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Research Article

Assessing And Modelling the Impact of Household Attributes on Individual Water Consumption in Sonipat, Haryana, India

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ABSTRACT
Sustainable water use in the domestic sector requires a comprehensive understanding of per capita water consumption and its influencing factors. Accurate assessment is essential for future water demand forecasts and providing tailored solutions to different demographic and housing groups. This paper examines various household attributes and their impact on domestic water consumption, with data collected from 401 households, resulting in 2003 individual responses. The data encompassed demographic, housing, water availability and accessibility, awareness characteristics, and per capita water consumption.
Statistical analysis revealed that water consumption increases with higher income and education levels, while households adopting water conservation measures consume less water. Additionally, a lack of awareness contributes to a false sense of water abundance. Using the collected data, five models were developed with the Multiple Linear Regression (STEPWISE) technique. The model incorporating all characteristics demonstrated the highest explanatory power, accounting for 80.7% of the variation in water consumption. Overall, this study highlights the significant role of these characteristics in determining domestic water usage.

Keywords: Household characteristics, STEPWISE regression, sustainable water use, water conservation, water demand management, water efficient devices

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INTRODUCTION

The growing scarcity of water is a major concern in both developing and developed countries. More than half of the world's population is expected to face water shortages by 2050 [1]. Currently, India is recognized as a water-stressed country, and if current trends continue, it could become a water-scarce nation in the coming years [2]. Urbanization, population growth, and migration from rural to urban areas have led to a significant increase in urban population, which in turn has caused a substantial rise in residential water demand [3]. This increased demand is associated with changes in household characteristics, such as built-up area, number of floors, presence of lawns, water availability, and accessibility. These factors, in turn, impact domestic water consumption [4].

There is a growing focus on water conservation measures, water-efficient technologies, demand management strategies, and the factors influencing domestic water consumption. While the assessment and modelling of water demand have been extensively studied in developed countries, less work has been done in developing countries [5]. Various household characteristics have been used to estimate and model water demand in developing countries, such as the number of women in a household [6], level of education [7], walking time to water source [8], family size [9], income levels [10], and physical household characteristics such as built-up area, garden area, number of rooms, and number of floors [4], as well as the number of children and family size [11].

Household characteristics, including demographic and housing factors, should be considered alongside water sources, water availability, accessibility, water storage, and awareness to develop effective models for estimating domestic water demand. The domestic water consumption patterns of some cities and villages in India have been investigated. For example, Seyed M. K. Sadr et. Al. studied the water consumption of Jaipur city to improve the domestic water efficiency [11]. Abdul Shaban and R.N. Sharma focused on domestic water use in seven major Indian cities: Delhi, Kanpur, Kolkata, Ahmedabad, Mumbai, Hyderabad, and Madurai. Their study found that only 18% of the households in these cities receive 24-hour municipal water supply, leading to a reliance on depleting groundwater resources [12]. Omvir Singh and Sushila Turkiya studied domestic water consumption patterns in a rural semi-arid village in Hisar, India, to optimize existing water resources for rural development [13].

This paper investigates 401 households, to determine per capita water consumption and the factors influencing domestic water consumption by collecting data on various household attributes such as demographic, housing, water availability, water accessibility, and awareness. The collected data is used to create models to demonstrate the impact of household attributes on individual water consumption in Sonipat, Haryana.

METHODOLOGY FOR DATA COLLECTION

Study area - Household characteristics have been investigated for Sonipat town, situated in the Sonipat District of Haryana, approximately 50 kilometers from Delhi (Fig-1). The city has a population of approximately 427,270, encompassing 85,454 households and covering an area of 103.90 km² [14]. The city has seen a notable increase in population from Delhi, largely due to the growth of infrastructure projects such as the Western Peripheral (Kundli-Manesar-Palwal) and Eastern Peripheral (Kundli-Ghaziabad-Palwal) Expressways, coupled with the rise of industrial developments.

