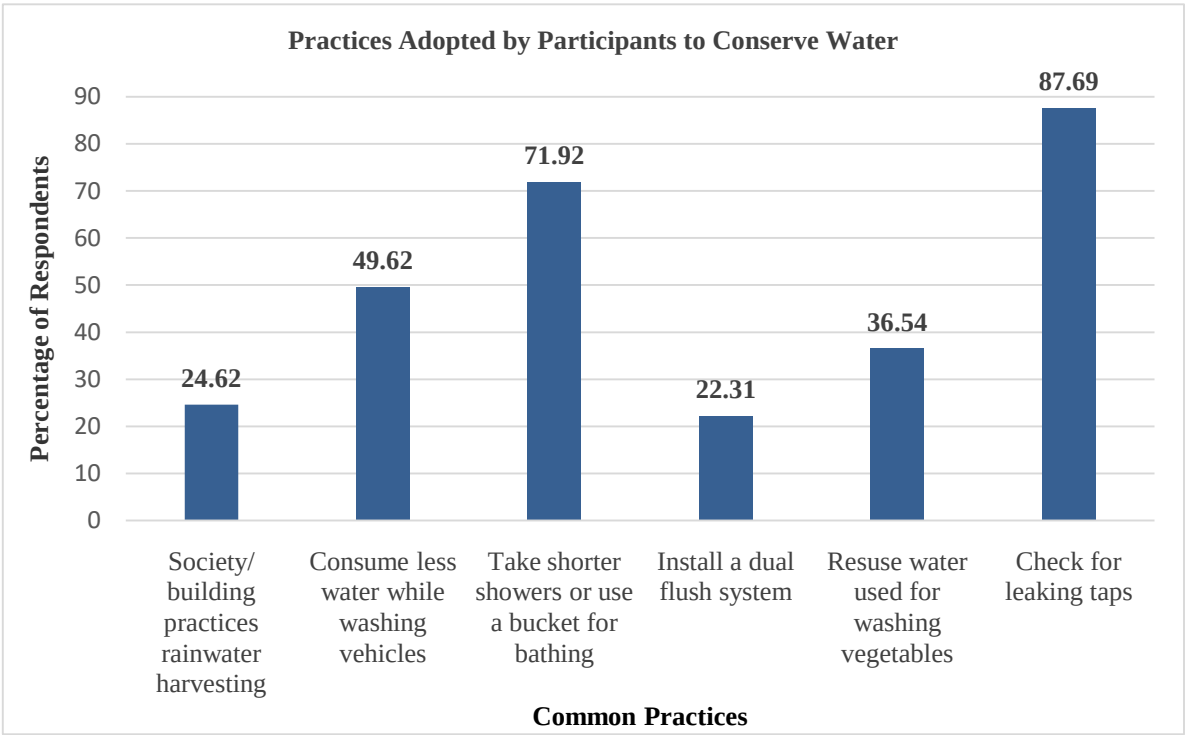

Figure 12: Practices Adopted by Participants to Conserve Water

Waste Management:

133 participants (51.12%) of the surveyed population said that they have always separated their waste. Out of the remaining 127 participants who do not segregate their waste, 80.32% reported a lack of separating bins in their houses or societies.

Furthermore, Figure13 shows the participants' average knowledge of various categories of waste as rated on a 5-point Likert Scale. Tukey's test was used to analyze the resulting mean of each category, and a comparison of the same is provided in Table 2. This highlights that the average knowledge of the surveyed population on plastic, paper, and kitchen waste differs significantly (P<0.0001) from their knowledge of both biomedical and e-waste. This suggests that participants are better aware of segregating plastic, paper, and kitchen waste than biomedical or e-waste.

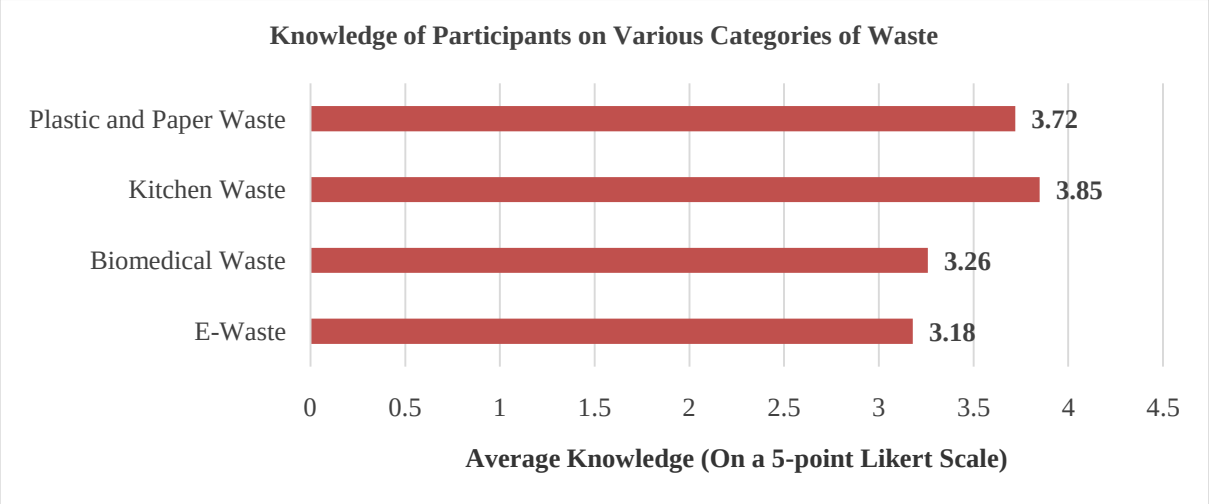

Figure 13: Knowledge of Participants on Various Categories of Waste

Table 2: Multiple Comparison of Groups (Categories of Waste) using Tukey's Test
A – Paper and Plastic Waste, B – Kitchen Waste, C – Biomedical Waste, D – E-waste.
*Highly significant - **** & not significant – ns.*

