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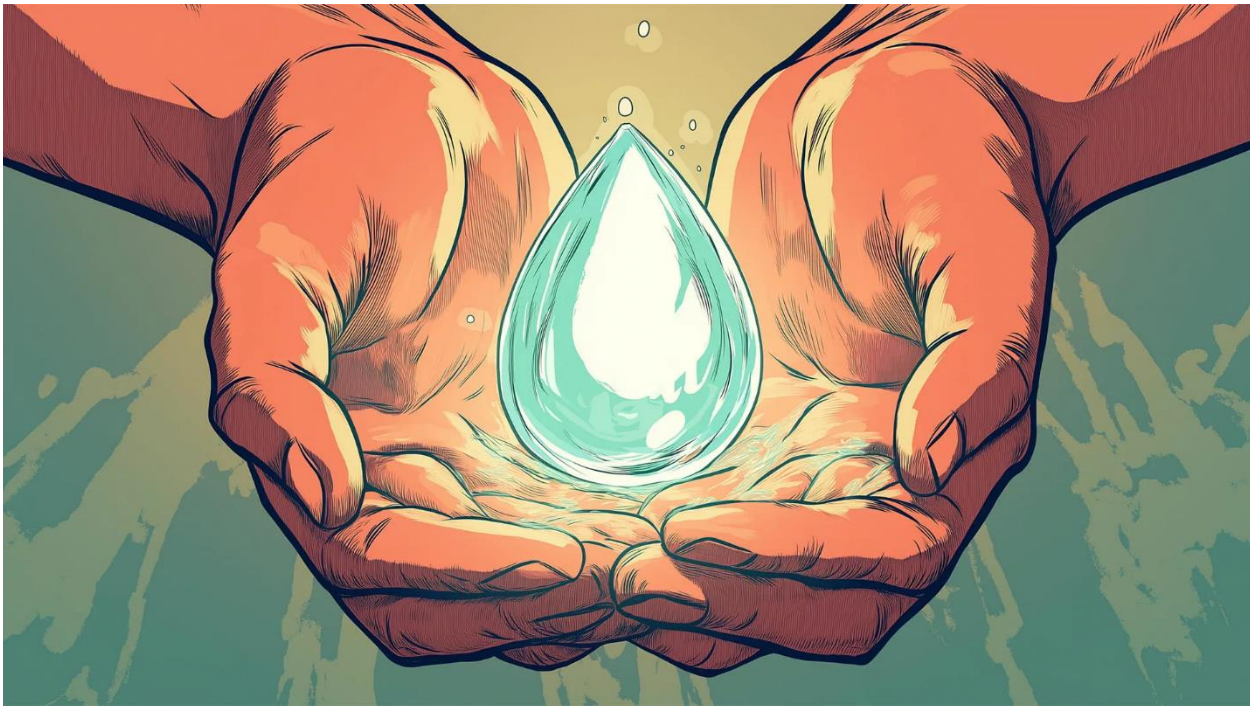

Why Water Consumption Is Declining in Gothenburg: Factors and Future Strategies

Exploring the driving forces behind decline in water consumption and suggest practical solutions

Master's thesis in Infrastructure and Environmental Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
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ABSTRACT

In the past two decades, the residential per capita water consumption has declined from 178 litres per capita per day (lpcd) in 2006 to about 130 lpcd in 2023. This decreasing trend was accomplished without any enforced municipal policies or coercive measures, with its scientific reason unknown and open to speculation. This thesis investigates the key factors driving the declining trend in a growing urban area that can help in developing effective water saving strategies for other cities. A multi-method approach was employed, incorporating quantitative data from Kretslopp och Vatten, qualitative insights from local resident surveys, and technical evaluations of fixtures and home appliances. The study reveals that improvements in appliance efficiency, retrofitting of fixtures, and public awareness on water conservation have significantly contributed to the reduced water use. Further, the study also examines future strategies to reduce the consumption further by adopting modern technologies on water recirculation, behavioural shift, policy reforms and volume-based water taxing. The concept of 50L Home was achievable through combining these strategies. Ultimately, this study offers solutions for sustainable water management and underscores the importance of integrating technology, policy reform, infrastructure design, and consumer behaviour to achieve long-term water security and resilience in the face of climate change.

Key words: water conservation, Gothenburg, sustainable urban water use, behavioural change, efficient appliances, 50L home

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Preface

Imagine a future where water is scarce. A future where every drop counts. For many parts of the world, that future is now. But in Gothenburg, something remarkable has happened—despite enormous source of freshwater availability and being an active urban area, water consumption has declined significantly over the past two decades, from 178 litres per person per day in 2006 to just 140 litres today. Understanding the reason behind this declining trend can be used to shape a more sustainable future.

During the course of my studies in Infrastructure and Environmental Engineering at Chalmers University of Technology, I have been consistently inspired by the potential of integrating science and engineering to address complex environmental challenges. Gothenburg's encouraging trend in reduced water consumption has provided a unique case study allowing exploration of sustainable urban resources for both academic and real life scenarios. This work is particularly personal to me because it reflects a commitment to developing practicable solutions that ensure long-term water security and enhance the resilience of our communities in the face of climate change.

I wish to express my sincere gratitude to my supervisor, Jesper Knutsson, whose continual guidance, expert insights, and unwavering support have profoundly shaped my research and thinking. I would also like to express my heartfelt gratitude to Birthe Riisnes, Alexander Centeno, Marius Stücheli, Tobias Svanberg, Markus Barkestedt, Visard Matias, Hariharan AT, Uchit Sangroula, and Olof Bergstedt for their support and contributions making this journey even more impactful.

I am especially grateful to my family and friends, whose constant moral support and encouragement kept me motivated throughout this endeavour. Their unwavering belief in my work provided the emotional fuel that carried me through the challenges of this research.

Finally, the outcome of this thesis gives a great contribution to the sustainable water management, and it is my hope that the strategies and insights it presents will inspire further research and policy reform aimed at securing a sustainable future.

Göteborg June 2025

KOUSHIKK SUYAMBULINGAM RAJA

List of Abbreviations

DWTP - Drinking Water Treatment Plant
KoV - Kretslopp och Vatten
HH - Household
IMS - Individual Metering System
IoT - Internet of Things
EU - European Union
IMD - Individual Metering Device
AMR - Automated Meter Reading

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1 Introduction

1.1 Background

Water is the most vital element for all living organisms on earth and while it is abundantly available throughout the world, it is distributed unequally making the planet have diverse ecosystem. The accessibility of potable water for consumption largely depends on the spatiotemporal distribution of water sources and is being heavily affected by human-caused climate change along with minor natural factors (Konapala, Mishra, Wada, & Mann, 2020). Although Sweden is blessed with enormous quantities of fresh water, the country is using less than 2% of the entire renewable water source (Worldometer, n.d.) (Statista, 2024).

Nevertheless, Sweden does experience challenges in continuous supply of water for the consumers. Though Sweden experiences temperate climate with recurring precipitation and snow, low groundwater levels and supply shortages during the warm season have become a growing problem (Barthel, et al., 2021). Furthermore, Sweden's population is projected to increase by about 22% reaching an estimated 12.6 million in 2070 up from 10.4 million in 2020 (Statistics Sweden, 2021). This increase is attributed to both domestic population growth and an influx of immigrants , which will consequently increase the demand for water production. Sweden also confronts issues in treating water from lakes and rivers, which have become progressively contaminated over time (Naturvårdsverket, 2022), potentially necessitating a change in treatment method or possibly a shift in water intake location. Moreover, Sweden also experiences about 20% water loss due to leakages which further increases the challenges in water production and maintenance (Sweden Water Research, n.d.). Above all, 40% of the Swedish municipalities report that the existing water services cannot meet the future demand (WSP, 2020).

The deficits in the potable water supply can be countered by substituting it with alternate sources, augmenting existing water supplies and/or conserving water (Moglia, Cook, & Tapsuwan, 2018). However, finding alternate sources of water and supplementing water supply can incur significant expenses, potentially increase the cost of water or even impacting the economy of the country. This makes water conservation the most sustainable ideal long-term approach. Notably, a city in Sweden, Gothenburg (Göteborg) has achieved remarkable reduction in water consumption, positioning itself as a model for conservation strategies. Recently, the Gothenburg city municipality's public service agency – Kretslopp och Vatten (KoV) released a statement on their social media page stating that daily water consumption decreased from 178 litres per capita per day (lpcd) in 2006 to 140 lpcd in 2023 [LinkedIn post]. The location map of the city is shown in Figure 1.1. Interestingly, this extraordinary reduction was accomplished without any enforced municipal policies or coercive measures, with its scientific reason unknown and open to speculation.

Identifying the key factors driving the water conservation in a growing urban area can help in developing effective water saving strategies. By highlighting the most impactful approaches, practical solutions can be suggested for policymakers, engineers, and everyday citizens who are willing to drive towards the path of water conservation and sustainability. Ultimately, a road map for achieving 50 lpcd can be formulated, not through restricting water consumption but by optimizing the needs paving the way for greater resilience to climate change, lower costs for households, and a blueprint for other cities to follow.