The water utilities in Sonipat supply 60.2 million liters of domestic water daily from multiple sources, including ranney wells, the Western Yamuna Canal, and tube wells. The average per capita consumption in the town is approximately 181 liters per day, surpassing the CPHEEO standard of 135 lpcd for cities with piped water and a sewerage system [15]. However, the town experiences an 18.7% shortfall in domestic water supply coverage and 14.3% in metering. The situation worsened due to the COVID-19 pandemic, which led to a reported water shortage of 2 MLD. The water bill revenue between 2019 and 2022 reflected this shift, with a significant rise in 2020 due to the pandemic's impact on water demand. By 2022, the revenue had increased modestly by 1.7%, bringing it back to levels similar to 2019 [16].

Data Collection Programme: A detailed questionnaire was developed to assess household attributes, including demographic factors (age, gender, family size, level of education, main occupation, and monthly per capita income), housing characteristics (house type, area, number of floors, presence of a lawn, and water meter). It also covered aspects related to water usage, such as the presence of water-using appliances, water-saving devices, sources of water supply, drinking water sources, water storage systems, accessibility, water shortage, and general awareness. The questionnaire included both closed and multiple-choice questions. The questionnaire was distributed to 700 households using stratified random sampling from July to August 2022. Responses were received from 401 households, with individual responses collected from each resident, resulting in a total of 2,003 responses. Data processing, analysis, and tabulation were carried out using IBM SPSS Statistics 29.0 software and MS Excel. The analyses performed included one-way ANOVA, t-tests, post hoc tests, and stepwise multiple linear regression.

Development of Statistical models: The study examined the factors affecting domestic water consumption using a stepwise multiple linear regression approach. Five models were developed, each focusing on different sets of household characteristics (independent variables): demographic, housing, water availability and accessibility, awareness, and a combined model incorporating all these factors.

Initially, each independent variable was analyzed individually in relation to the dependent variable (domestic water consumption) using one-way analysis of variance (ANOVA) or t-tests. This preliminary analysis aimed to determine the influence of individual independent variables on water consumption. ANOVA (F-test) was used to identify significant differences in means among multiple groups, while t-tests compared means between two groups. A significance level (p-value) of less than 0.05 indicated statistically significant differences, suggesting that the independent variable had a significant effect on water consumption. Conversely, a p-value greater than 0.05 suggested no significant effect. Although ANOVA analysis is robust, it does not identify specific groups that differ from each other. Therefore, after conducting the ANOVA test, a Bonferroni post hoc t-test was performed to pinpoint the specific group differences.