	A	B	C
B	ns		
	P>0.05		
C	****	****	
	P<0.0001	P<0.0001	
D	****	****	ns
	P<0.0001	P<0.0001	P>0.05

Survey 2

World Energy Crisis and Energy Conservation:

Among the surveyed population, 83.65% were aware of the world energy crisis, and 62.50% strongly believed that it could be solved by taking action at a household level. Moreover, 97.12% of the participants were willing to follow a set of guidelines to lower their energy consumption.

Renewable Energy:

77% of participants firmly believe that the global energy crisis could be solved by increasing our dependency on renewable energy sources. However, only 5 out of 104 people (4.81%) use devices powered by renewable energy, such as solar water heaters, geysers, and solar ovens.

Carbon Footprint Calculator:

The survey shows that 82.69% of the participants had previously heard the term carbon footprint, but only 27.88% were aware of existing websites and applications that could be used to calculate the carbon footprint. Even so, merely 14% of the total surveyed population have used carbon footprint calculators in the past (Figure 14). While some of the individuals who used available web-based calculators found it easy to use, the rest thought that the questions asked were unclear and unsuited for India. Further, only 4% of individuals succeeded in reducing their carbon footprint; 7% tried but were unsuccessful in doing so. Lastly, only 3% were continually using a calculator to record their carbon footprint.

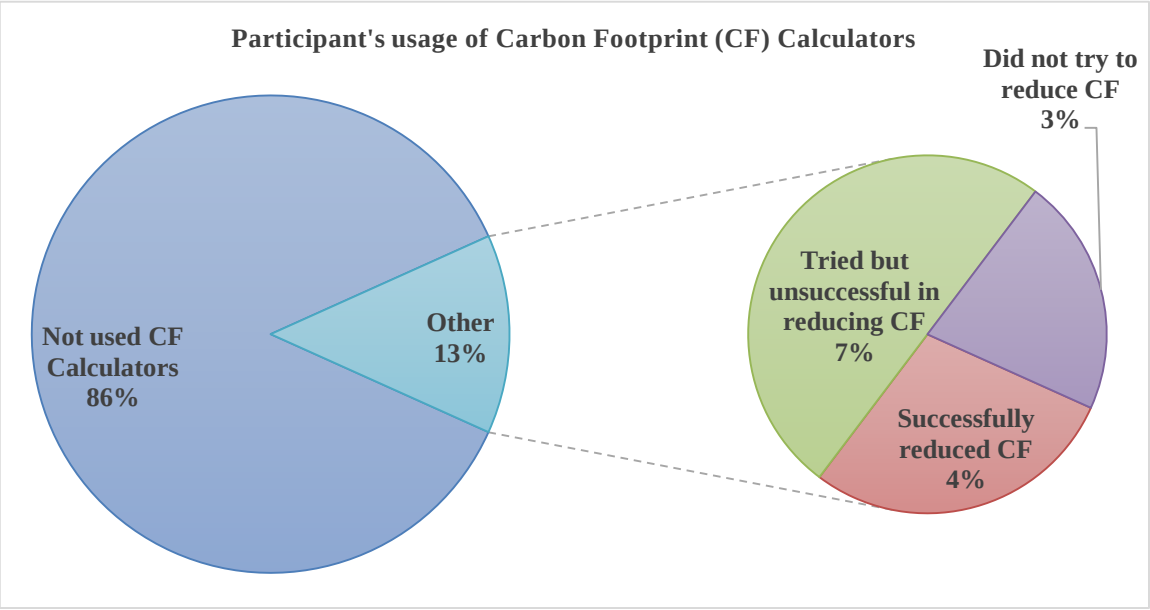

Figure14: Participant's usage of Carbon Footprint (CF) Calculators

Conclusion:

The following points summarize the outcome of this project:

1. There was little awareness among the respondents regarding the causes of carbon expenditure and ways in which carbon footprint could be reduced during daily activities.
2. Although most people were less willing to adopt an entirely sustainable lifestyle, they were ready to conserve energy at home, provided no monetary investment was involved.
3. By participating further in the project, they could be motivated to reduce their energy consumption which would lead to some monetary savings in the bills.
4. This project also highlighted the fact to the researchers that the reduction of carbon footprint needs to be a multi-step approach where each daily activity of the household, such as transport, fuel usage, electricity, etc., must be accounted for.

Thus, by correlating the daily expenses and carbon footprint every month using tools such as the Eco-life Carbon footprint calculator, more families could be encouraged to take a step towards sustainable living.

This project achieved its main objective of familiarizing common people with the term carbon footprint and ways to save energy during daily activities. The next phase of this project will include reaching out to more people by spreading awareness via webinars and workshops, along with offering user-friendly mobile applications to calculate carbon footprints. This would motivate people to consider changing their behavior to a more environmentally conscious one. The authors plan to collaborate with NGOs and Environmental agencies to extend this research work to other urban cities of India and, gradually, India as a whole.

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