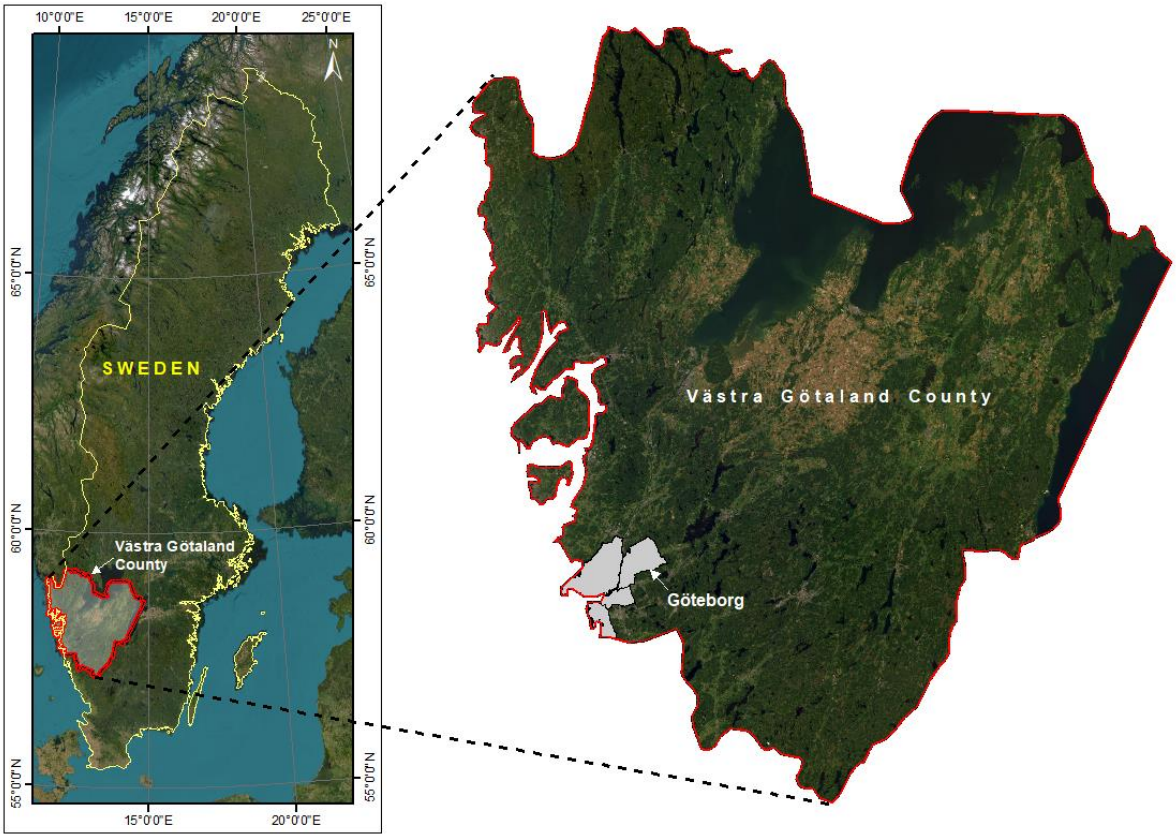

Figure 1.1 Location map of Gothenburg (Göteborg)

1.2 Aim and Research Questions

This thesis aims to discover the key factors driving this trend of reducing water consumption in Gothenburg by analysing historical data, conducting a survey, examining technological advancements & infrastructural improvements and comparing similar cities & scenarios. This thesis is not limited to understanding the past, it aims to shape the future by providing suggestions for effective water conservation. In order to get valuable outcome, the thesis will answer to the following overarching research questions:

i. What are the primary factors contributing to the reduction in water consumption in Gothenburg over the past two decades?
ii. How have changes in consumer behaviour patterns influenced water usage in Gothenburg?
iii. What role have new technologies and infrastructure changes played in reducing water consumption?
iv. How do demographic and socioeconomic factors correlate with changes in water consumption?
v. What is the most effective water-saving strategies implemented in Gothenburg, and how can they be applied systematically to continue reducing consumption?

The methodology of addressing the above research questions is by collecting water consumption data from Kretslopp och Vatten and analysing it with need for water and how it is used over the period of time. This will be supplemented by exploring and examining potential factors contributing the observed decline in daily per capita water consumption, including improvements in fixtures, innovation in efficiency of home appliance, behavioural changes and implantation of water conservation policies and recommendations. A dive into both quantitative and qualitative data on water consumption will help identify the factors driving reduction in water consumption. More detail on methodology of this thesis is given in the next Chapter.

2 Methodology

2.1 Research Design

The proposed study aims to research the underlying factors contributing to the unexpected decline in water consumption in an urban area characterized by steady population growth and infrastructure development, using a multi-approach method. To achieve this, the thesis employs systematic data collection incorporating different perspectives including historical trends, socio-economic influences, policy interventions, and behavioural changes by engaging various stakeholders working for water conservation.

Given the rarity of this phenomenon, especially in an urban area, the study aims to gather insights from the analysis of comprehensive quantitative, qualitative, technical and comparative data collection. Statistical interpretation and trend analysis are conducted to identify the possible factors influencing declined water consumption and are supported by extensive literature review. Additionally, the outcome of this research is used to develop a structured framework that can be applied for further declining the water consumption in Gothenburg City and sustainable water conservation in other urban regions globally.

2.2 Data Collection

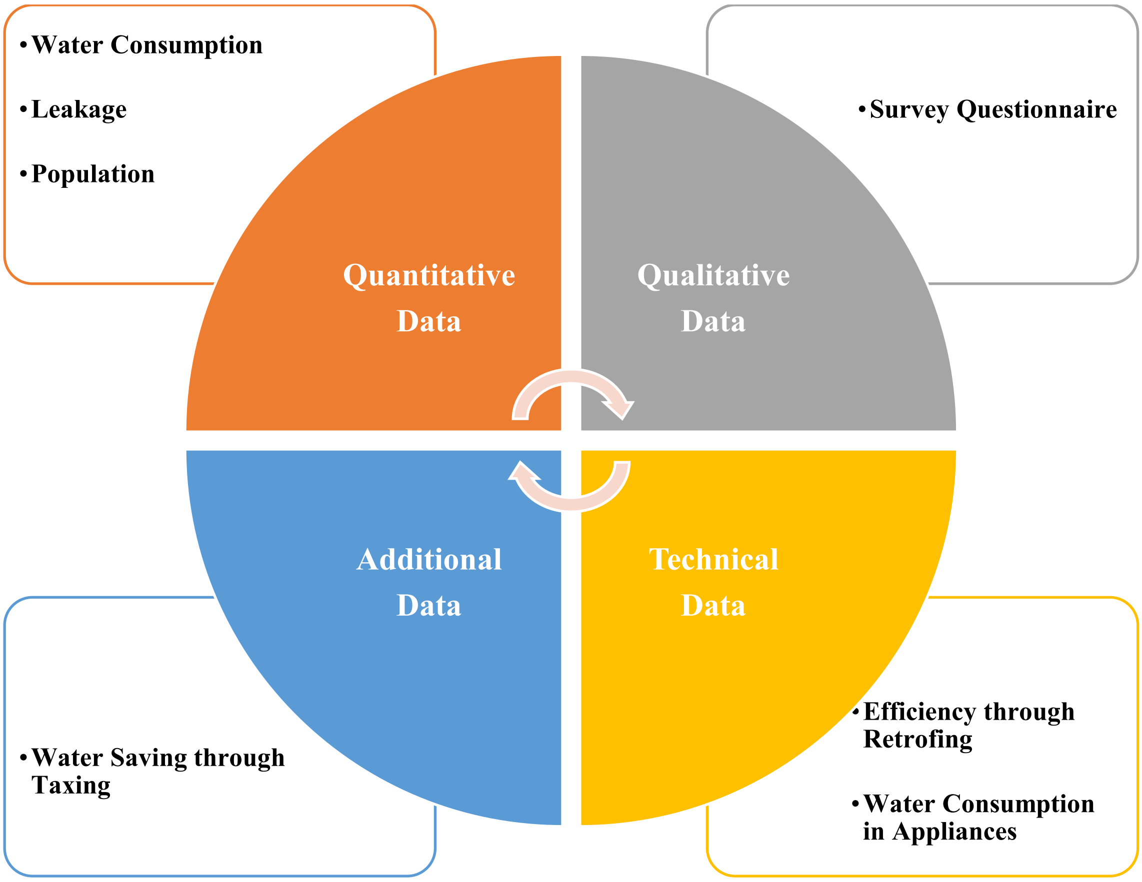

Figure 2.1 Classification of Types of Data Collection for Water Usage Analysis

2.2.1 Quantitative Data

A collaboration with the municipal agency - Kretslopp och Vatten was involved, who are responsible for both the supply of potable water and discharge of sewage for the inhabitants in Gothenburg. The city receives its tap water from the Vänern Lake and Göta River which are treated by Alelyckan DWTP at Lärjeholm and Lackarebäck DWTP at south of Delsjömotet (Göteborgs Stad, n.d.). While the first water supply system of Gothenburg dates back two centuries ago, the Alelyckan and Lackarebäck DWTPs were constructed between 60 and 160 years ago (Pettersson, 1987). KoV operates these two DWTPs along with the extensive water network distributed across the city. Additionally, they are also tasked with maintaining water quality and planning for expansions to satisfy the future drinking water demands in the Gothenburg City.