To investigate the collective impact of all independent

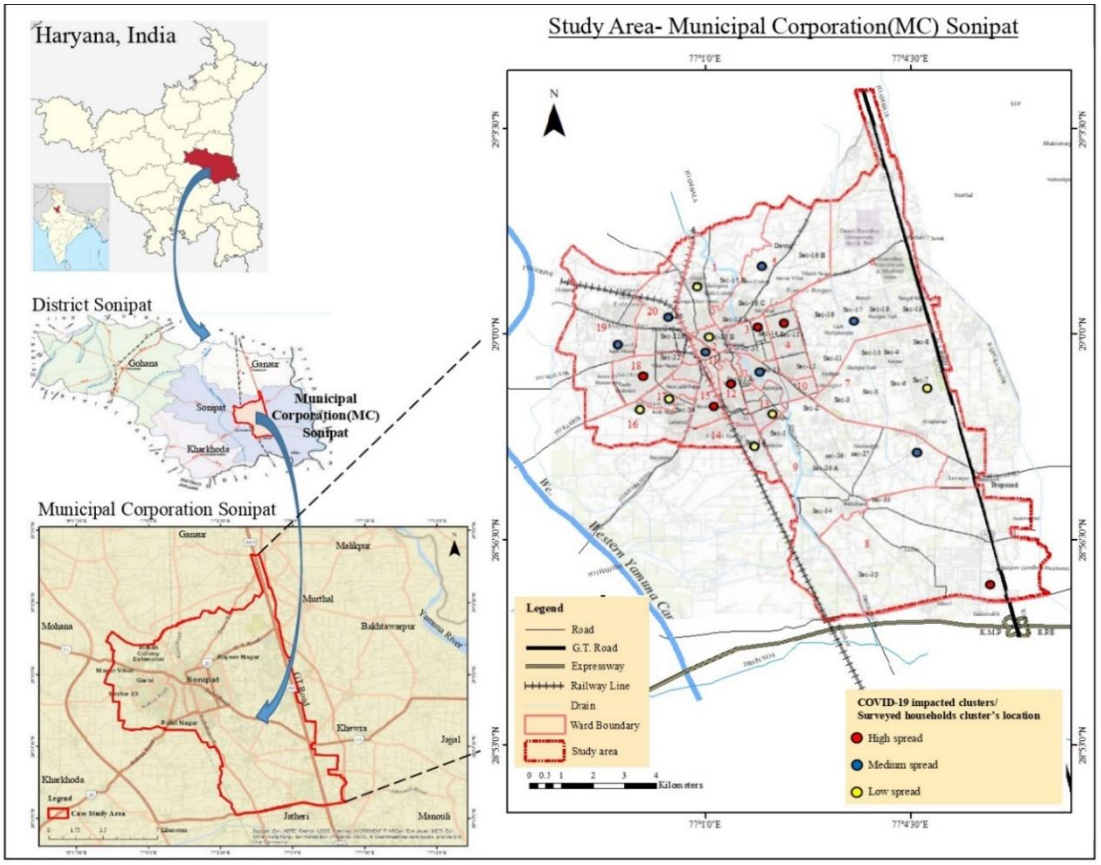

Figure1: Geographic location of Sonipat town, Haryana and the distribution of surveyed clusters in the town

variables on the dependent variable, while considering potential confounding or interaction effects, multiple linear regression analysis was conducted using IBM SPSS software. One of the multiple regression techniques employed was the stepwise method, which is effective for selecting the best combination of independent variables [17]. This approach was utilized to assess the strength of the relationship between the dependent variable and the set of independent variables, and to identify which variables significantly contributed to the model.

RESULTS AND DISCUSSION

Analysis of Household Attributes

The profile of 2003 respondents, including household characteristics and per capita water consumption, is summarised in Table 1. The household attributes were divided into four groups:

1. Demographic characteristics: age, gender, family size, level of education, main occupation, and monthly per capita income.
2. Housing characteristics: house type, area of house, number of floors, number of rooms, presence of lawn, presence of water meter, presence of water saving devices and, presence of water use appliances.
3. Water availability and accessibility factors: sources of water supply, sources of drinking water, system of water storage and, water accessibility.
4. Level of Awareness: various sources of water, ground water status, water recycling, government initiatives

1. **Demographic Characteristics**: Among the respondents, a significant proportion (58%) were male, with females representing 42%. Age distribution reveals a young population, with 35% of respondents in the 20-39 age range—an economically active group that plays a key role in household water usage. Family sizes were predominantly medium (56%), with an average of 5 members, which reflects typical household structures in the region. Education levels varied, with a notable 36% completing primary education and 26% being graduates, but 8% remained illiterate, highlighting areas for potential improvement in educational outreach. Employment patterns also varied: 31% were housewives, retired, or unemployed, 33% were students, while 24% worked in services, and 11% were involved in business or agriculture. Income levels showed that 44% earned between ₹5,000-₹30,000, positioning the community in a moderate-income bracket.
2. **Housing Characteristics**: A striking 97% of households lived in pucca (permanent) houses, with 58% in smaller homes (<100 sqm). A majority

of homes (42%) were single-story, indicating limited space for water storage and conservation efforts. Interestingly, 78% of households did not have lawns, a telling sign of practical living prioritizing functional spaces. The installation of water meters in 77% of homes reflects a growing awareness of water usage, but when it comes to actual water conservation, only 8% of respondents made active efforts. Although 52% recycled RO waste water, and 19% used dual-flush cisterns, there's clearly much room to encourage more sustainable water-saving habits within the community.