The total quantity of water production in Gothenburg was used to analyse the trends in water consumption. The thesis focuses solely on household water consumption; thus, the data was refined by the distribution of water usage among different types of consumers such as residential, industrial, and municipal. This data was then compared with population statistics from Statistics Sweden's database. Based on the interactions with officials from KoV, roughly 99% of the population in Gothenburg has municipal water connections, so the data was adjusted accordingly. Leakage volumes were also subtracted from the total quantity of water production to enhance the accuracy of the analysis.

Data collection was extended to high resolution data sets, including daily and hourly water consumption to gain deeper insights. To minimize bias, data was collected from three District Meter Areas (DMA) comprised of individual houses and another three DMAs representing apartment type residential area. This approach allowed to validate the consumption data for different house types, seasons and times of day. The graphs of the collected data are given in Appendix A.

A hypothesis was also made stating that there is a rising trend in usage of public facilities, as more individuals are showering at the gym post-workout or at the office after biking to work. Hence, data on water consumption at such commercial complexes were sought to investigate whether the decline in residential water consumption was a mere shift to commercial areas. However, limitations were encountered as data specific to certain commercial locations as mentioned above could not be appropriately refined for analysis.

2.2.2 Qualitative Data

The water consumption pattern in Gothenburg cannot be studied only through quantitative data as it does not reflect upon the psychological and behavioural aspects of a consumer. While quantitative data focuses on numerical metrics, qualitative data provides insights on consumer perspectives over water conservation. Collection and analysis of qualitative data aids in the exploration of behavioural tendencies, awareness level and inclinations towards water consumption which thereby influences the declining water consumption trend. The findings can help identify the demographic groups that require more awareness on water conservation and provide recommendations to policy makers for effective water conservation in households.

A set of interview questions was framed to target inhabitants in Gothenburg to understand the water usage behaviour, perception, awareness and attitude towards water conservation. These questions were prepared using Google Forms in both Swedish and English and was circulated via social media platforms such as Facebook and LinkedIn and also through WhatsApp Messenger. The interview questions are given in Appendix D. The survey was carried out online for all the consumers who receive water from KoV. Efforts were made to gather responses from diverse groups, ensuring representation from different demographic profiles and avoid bias.

Thematic analysis was conducted on the responses received from the survey interview responses to detect patterns and themes. Data was categorized based on demographic profiles, highlighting common behavioural tendencies related to water usage and sustainability consciousness. Further, the outcomes were triangulated with the available quantitative data and literature reviews to validate the responses and have a broader perspective on the declining water consumption trend in Gothenburg.

Despite all the efforts taken to ensure a representative sample, this methodology also has its limitations. While the intention of the survey was to cover diverse sample, the responses might not reflect the entire consumer base receiving water from KoV. Additionally, the responses received might also include interviewees' favourable answers rather than their actual behaviour which makes the collected responses influenced by social desirability bias. No personal information was taken from the respondents, and they were informed of this in order to obtain unbiased results and uphold ethical integrity.

2.2.3 Technical Data

Household water consumption occurs both directly through fixtures for sanitary and kitchen purposes and indirectly through electronic appliances for washing clothes and dishes. Therefore, the efficiency of water consuming installations such as taps, faucets, flush tanks in toilets, laundry machines and dishwashers play a crucial role in determining the overall water consumption pattern. This study reviews the technical specification of various fixtures and appliances manufactured over different time periods, assessing the efficiency improvements in comparison with similar older installations.

Additionally, in order to conserve water and reduce energy cost associated with consumption of hot water, Bostad Bolaget replaced all the faucets in their apartment with sustainable models. This transition aimed to reduce water consumption without requiring behavioural changes from the residents. Water consumption data from Bostad Bolaget provides direct evidence of reductions in water usage achieved through the installation of efficient faucets in their residential properties. This study evaluates the impact of this switch through the water consumption data.

Furthermore, electronic appliances which consume water, such as laundry machines and dishwashers comes with technical specification sheets that contain essential details such as water consumption, sustainability ratings and efficiency metrics. Appliances with the same operational capacity but manufactured at different periods of time since at least two decades ago are considered to track the evolution of water efficiency in such appliances.

The technical data analysed in this study presents a holistic evaluation of water efficient technologies and infrastructure improvement over time. By integrating details from product specifications with real world water consumption data, this analysis highlights the technical advancements contributing to the ongoing decline in water consumption pattern in Gothenburg. This research also validates the effectiveness of sustainable technologies in reducing water consumption.

2.3 Additional Studies

An additional study was conducted to assess the influence of individual metering system (IMS) on households to conserve water by implementing consumption-based water pricing rather than a fixed cost tariff for the water supply. A pilot project on advanced Internet of Things (IoT)-based smart water distribution system that was implemented in Cheran Nagar, Coimbatore Smart City, India was evaluated for this study. The system provided real-time monitoring of water usage in HH. Additionally, telescopic water pricing was levied to further encourage consumer awareness on the importance of water conservation efforts. This study aims to evaluate the behavioural changes in water consumption resulting from a unique pricing model based on actual water usage instead of a predetermined tariff.

The key objective of implementing telescopic pricing was to incentivise water conservation by imposing higher water charges on excessive consumption. Following the implementation of IMS in the District Metered Area – Cheran Nagar, Coimbatore Corporation provided data on water consumption recorded in the DMA. A novel tariff system was introduced and facilitated through the digital initiative of the 'ROPeS Coimbatore WSMM' app for smart phones. This application enables real time synchronisation of water consumption data recorded through the IoT devices. The tariff structure operates on a prepaid basis making the households to pay a fixed monthly fee for a basic water allocation irrespective of actual usage. Consumers requiring additional water supply can purchase extra quantities through the app which are subjected to expensive rates to discourage excessive use of water.

The methodology of implementation, tariff structure and percentage of water saved beyond the allocated quantity are discussed in Section 3.7.4, presenting IMS as a viable strategy for sustainable water management in Gothenburg City. This additional study explores the integration of technological advancements with behavioural economics to improve water conservation.

2.4 Proposal for Future Strategies

A comprehensive methodological approach was adopted to develop feasible and effective strategies for water conservation in households, contributing to the practical implementation of the 50L home initiative in Gothenburg. The 50L home is a futuristic concept aimed at enabling a standard living experience with an average water consumption of 50 lpcd without compromising essential water usage. The methodology integrates the enhancement of key factors identified earlier, the exploration of emerging technological innovations and the development of awareness-based initiatives.

The insights are gathered from the methodologies adopted to identify key factors including behavioural changes and technological assessment. Additionally, a strategic framework was created to enhance awareness among the consumer and promote water conservation. The feasibility of these strategies was analysed by identifying potential limitations and providing mitigation measures to ensure effective implementation in Gothenburg City.

3 Results

3.1 Overview of Water Consumption Data

Increase in population have direct influence in the raising water demand. The population growth in Sweden is steadily increasing with a projected raise of about 370,000 in five years from 2025 (IMF, 2025). This trend is reflected in Gothenburg municipality which has a substantial expanding population growing from 462,756 in 2000 to 608,993 by the end of 2023 (SCB, 2025).

Kretslopp och Vatten (KoV) is responsible for production and supply of potable water for the households in Gothenburg municipality. Comprehensive data on the quantity of water produced, lost due to leakage and consumed by different categories such as house, apartment, industry and general service are provided by KoV over a span of two decades, i.e. from 2004 to 2023. The per capita water consumption in lpcd was estimated using the household consumption figures relative to the population and is given in Table 3.1.

A clear declining trend emerging from the per capita water consumption data over the past two decades can be observed from the Figure 3.1. The per capita daily average water consumption stood at 174.7 lpcd in 2004 which then steadily decreased to 131.9 lpcd by 2023. This represents 24.5% reduction in water consumption, suggesting an overall improvement in water usage efficiency and awareness on water conservation among residents.

An anomaly occurred in this downward trend during the years 2020 and 2021, coinciding with the COVID-19 pandemic. The curfew imposed during the pandemic period resulted in lifestyle changes, which led to higher water consumption in the kitchen for cooking and dishwashing as most restaurants were closed, more personal hygiene activities like taking multiple longer showers and handwashing, as well as more laundry and housekeeping (Campos, et al., 2021; Özbaş, Güneysu, Özcan, & Öngen, 2022). However, the declining trend continued once the pandemic was over while the curfew was lifted and more people started going to their workplace, schools, universities and shopping venues.

The total volume of water supplied for various categories of consumers were found to have a relative stability which varied between 43 to 45 Mm^3. Similar stability can be observed in water production as well. Overall, the presented data in this section indicates that the inhabitants of Gothenburg municipality have made progress towards efficient water use in their residences. Although total water consumption in houses have slightly increased, it has significantly decreased in apartments, thereby allowing to allocate more water to be used by industries and general service.

Table 3.1 Data on water production, leakage, supply, population and per capita consumption

Year	Total water production[1] (Mm^3)	Lost due to leakage[1] (Mm^3)	Total supplied[1] (Mm^3)	Supplied to different categories in Gothenburg municipality[1] (Mm^3)					Sold to other municipalities[2] (Mm^3)	Population in Gothenburg[3] (nos.)	Yearly household consumption[2] (Mm^3)	Daily consumption[2] (l)	Daily per capita consumption[2] (lpcd)
				House	Apartment	Industry	General service	Total					
2004	61.502	12.797	48.705	4.2	26.6	5.6	8.0	44.4	4.305	481564	30.8	84153005	174.7
2005	59.060	10.714	48.346	4.5	26.4	5.5	7.9	44.3	4.046	484942	30.9	84657534	174.6
2006	60.610	11.981	48.629	4.7	26.3	5.5	8.3	44.8	3.829	489866	31.0	84931507	173.4
2007	60.586	11.987	48.599	4.7	25.9	5.5	8.3	44.4	4.199	493575	30.6	83835616	169.9
2008	61.793	12.406	49.387	4.8	25.9	5.4	8.4	44.5	4.887	500274	30.7	83879781	167.7
2009	62.916	13.711	49.205	4.8	26.1	5.0	8.4	44.3	4.905	507330	30.9	84657534	166.9
2010	63.913	14.904	49.009	4.7	25.6	5.2	8.5	44.0	5.009	513751	30.3	83013699	161.6
2011	61.731	12.500	49.231	4.6	25.5	5.0	8.3	43.4	5.831	520396	30.1	82465753	158.5
2012	61.274	12.706	48.568	4.6	25.6	5.0	7.9	43.1	5.468	526089	30.2	82513661	156.8
2013	62.512	13.770	48.742	4.7	25.6	4.9	8.0	43.2	5.542	533271	30.3	83013699	155.7
2014	63.306	14.539	48.766	4.8	25.7	4.8	8.2	43.5	5.266	541203	30.5	83561644	154.4
2015	63.353	12.984	50.369	4.8	25.8	4.9	8.1	43.6	6.769	548190	30.6	83835616	152.9
2016	65.591	14.810	50.781	4.7	25.8	4.8	8.2	43.5	7.281	556640	30.5	83333333	149.7
2017	62.727	14.216	48.511	4.8	25.4	5.0	8.1	43.3	5.211	564039	30.2	82739726	146.7
2018	64.728	15.296	49.432	4.8	25.3	5.2	8.3	43.6	5.832	571868	30.1	82465753	144.2
2019	62.659	13.615	49.045	4.8	25.3	5.4	8.2	43.7	5.345	579281	30.1	82465753	142.4
2020	62.623	12.760	49.863	5.1	26.4	5.1	7.3	43.9	5.963	583387	31.5	86065574	147.5
2021	63.781	14.416	49.365	5.3	26.0	5.5	7.7	44.5	4.865	587549	31.3	85753425	146.0
2022	60.614	12.293	48.321	5.0	25.1	5.5	8.1	43.7	4.621	596841	30.1	82465753	138.2
2023	59.093	9.769	49.324	4.6	24.5	5.8	8.9	43.8	5.524	604616	29.1	79726027	131.9

Calculations:
Sold to other municipalities = Total supplied – Total supplied only in Gothenburg municipality
Yearly household consumption = Water supplied in houses + Water supplied in apartments
Daily consumption = Yearly household consumption / No. of days in the particular year
Daily per capita consumption = Daily consumption / Population in Gothenburg

[1] Data from KoV
[2] Calculated values
[3] Data from Statistikmyndigheten

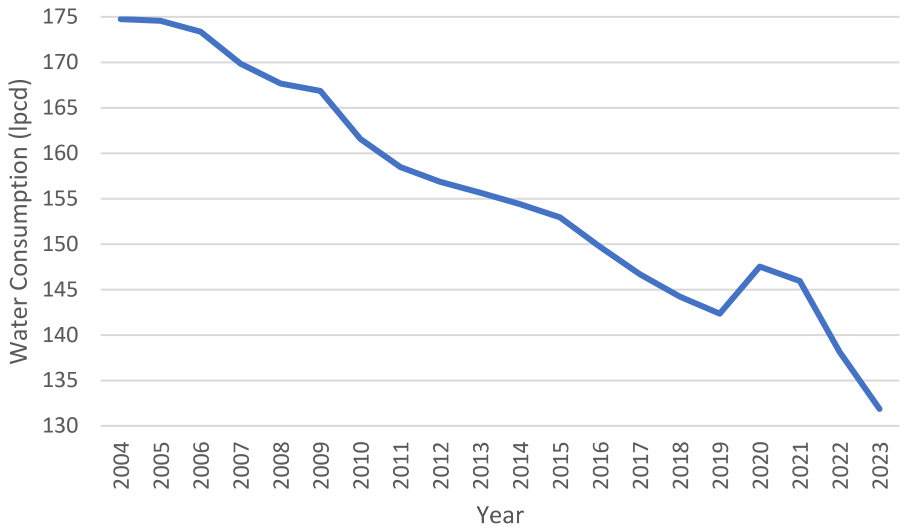

Figure 3.1 Daily per capita water consumption in Gothenburg since 2004

3.2 Temporal Dynamics and Influencing Factors

An in-depth temporal analysis was conducted on the water consumption data provided by KoV of all the eight zones. The zones represent different residential building types and the proximity to the city centre which is present in Table 3.2 and shown in Figure 3.2. Four zones were typified by multi-family apartment buildings, while the remaining four encompassed single-family houses and townhouses. This distinction in residential typology has significant influence over water consumption due to different behaviour and needs (Bich-Ngoc & Teller, 2018).

Table 3.2 Specification of the zones based on building types and location

Zone	Type of buildings	Approx. location
1	Apartments and a few commercial	South of city centre
2	Only Houses (Some are townhouses/row-houses)	North-east, more peripheral.
3	Mostly apartments, a few houses and a few commercial	West of city centre
4	Only houses	West, more peripheral.
5	Houses and a few apartments	North of city centre
6	Houses and a few apartments	East of city centre
7	Apartments (at high density) and a few commercial	West of city centre
8	Apartments and a large amount of commercial	City centre

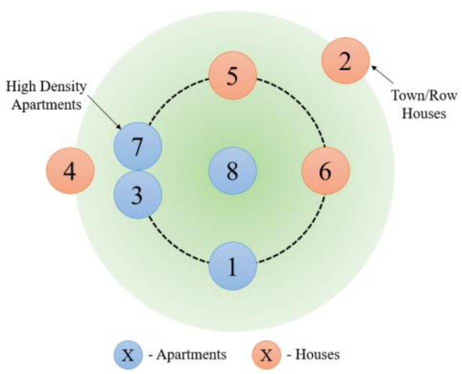

Figure 3.2 Spatial distribution of zones by proximity to city centre

The data revealed consistent differences in average water consumption across housing types, with zones primarily consisting of apartments consuming more water than those containing houses. Conversely, water usage was substantially lower in high-density apartment complexes, which may be attributed to spatial constraints limiting water-intensive activities like gardening or swimming pool and the presence of efficient plumbing systems. Furthermore, the limited availability of space in these apartments often precludes the owenership of individual washing machines, necessitating the use of communal laundry facilities which contributes positively to overall water conservation. Additionally, the spatial limitations may also avoid having leisure amenities such as bathtubs, which typically require greater water volumes compared to showers. Specifically, any bathtub requires over 200 litres of water, whereas an inefficient shower with a flow rate of 8 l/min consumes 80 litres for a 10-minute-long shower. Moreover, high-density housing tends to accommodate a greater proportion of working professionals or smaller households, who may spend less time at home and subsequently exhibit lower water consumption. Together these factors likely contribute to an average water consumption less than 50 lpcd. However, a detailed analysis of water consumption for specific activities within these apartments is not feasible due to the confidentiality of location details of Zone 4.

Notably, townhouses and row houses in Zone 2 recorded consumption levels comparatively higher than other zones containing houses which may be attributed to the fact that most detached houses are subject to individual metering, aging infrastructure, absence of modern water-saving fixtures and have obsolete and inefficient water consuming appliances. However, these interpretations are speculative due to the lack of detailed contextual information such as building age, exact geographic location or demographics of household.

To examine long-term patterns, daily water usage figures were visualized across years for each zone and vice versa (Refer Appendix A). This facilitated the identification of recurrent anomalies, such as distinct consumption spikes and dips correlating with population dynamics. As given in Table 3.3 and Table 3.4, the dips in water consumption were observed during key holiday periods such as Easter, Midsummer, and Christmas, likely corresponding to temporary outward migration of the city residents to celebrate in their native towns. Similarly, events such as Melodifestivalen—a prominent national music competition—appeared to coincide with the dip in water consumption may have occurred potentially due to the exodus of attendees to Malmö, the host city. Conversely, localized events such as Göteborgsvarvet Marathon, Partille Cup, and West Pride Festival were associated with increased consumption, presumably due to heightened visitor influx and major urban activity. However, these associations remain unverified and given the absence of event-specific consumption tracking, these correlations should be further interpreted with caution.

The household water consumption patterns vary significantly throughout the week, reflecting urban working routines (Refer Table 3.5 and Figure 3.3). Weekly usage analysis further emphasized structured behavioural patterns, with average weekday (Monday, Tuesday, Wednesday, Thursday and Friday) water consumption appeared typically lower than weekend (Saturdays and Sundays) consumption across most zones. This discrepancy reflects structured weekday routines characterized by work and school commitments leading to shorter showers and reduced in-home activities, while weekends are predominantly dedicated to domestic tasks such as cooking, cleaning, and laundry (Ioannou, Kofinas, Spyropoulou, & Laspidou, 2017; Flume, 2020). An outlier was observed in Zone 8, where weekday consumption surpassed weekend levels, plausibly due to increased commercial activity during weekdays attracting greater foot traffic which is in accordance with the zone's characteristics.