3. **Water Availability and Accessibility Characteristics**: The study revealed significant shifts in water consumption based on supply conditions. Under normal circumstances, 58% of respondents rely exclusively on municipal water, while 24% depend solely on submersible pumps or hand pumps—raising concerns about the sustainability of groundwater extraction. The preference for RO-filtered water (54%) over unfiltered tap water (43%) indicates heightened awareness of water quality, particularly in regions affected by high fluoride content in groundwater. This finding is in line with local engineers' concerns about water quality and its health implications.

1. Regarding water storage, 73% of households used overhead tanks, a common practice for continuous water access. However, 14% lacked proper storage systems altogether and relied on buckets or pots, pointing to disparities in infrastructure access. A critical issue emerged regarding water accessibility, with 12% of households needing to collect water from outside their premises, often due to disruptions in the water supply.
2. Despite these challenges, 24% of respondents reported regular water shortages, and 43% never faced such issues. The data thus illustrates the complexities of water supply systems and their direct impact on household water consumption, suggesting both strengths and areas for improvement in local water management.

4. **Awareness:** Awareness about water issues is influenced by the environment, educational qualifications, and age. To evaluate the respondents' awareness levels, we asked various questions concerning water sources, groundwater availability in Sonipat, water recycling, and new government policies. Responses were numerically coded for analysis. The analysis revealed that 54% of the respondents were unaware of the various water sources in Sonipat. Furthermore, 67% were not informed about the groundwater extraction status, with only 15% considering it critical to safe. Notably, 18% of respondents correctly

   Identified that Sonipat's groundwater is over-exploited. This over-exploitation lowers the water table, affecting water availability and ecosystems adversely.

   When asked about water recycling, 61% were unfamiliar with the concept and process. Among the 39% who were aware, most indicated that waste water from AC & RO could be used for flushing and cleaning purposes. Additionally, 60% of the respondents were unaware of any new government policies, while 40% cited initiatives like the Jal Jeevan Mission and rainwater harvesting structures. The overall awareness score, calculated by summing the numerical values assigned to responses, revealed that 45% of the respondents had a low level of awareness, 30% had a moderate level, and 25% had a high level. This lack of awareness suggests a false sense of water abundance in Sonipat, posing a significant barrier to effective water conservation efforts.

Table 1: Profile of Respondents-Demographic, Housing, Water availability and accessibility, Awareness Factors and individual water consumption

Sr. No	Household Attributes	Groups/Categories	Total(N=2003)	Consumption (lpcd)
1	**Age**	Youth (below 19)	493 (25%)	180
		Young (20-39)	701 (35%)	180
		Middle age (40-60)	464 (23%)	176
		Old age (above 60)	345 (17%)	192
2	**Gender**	Male	1166 (58%)	177
		Female	837 (42%)	186
3	**Family size**	Small (1 to 3)	746 (37%)	173
		Medium (4 to 6)	1126 (56%)	184
		Large (above 6)	131 (7%)	202
4	**Level of education**	Post graduate	329 (16%)	188
		Graduate	517 (26%)	180
		Higher secondary/12th	272 (14%)	184
		Primary/<12th	717 (36%)	177
		Illiterate	168 (8%)	185
5	**Occupation**	Service	492 (24%)	168
		Business/Agriculture	216 (11%)	189
		Labour	20 (1%)	138
		Housewife/retired/not working	620 (31%)	189