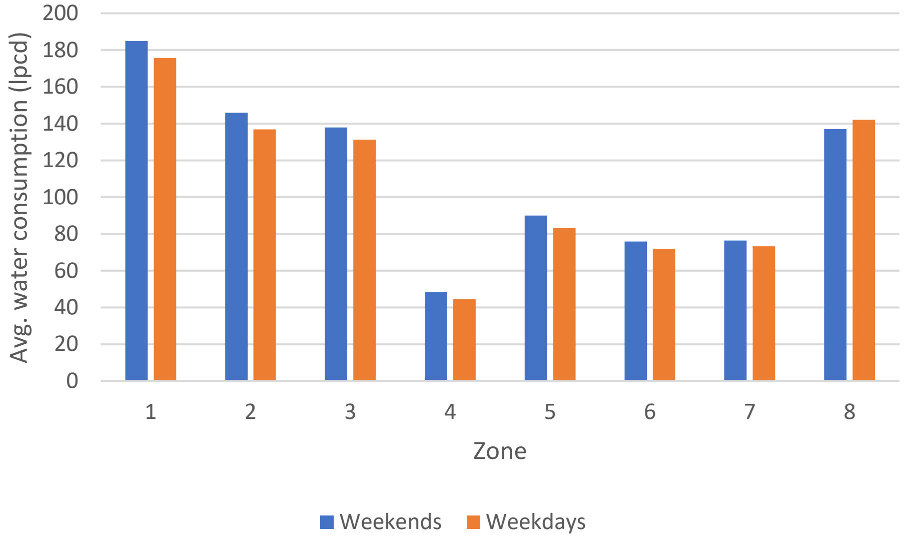

Figure 3.3 Comparison of average daily per capita water consumption between weekends and weekdays

Seasonal water consumption trends were also evaluated using astronomical seasonal demarcations: Spring (March 20 – June 20), Summer (June 21 – September 21), Autumn (September 22 – December 20), and Winter (December 21 – March 19) (Time and Date, n.d.). The average zone wise per capita water consumption data is shown in Figure 3.4. Winter recorded the highest average residential water consumption across most zones. This trend may be linked to behavioural shifts, including longer shower durations and possible reliance on supplementary water-based heating solutions, although the latter is uncommon in Gothenburg (Rathnayaka, et al., 2015; Smart City Sweden, n.d.). In general, water consumption is expected to be higher during summer season due to increased demand for frequent showering, irrigation and recreational activities like swimming and other water sports (Bergel, Szeląg, & Woyciechowska, 2017). However, Gothenburg's consistent year-round precipitation (Refer Figure 3.5), limited urban space for irrigation and the classification of public green space outside residential category significantly reduce water demand during summer. Only zones 2, 4, 5, and 6 which contain houses might potentially contribute to water usage for gardening purposes.

The data on per capita daily water consumption obtained from KoV contains missing values, negative figures and highly fluctuating error data. These inconsistencies may have resulted from infrastructure maintenance, leakage or malfunctioning water meters.

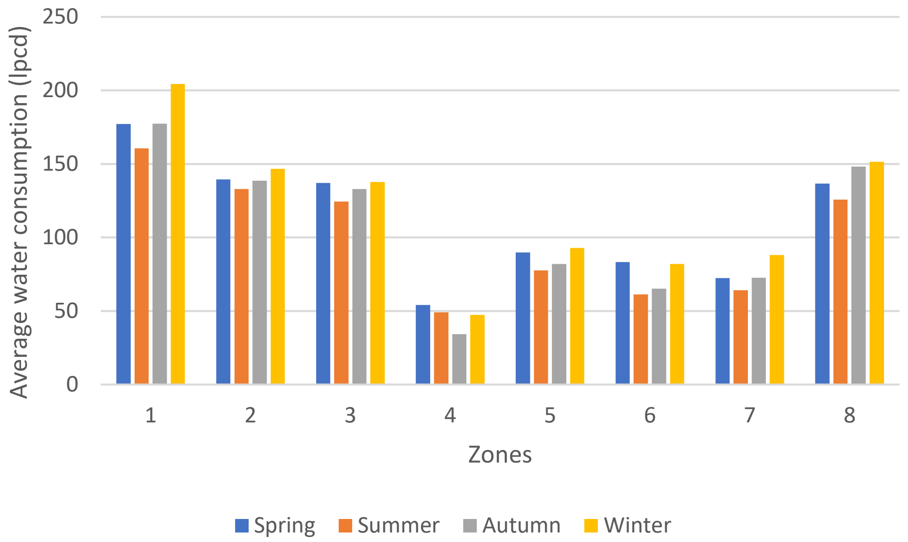

Figure 3.4 Zone wise seasonal average daily per capita water consumption distribution

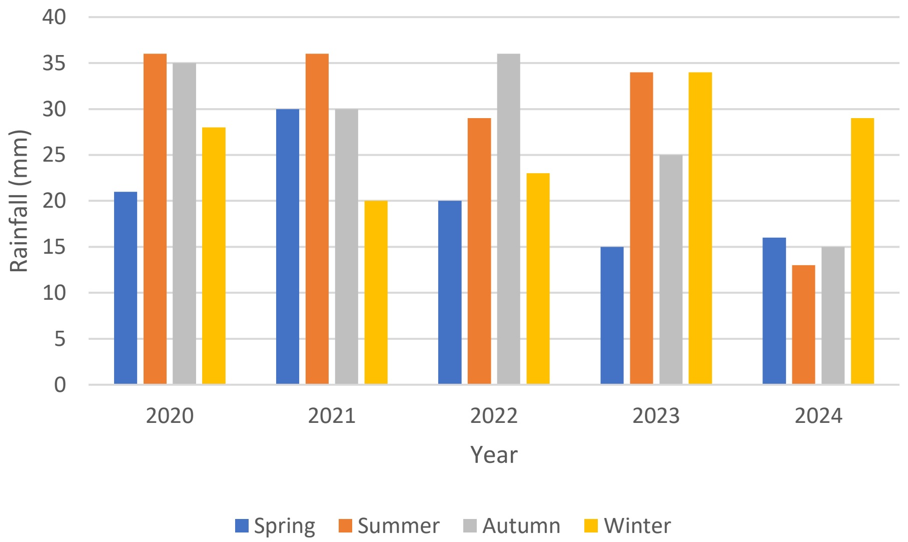

Figure 3.5 Yearly seasonal average rainfall distribution (World Weather Online, n.d.)

Table 3.3 Year wise observed similar dips and spike among different zones with possible causes

Year	Month	Dates	Water consumption	Zone	Possible cause
2020	Feb	15-03 (Mar)	Spike	3	Sports holiday
2020	Feb	19-02 (Mar)	Spike	7	
2020	Sep	23-24	Dip	2	Unknown
2020	Sep	23-24	Dip	6	
2020	Sep	23	Dip	7	
2020	Oct	1	Dip	2	Unknown
2020	Oct	1	Dip	3	
2020	Oct	1	Dip	6	
2020	Oct	1	Dip	7	
2021	Apr	21	Dip	3	Unknown

Year	Month	Dates	Water consumption	Zone	Possible cause
2021	Apr	21	Dip	6	
2021	Jun	25-26	Dip	1	Midsummer
2021	Jun	25-26	Dip	2	
2021	Jun	25-26	Dip	3	
2021	Jun	25-26	Dip	6	
2021	Jun	25-26	Dip	7	
2022	Apr	16-17	Dip	1	Easter holiday
2022	Apr	16-17	Dip	2	
2022	Apr	16-17	Dip	3	
2022	Apr	16-17	Dip	6	
2022	Apr	16-17	Dip	7	
2022	Apr	16-17	Dip	8	
2022	Jun	24-25	Dip	3	Midsummer
2022	Jun	24-25	Dip	7	
2022	Jun	24-25	Dip	8	
2022	Oct	12-13	Dip	2	Unknown
2022	Oct	12-13	Dip	3	
2022	Oct	12-13	Dip	5	
2022	Oct	12-13	Dip	6	
2022	Dec	6	Dip	5	Unknown
2022	Dec	6	Dip	6	
2022	Dec	24-25	Dip	3	Christmas Holiday
2022	Dec	24-25	Dip	7	
2022	Dec	24-25	Dip	8	
2023	Feb	11	Dip	3	Unknown
2023	Feb	10-11	Dip	5	
2023	Feb	10-11	Dip	6	
2023	Feb	10-11	Dip	7	
2023	Feb	24	Dip	2	Melodifestivalen in Malmö
2023	Feb	24-25	Dip	3	
2023	Feb	23-25	Dip	5	
2023	Feb	23-25	Dip	6	
2023	Feb	23-25	Dip	7	
2023	Apr	07-09	Dip	3	Easter holiday
2023	Apr	07-09	Dip	7	
2023	Apr	07-09	Dip	8	
2023	Jun	11	Spike	1	Clandestino Festival & West Pride
2023	Jun	11	Spike	2	
2023	Jun	11	Spike	3	
2023	Jun	11	Spike	4	
2023	Jun	11	Spike	5	
2023	Jun	11	Spike	6	
2023	Jun	23-24	Dip	1	Midsummer
2023	Jun	24	Dip	3	
2023	Jun	23-24	Dip	7	
2023	Aug	5	spike	3	Unknown
2023	Aug	7	spike	6	
2023	Aug	27	spike	2	
2023	Aug	27	spike	3	
2023	Dec	10-11	spike	2	Unknown
2023	Dec	11	spike	6	
2023	Dec	24-25	Dip	1	Christmas Holiday

Year	Month	Dates	Water consumption	Zone	Possible cause
2023	Dec	24-25	Dip	3	
2023	Dec	24-25	Dip	7	
2023	Dec	24-25	Dip	8	
2024	Mar	30-31	Dip	1	Easter holiday
2024	Mar	30-31	Dip	3	
2024	Mar	30-31	Dip	7	
2024	Mar	30-31	Dip	8	
2024	May	26	Dip	1	Unknown
2024	May	24	Dip	2	
2024	May	24	Dip	3	
2024	May	22-24	Dip	5	
2024	May	23-24	Dip	6	
2024	May	23-24	Dip	7	
2024	Jun	21-22	Dip	1	Midsummer
2024	Jun	21-22	Dip	2	
2024	Jun	21-22	Dip	3	
2024	Jun	21-22	Dip	7	
2024	Jun	21-22	Dip	8	
2024	July	2	Spike	1	Partille Cup
2024	July	2	Spike	8	
2024	July	24-25	Dip	2	Unknown
2024	July	24-25	Dip	3	
2024	July	25	Dip	5	
2024	July	23-24	Dip	6	
2024	July	23-24	Dip	7	
2024	Dec	24-25	Dip	1	Christmas Holiday
2024	Dec	24-25	Dip	3	
2024	Dec	25	Dip	6	
2024	Dec	24-25	Dip	7	
2024	Dec	24-25	Dip	8	

Table 3.4 Zone wise observed similar dips and spike among each year with possible causes

Year	Month	Dates	Water consumption	zone	Remark
2021	Jun	25-26	dip	1	Midsummer
2022	Jun	24-25	dip	1	
2023	Jun	23-24	dip	1	
2024	Jun	21-22	dip	1	
2021	Dec	24-26	dip	1	Christmas Holiday
2022	Dec	25-27	dip	1	
2023	Dec	24-25	dip	1	
2024	Dec	24-25	dip	1	
2020	May	27-28	dip	2	Unknown
2024	May	24	dip	2	
2020	Dec	24-26	dip	2	Christmas Holiday
2021	Dec	24-26	dip	2	
2022	Dec	24-30	dip	2	
2023	Dec	24-29	dip	2	
2020	Apr	11 & 14	dip	3	Easter holiday
2021	Apr	03-04	dip	3	

Year	Month	Dates	Water consumption	zone	Remark
2022	Apr	16-17	dip	3	
2023	Apr	07-09	dip	3	
2024	Mar	30-31	dip	3	
2020	Jun	19-20	dip	3	Midsummer
2021	Jun	25-26	dip	3	
2022	Jun	24-25	dip	3	
2023	Jun	24	dip	3	
2024	Jun	21-22	dip	3	
2020	Dec	24-26	dip	3	Christmas Holiday
2021	Dec	24-26	dip	3	
2022	Dec	24-25	dip	3	
2023	Dec	24-25	dip	3	
2024	Dec	24-25	dip	3	
2021	Apr	16-18	Spike	4	Unknown
2022	Apr	18	Spike	4	
2023	Apr	16 & 22	Spike	4	
2023	May	13-14	Spike	4	Göteborgsvarvet Marathon
2024	May	18-22	Spike	4	
2021	Dec	25-30	dip	4	Christmas Holiday
2022	Dec	25-30	dip	4	
2023	Dec	25-30	dip	4	
2024	Dec	25-30	dip	4	
2021	Feb	05-07	Spike	6	Unknown
2022	Feb	1	Spike	6	
2023	Feb	10-11	Spike	6	
2022	May	22-23	dip	6	Unknown
2023	May	23	dip	6	
2024	May	23-24	dip	6	
2023	Aug	7	Spike	6	Unknown
2024	Aug	5	Spike	6	
2021	Apr	03-04	dip	7	Easter holiday
2022	Apr	16-17	dip	7	
2023	Apr	07-09	dip	7	
2024	Mar	30-31	dip	7	
2021	Jun	25-26	dip	7	Midsummer
2022	Jun	24-25	dip	7	
2023	Jun	23-24	dip	7	
2024	Jun	21-22	dip	7	
2022	Apr	16-17	dip	8	Easter holiday
2023	Apr	07-09	dip	8	
2024	Mar	30-31	dip	8	
2022	Jun	24-25	dip	8	Midsummer
2023	Jun	23-24	dip	8	
2024	Jun	21-22	dip	8	
2021	Dec	24-26	dip	8	Christmas Holiday
2022	Dec	24-25	dip	8	
2023	Dec	24-25	dip	8	
2024	Dec	24-25	dip	8	

Table 3.5 Average water consumption during weekends and weekdays

Zone	Average water consumption (lpcd)		Change
	Weekends	Weekdays	
1	184.91	175.66	5%
2	145.91	136.83	6%
3	137.88	131.29	5%
4	48.27	44.49	8%
5	90.05	83.15	8%
6	75.78	71.84	5%
7	76.47	73.24	4%
8	137.01	142.13	4%

3.3 Conservation through Fixtures and Fittings

Household water consumption is generally distributed across a range of domestic activities, including personal hygiene (e.g., showering and handwashing), direct ingestion through food and drinks, toilet flushing, dishwashing, laundry, and other miscellaneous uses. The proportional breakdown of these categories is illustrated in Figure 3.6 (Segerström, 2022). As depicted in the figure, the majority of household water use is attributable to personal hygiene and toilet flushing, which together represent the most water-intensive activities within a typical residence.

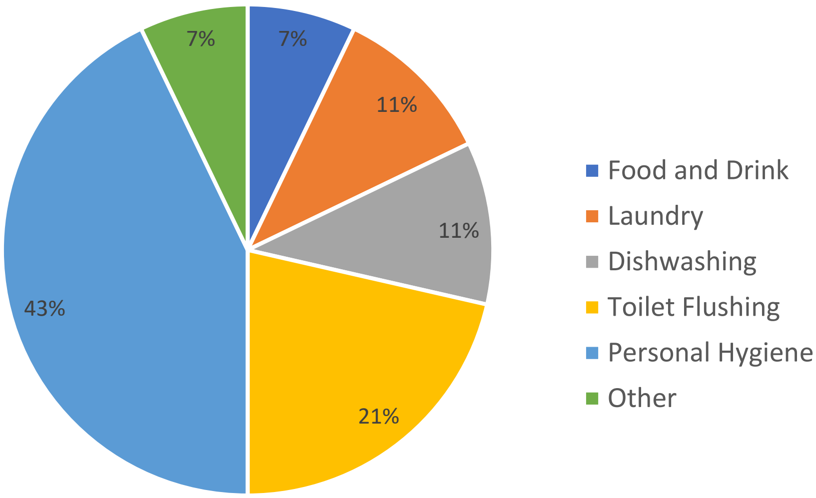

Figure 3.6 Household water use representation

In Sweden, the municipalities provide potable water without constraints on volume or pricing structures, reflecting a historical context of abundant water resources. As governmental agencies have gradually recognized the necessity of water conservation, many government boards have implemented regulatory measures to restrict water flow rates in residential fixtures and fittings. The timeline of these regulatory frameworks along with other water conservation measures implemented so far by the Swedish government and European Union are illustrated in Figure 3.7. In response to such regulations, manufacturers have gradually transitioned more towards the production of water-efficient appliances and fittings, facilitating their adoption across households worldwide.

Despite Sweden has a longstanding reputation as a forerunner in environmental sustainability and water conservation, there were no formal regulations governing water use efficiency such as maximum flush volumes or flow rates for faucets and shower heads until 2020. The Boverket's Building Regulations since 2014 requires a mandatory provision of 6 l/min flow rate in faucets but the latest EU Taxonomy Regulation have limited the flow rate to a maximum of 6 l/min 2021 which contradicts to each other and there is no amendment is the Swedish Regulations on flow rate. Following updates in European Union directives, current regulations stipulate that bathroom and kitchen faucets should not exceed a maximum flow rate of 6 litres per minute, showers are restricted to 8 litres per minute, and toilet flush capacity must comply with a maximum full flush volume of 6 litres and an average flush volume of 3.5 litres (European Commission, 2021). Notably, Swedish manufacturers such as Gustavsberg and FM

Mattsson proactively began incorporating water-saving technologies into their product designs prior to the enforcement of such mandates, thereby contributing to both water and energy conservation efforts (Gustavsberg, n.d.; FM Mattsson, n.d.).