		Students	655 (33%)	181
6	**Monthly family Income**	Group-1(below 5000)	427 (21%)	138
		Group-2(5000 to 30000)	886 (44%)	184
		Group-3 (31000 to 50000)	449 (23%)	204
		Group-4 (above 50000)	241 (12%)	204
7	**House type**	Pucca	1,935 (97%)	182
		Kutcha	68 (3%)	156
8	**Area of house**	Small (<100 sqm)	1167 (58%)	172
		Medium (100 to 300 sqm)	556 (28%)	186
		Large (301 to 500 sqm)	280 (14%)	207
9	**Number of floors**	Single floor	844 (42%)	184
		Two floors	775 (39%)	179
		Three floors	324 (16%)	
		Four floors	60 (3%)	
10	**Presence of lawn**	Yes	436 (22%)	195
		No	1567 (78%)	177
11	**Presence of water meter**	Present	1537 (77%)	193
		Not present	466 (23%)	140
12	**Presence of number of water use appliances**	Group-1	641 (32%)	138
		Group-2	664(33%)	184
		Group-3	441 (22%)	214
		Group-4	257 (13%)	225
13	**Level of water conservation practices adopted**	Low	1839 (92%)	184
		Moderate	128 (6%)	155
		High	36 (2%)	138
14	**Sources of water supply**	Only Municipal water	1166 (58%)	183
		Municipal + Submersible	371 (18%)	226
		Submersible	234 (12%)	200
		Hand pump	232 (12%)	80
15	**Drinking water sources**	Tap water without filtration	869 (43%)	156
		RO water	1071 (54%)	200
		Bottled water	63 (3%)	196
16	**Water storage system**	Overhead tank	1464 (73%)	188
		Overhead tank+ Underground tank	259 (13%)	222
		Bucket/Pot	280 (14%)	105
17	**Water accessibility**	Within premises	1771 (88%)	194
		Outside premises (100 to 1000 m distance)	232 (12%)	80
18	**Water shortage**	Yes	488 (24%)	183
		Rarely	665 (33%)	189
		No	850 (43%)	173
19	**Awareness**	High	602 (30%)	174
		Moderate	299 (15%)	182
		Low	1102 (55%)	185

Source: Computed Model

Based on Demographic Characteristics and Their Impact on Water Consumption

This section examines the relationship between various demographic factors and daily per capita water consumption. The analysis reveals significant differences in water usage based on age, gender, family size, education, occupation, and income.

1. Age: The study found that the elderly (above 60 years) consume significantly more water (192 lpcd) compared to other age groups. While the youth, young adults, and middle-aged groups showed no significant differences in water consumption, the elderly's higher intake may be linked to health needs or medication-related hydration requirements.
2. Gender: Women tend to consume more water (186 lpcd) than men (177 lpcd), a difference that may be attributed to lifestyle factors, including physical activities such as fitness routines.
3. Family Size: Larger households tend to use more water, with those in families of six or more consuming 202 lpcd. This can be explained by the increased demand for water-intensive activities like laundry and cooking in bigger families.
4. Education: Higher water consumption was observed among both postgraduates and illiterates.

Postgraduates may have better access to facilities, while the illiterate group may lack awareness of efficient water use.

5. Occupation: Laborers and those in the service industry consume less water (138 and 168 lpcd, respectively), likely due to lower access or limited water-saving habits. Meanwhile, business owners and retirees/housewives exhibit higher water consumption.
6. Income: A direct correlation exists between higher income and increased water consumption. Those with a per capita income above ₹30,000 use more water (204 lpcd), reflecting a higher standard of living, larger homes, and more water-intensive appliances.

Collective Impact: The model assessing the combined effect of these demographic variables on water consumption shows that age, education level, occupation, and income are significant predictors. Notably, monthly per capita income was found to be the most significant predictor. Family size and gender did not have significant effects when all variables were considered together. This model explains 21.2% of the variation in water consumption, with an F-statistic of 134.86 and a p-value less than 0.05, indicating statistical significance (Table 2).

Table 2: Model Based on Demographic Characteristics of Respondents

Demographic characteristics	Coefficients	Standard Error	t Stat	P-value	Inference
Age	3.17	1.06	2.9	<0.05	Significant
Level of Education	2.35	0.87	2.7	<0.05	
Occupation	4.36	0.72	6	<0.05	
Monthly per capita income	24.26	1.17	20.5	<0.05	
Model summary	**R Square=0.214; F=90.7**				
Demographic characteristics	P-value			Inference	
Family size	>0.05			Insignificant	
Gender	>0.05				

Source: Computed

Model Based on Housing Characteristics and Their Impact on Water Consumption

The analysis of housing characteristics reveals significant factors influencing daily per capita water consumption. Various housing features, including house type, area, number of floors, presence of a lawn, water meter, water-use appliances, and water conservation practices, were examined.