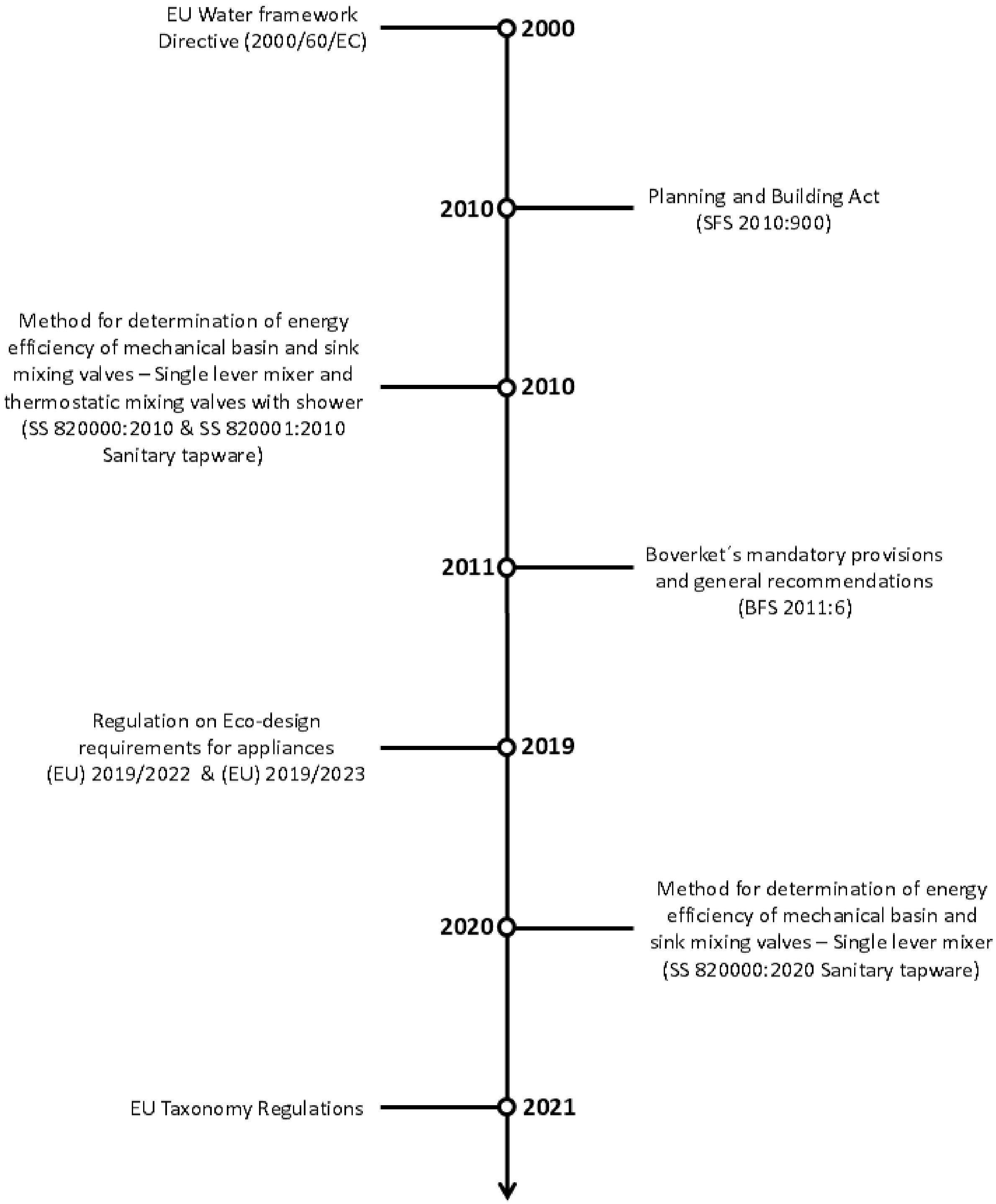

Figure 3.7 Timeline of regulatory frameworks and recommendations issued by government bodies

A practical illustration of the effectiveness of these interventions can be found in the case of BostadsBolaget, a housing company that undertook significant measures to reduce water consumption by replacing traditional fixtures with water efficient alternatives. Since 2020, the company has invested approximately 12.8 million SEK to retrofit 25 residential complexes in Gothenburg. Of these, 7 complexes were selected for detailed analysis due to the availability of comprehensive water usage data of at least 12 months before and after retrofitting. A comparative plot of monthly water consumption each before and after retrofitting with corresponding values for each month is shown in Figure 3.8. The water consumption data during this intervention are presented in Appendix B. The results indicate that the percentage reduction in annual water usage across the seven studied complexes ranged from 4.13% to 10.77%, with an average reduction of 7.58%. Out of 25 complexes, 22 showed a positive trend towards water conservation, with an average monthly reduction in consumption of 9.6%. These reductions translated into substantial financial savings, amounting to approximately 5.2 million SEK, which includes both water costs and the energy costs associated with heating hot water.

A rough estimate calculation was carried out to showcase the potential water savings by switching to more water-efficient showers and faucets. On an average, individuals wash their hands two to four times daily (Merk, Kühlmann-Berenzon, Linde, & Nyrén, 2014), and takes about 28 to 31 seconds each time (Shi, et al., 2023). An additional 5 seconds is added to account for water wasted in adjustment to the desired temperature as Gothenburg experiences cold weather around the year. Considering a frequency of four handwashing instances a day and with a total duration of 30 + 5 seconds per instance, the daily water use for handwashing amounts to 140 seconds. The EU taxonomy's recommended maximum flow rate in a faucet is 6 l/min, which translates to approximately 14 litres of water used for handwashing each day. Similarly, for calculating water spent on showering, an assumption of shower duration of 8 minutes per day (inclusive of the initial water wastage in adjusting the temperature) and people are considered to shower daily. On using the EU-recommended maximum shower flow rate of 8 l/min, daily water consumption in showering is estimated to be 64 litres. With water-conserving faucets of 4 l/min flow rate and showers of 6 l/min flow rate, overall daily water consumption can be reduced to 57.3 litres from the original 78 litres, i.e., approximately 20 lpcd reduction.

These savings were achieved without the need for direct behavioural interventions or awareness campaigns targeting residents. Instead, the mere replacement of conventional fixtures with water-efficient alternatives was sufficient to generate meaningful reductions in consumption. This underscores the potential of technological solutions to drive sustainability outcomes even in the absence of user-driven behavioural change. The broader implications of this initiative are evident in a citywide trend toward reduced residential water consumption in Gothenburg, establishing it as a key driver of the overall decline in water usage.

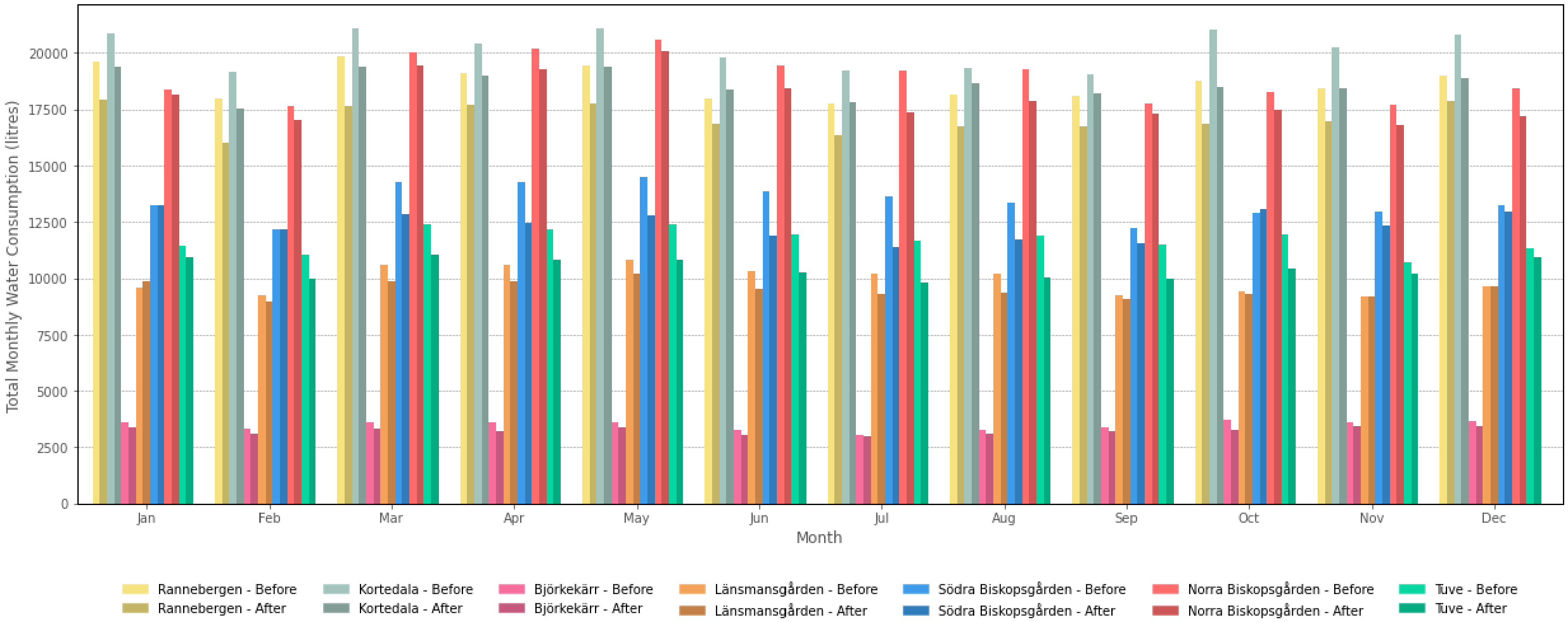

Figure 3.8 Comparison between total monthly water consumption between before and after retrofitting faucets in selected apartment complexes

3.4 Evolution of Home Appliances

As illustrated in Figure 3.6, laundry and dishwashing collectively account for approximately 21% of total household water consumption.