1. **House Type**: Pucca houses consume more water (182 lpcd) on average compared to kutcha houses (156 lpcd). The increased water consumption in pucca houses could be attributed to better amenities, water accessibility, and storage systems.
2. **House Area**: Larger homes (301-500 sqm) tend to use more water (207 lpcd) due to the higher number of amenities and water-intensive activities. Households with more space often have larger gardens, more appliances, and a higher perception of water abundance.
3. **Number of Floors**: Single-floor houses show higher water consumption (184 lpcd) than multi-floor houses (179 lpcd). This may be because single-floor houses are typically older and less likely to incorporate water-saving technologies compared to newer, multi-floor homes.
4. **Presence of Lawn**: Households with lawns consume more water due to the need for frequent irrigation, contributing to overall higher per capita consumption.

   Water Meter: The presence of a water meter leads to significantly higher water consumption, possibly due to improved infrastructure and better access to water.
5. **Number of Water-Use Appliances**: Households with more appliances (>4 toilet flush+ >4Hand Basin+ Washing Machine+ >4 Shower + >12 taps) consume more water, as number of showers, washing machines, and taps increases overall water usage.
6. **Water Conservation Practices**: Households that adopt effective water conservation measures tend to consume less water. A significant difference is observed between those with high conservation practices and those with low practices (138 lpcd vs 184 lpcd).

Collective Impact: The combined effect of these housing characteristics explains a substantial portion of water consumption variability. The presence of a water meter emerged as the most significant predictor. The model's R-Square value of 0.550 indicates that about 55% of the variation in water consumption can be attributed to these housing characteristics. While house type and the number of floors showed no significant influence when all factors were considered together, other variables like house area, lawn presence, and water conservation practices significantly impacted daily water consumption. This model underscores the importance of considering multiple housing characteristics to understand and manage water consumption effectively (Table 3).

Model Based on Water

Availability and Accessibility Characteristics and Their Impact on Water Consumption

The study examined the collective impact of water availability and accessibility on daily per capita water consumption. Statistical analysis using ANOVA and t-tests revealed significant differences in water consumption based on various factors, such as water sources, storage systems, accessibility, and perceptions of water shortage.

1. **Domestic Water Supply Sources:** Significant variations in consumption were found between groups, with individuals using hand pumps consuming the least (80 lpcd), while those relying on

municipal or submersible sources had higher consumption levels.

2. **Drinking Water Sources:** People using tap water without filtration had lower consumption to those relying on RO or bottled water.

Table 3: Model Based on Housing Characteristics of Respondents

Housing characteristics	**Coefficients**	**Standard Error**	**t Stat**	**P-value**
House area	11.4	1.19	9.57	<0.05
Presence of lawn	7.95	1.89	4.19	<0.05
Presence of water meter	39.91	2	19.9	<0.05
Presence of number of waters use appliances	24.05	0.86	27.83	<0.05
Level of water conservation practices adopted	-34.7	2.16	-16.04	<0.05
Model summary	**R Square=0.550; F=349.82**			
Housing characteristics	P-value		Inference	
House type	>0.05		Insignificant	
Number of floors	>0.05			

Source: Computed

advanced storage systems (overhead or underground) consumed more water, while bucket/pot users had the lowest consumption.

3. **Water Accessibility:** Access to water within premises was linked to higher consumption (194 lpcd), possibly due to convenience and perceived availability.
4. **Water Shortage Perception:** Individuals who felt they experienced water shortage tended to consume more water, possibly as a compensatory behaviour.

Collective Impact: A regression model demonstrated that water availability and accessibility characteristics collectively explained 68% of the variation in daily per capita water consumption. Among these factors, water accessibility was the most significant predictor of higher consumption, followed by the water storage system (Table 4).

Table 4: Model Based on Water Availability & Accessibility Characteristics of Respondents

Water Availability and Accessibility characteristics	**Coefficients**	**Standard Error**	**t Stat**	**P-value**
Domestic water supply sources	4.22	0.18	22.49	<0.05
Drinking water sources	8.12	1.04	7.79	<0.05
Water storage system	23.89	1.51	15.79	<0.05
Water accessibility	152.27	3.49	43.55	<0.05
Water shortage	2.1	0.82	2.54	<0.05
Model summary	**R Square=0.682; F= 858.67**			

Source: Computed

Model Based on Awareness and Its Impact on Water Consumption

This section examines the relationship between the level of awareness and daily per capita water consumption. The ANOVA test results revealed a significant difference in average water consumption based on awareness levels. Individuals with high awareness of water-related issues, such as sources, availability, conservation, and government policies, tended to consume less water. In contrast, individuals with low or moderate awareness consumed more water.

A regression analysis indicated a weak but statistically significant negative relationship between awareness level and water consumption. This suggests that higher awareness slightly correlates with reduced water consumption. However, the "level of awareness" explains only a small portion of the variation in consumption, as reflected by the R-squared value of 0.008. The F-statistic of 16.21 with a p-value of 0.00 indicates statistical significance, despite the model's limited explanatory power (Table 5).

Table 5: Model Based on Awareness Characteristics of Respondents

Level of awareness	**Coefficients**	**Standard Error**	**t Stat**	**P-value**
Level of awareness	-5.06	1.25	-4.02	<.05
Model summary	R Square=0.008; F= 16.21			

Source: Computed

Model Based on All (Demographic, Housing, Water Availability & Accessibility, Awareness) Characteristics of the household

This section analyses the combined effect of

demographic, housing, water availability, accessibility, and awareness characteristics on domestic water consumption. The regression model indicates that factors such as age, education level, occupation, income, house area, presence of water meters, water appliances, water conservation practices, water sources, water accessibility, and awareness significantly predict water consumption. Notably, water accessibility, conservation practices, and the number of waters use appliances are the most influential predictors.

The model explains 80.7% of the variation in water consumption, with a highly significant F-statistic of 596.62. Among these variables, the presence of a lawn was found to be a confounding factor. Overall, this model demonstrates that these characteristics, collectively, play a significant role in determining domestic water usage (Table 6).

Table 6: Model Based on All Characteristics (Demographic, Housing, Water Availability & Accessibility, Awareness) of Respondents

Sr.No	All characteristics	Coefficients	Standard Error	t Stat	P-value
1	Age	2.3	0.54	4.28	<.05
2	Level of Education	-3.07	0.78	-3.92	<.05
3	Occupation	4.4	0.35	12.68	<.05
4	Monthly per capita income	4.46	0.76	5.85	<.05
5	Area of house	9.83	0.96	10.25	<.05
6	Presence of water meter	-4.95	1.72	-2.88	<.05
7	Presence of number of water use appliances	10.17	0.77	13.19	<.05
8	Level of water conservation practices adopted	-36.43	1.48	-24.68	<.05
9	Sources of domestic water supply	1.75	0.19	9.02	<.05
10	Drinking water source	2.45	0.9	2.72	
11	System of water storage	9.61	1.38	6.96	<.05
12	Water accessibility	121.19	3.55	34.1	<.05
13	Water shortage	4.01	0.73	5.52	<.05
14	Level of awareness	-7.45	1.07	-6.98	<.05
Summary of model	**R Square=0.807; F =596.62**				

Source: Computed

Comparison of Models

In this study, multiple regression models were developed using a stepwise approach to understand the factors influencing per capita water consumption. The models were evaluated based on their R-square values, indicating how well they explained the variability in water consumption. The model incorporating all characteristics—demographic, housing, water availability and accessibility, and level of awareness—demonstrated the highest explanatory power, accounting for 80.7% of the variation in water consumption. Among the individual models, water availability and accessibility (Model-3) contributed the most, explaining 68% of the variability, followed by housing characteristics (Model-2) at 55%. Demographic factors (Model-1) and the level of awareness (Model-4) accounted for 21% and 8%, respectively (Table 7).

Table 7: Comparison of Models

Sr. No	**Models**	**R square**
1	Model based on demographic characteristics of the respondents	0.21
2	Model based on Housing characteristics of the respondents	0.55
3	Model based on water availability & accessibility of the respondents	0.68
4	Model based on level of awareness of the respondents	0.008
5	Model based on all characteristics of the respondents	0.807

CONCLUSION

The study provides an in-depth analysis of the various factors influencing water consumption at the household level. Key findings from the analysis of 2003 respondents highlight significant demographic, housing, water availability, accessibility and awareness characteristics that affect daily per capita water usage.

1. **Demographic Characteristics**: Age, education, occupation, and income are significant predictors of water consumption. Family size and gender are not impacting domestic water consumption. Elderly individuals and women consume more water, likely due to health needs and lifestyle factors, respectively. Higher income and educational levels correlate with increased water usage, reflecting access to better amenities and a lack of awareness about water conservation among illiterates.
2. **Housing Characteristics**: Larger houses, the presence of lawns, and more water-use appliances are associated with higher water consumption. Households without water meters and those adopting water conservation practices show contrasting impacts, indicating the potential for improved water management through infrastructure and

behavioral changes.

3. **Water Availability and Accessibility**: Dependence on municipal water and submersible pumps indicates varied water sources, with RO-filtered water being preferred due to quality concerns. The presence of water storage systems like overhead tanks is common, but disparities in infrastructure access persist, affecting overall water consumption patterns.
4. **Awareness**: There is a significant gap in awareness regarding water sources, groundwater status, and government initiatives. This lack of awareness contributes to a false sense of water abundance, hindering effective water conservation efforts.

The models developed in the study explain substantial variability in water consumption based on all these attributes, with the combined characteristics accounting for 80.7% of the variation.

Policy Suggestions

1. **Educate People on Water Conservation:** Execute community-based awareness campaigns to educate residents about water conservation, efficient water use, and the current critical status of groundwater. The program should target both educated individuals and illiterates to bridge the gap.
2. **Promote Water-Efficient Appliances:** Educate people regarding water saving fixtures such as dual flush cisterns, low flow showerhead, aerator faucets, sensor taps, front loading washing machine, etc. The implementation of these technologies can significantly reduce water consumption in short term.
3. **Launch Rebate and Subsidy Program:** Encourage the installation of water-saving fixtures by providing rebates/subsidies for such appliances. Highlight the environmental benefits and long-term cost savings to residents through the use of these fixtures.
4. **Improve Water Metering:** Expand water metering coverage to all households. This will promote accountability among residents and enhance efficient water usage by keeping track of the amount of water consumed.
5. **Enhance Monitoring by Installing Smart Water Meters and Flow Sensors:** Install smart meters and flow sensors for real-time water usage monitoring. Develop mobile apps that provide water conservation tips and track residents' usage patterns. This will help identify high water consumption patterns and provide feedback to residents regarding their water usage.
6. **Improve Water Infrastructure**: Address disparities in water storage and supply systems by investing in reliable infrastructure. Ensure that all households have access to water and adequate water storage facilities.
7. **Implement Regulations and Standards for Water Efficiency:** Mandate the use of water-efficient appliances, fixtures, and smart meters in all constructions and renovations.
8. **Support Research and Data Collection**: Continue research on water consumption patterns and the effectiveness of conservation measures. Collect and analyze data to inform policy decisions and tailor interventions to the specific needs of different demographic and housing groups.

By addressing the identified factors influencing water consumption, these policy suggestions aim to promote sustainable water use and ensure the long-term availability of this critical resource in Sonipat, Haryana.

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