3.4.1 Evolution of Washing Machines

Although communal laundry facilities remain prevalent in Sweden, the adoption of private washing machines began to accelerate in the early 1990s. This shift now encompasses around 46% of rental apartments across the country (Klint & Peters, 2021). The type of the washing machines used, whether private or semi-professional has a significant influence on water consumption. Private models generally use more water per load than the semi-professional machines typically found in communal laundry rooms which has a negative effect over the declining water consumption trend. Hower, the survey on attitude toward water conservation in Gothenburg proves that most people use communal laundry facility irrespective of the ownership the residence and they do not prefer to own a private machine (More details on Section 3.6 and Appendix D). Hence adoption towards private washing machines is assumed to be low in Gothenburg. On average, an individual is estimated to operate a washing machine approximately 1.3 times per week (Schmitz & Stamminger, 2014).

This study aims to investigate the underlying factors that have contributed to the long-term reduction in water consumption by washing appliances. To do so, four semi-professional laundry machines produced by the same Swedish manufacturer, all launched after the year 2000 are examined. Technical specifications are provided in Table 3.6, and Figure 3.9 visualizes their respective water usage. The data clearly demonstrates an improvement in water efficiency, with total consumption per cycle declining by approximately 54% over the past two decades. In addition, since private washing machines are still used by some of the residences, their evolution since 2015 is compared as similar to the comparison of semi-professional laundry machines. Although water consumption per cycle was considerably higher five years ago, latest models operate at levels comparable to their semi-professional counterparts at present. Figure 3.10 illustrates the evolution of decline in water consumption per cycle in private washing machines since 2015. The selected models are all from the Electrolux brand, and have a load capacity of 7–8 kg which shows 49% reduction in water consumption over the past decade. It should also be noted that the selection of these machines is subject to data availability. The data presented in the graphs (Figure 3.9 and Figure 3.10) shows that the water consumption per cycle in both semi-professional and private machines is almost same, indicating less discrepancy. This outcome could be attributed to the selection private washing machine models which are most efficient. However, having a private machine allows the consumer to use it multiple times, even at half loads, resulting in consuming more water. Various models with differing efficiencies and specialized features were available on the market, which may influence the comparative analysis presented in this study.

Notably, in a consultation with Marius Stücheli (Head of Advanced Development Northern – Electrolux Professional Group), it was noted that laundry machines manufactured in the late 20th century consumed around 150 litres per cycle which is a threefold increase compared to the water use of contemporary models.

Table 3.6 Evolution of water consumption in l/cycle for washing machines launched since 2000

Brand	Model No.	Year launched	Max load	Hot water	Cold water	Total water consumption
Electrolux Professional	W375H	2000	7.5	14	76	90
	W475H	2007	8	4	64	68
	W575H	2011	8	12	50	62
	WH6-8C	2020	8	3	46	49

Source: Respective product specification manual

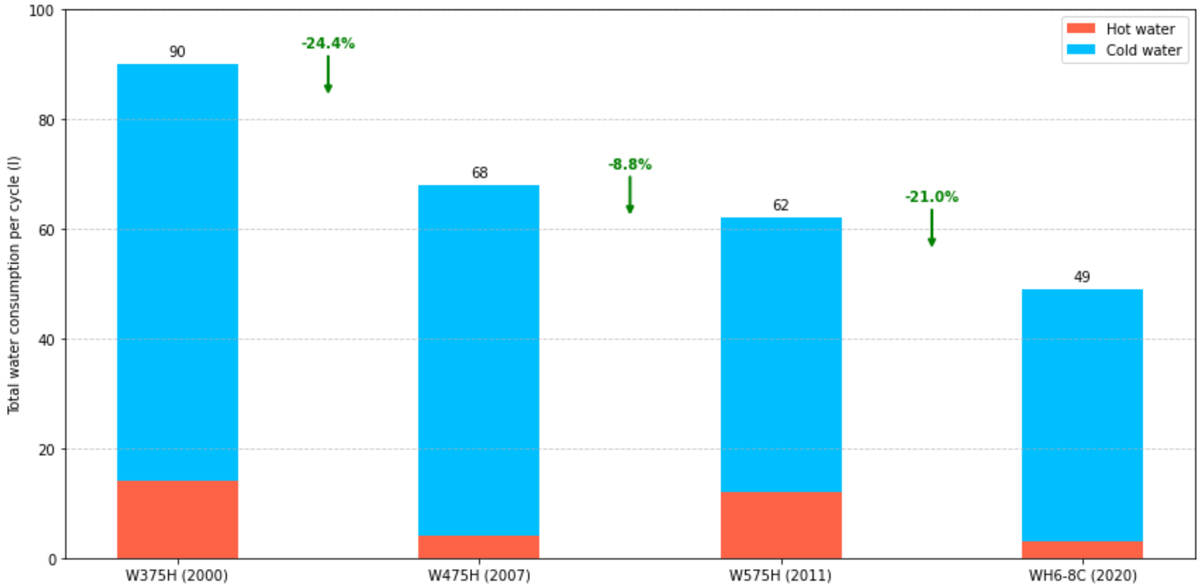

Figure 3.9 Evolution of water consumption in semi-professional laundry machines since 2000

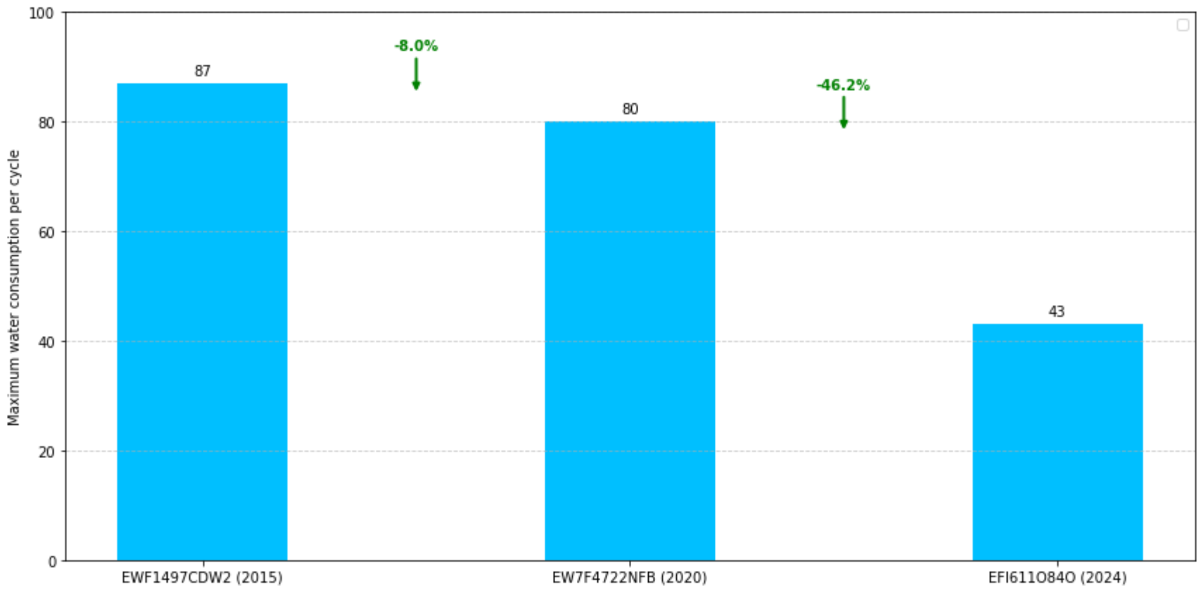

Figure 3.10 Evolution of water consumption in private laundry machines since 2015

3.4.2 Evolution of Dishwashers

A parallel analysis was conducted on dishwashers, given their similar contribution to the overall household water consumption. Dishwashing is a routine domestic task, and using a dishwasher instead of manual washing has been shown to reduce water use by 50% to 80% (Richter, 2011). Sweden also holds the highest rate of household dishwasher ownership in Europe (Actual Market Research, 2023), underscoring the importance of these appliances in national consumption patterns. On an average the dishwasher is estimated to be operated at a frequency of 1.9 cycles per week per person (Alt, et al., 2023). To assess trends in water use, six dishwashers of the same size (60 cm wide), all manufactured by the same brand and launched between 2000 and 2025, were selected for comparison. Their specifications are given in Table 3.7, and the water consumption trends are illustrated in Figure 3.11. The findings reveal a substantial improvement in efficiency, with a 44% reduction in water use over the two-decade span, highlighting a critical technological driver behind the observed decline in residential water consumption in Gothenburg.

Table 3.7 Evolution of water consumption in l/cycle for dishwashers launched since 2005

Brand	Model No.	Year launched	Total water consumption
Electrolux	EDW5505EPS	2005	27.6
	ESL64022	2008	25
	ESL68500	2010	23
	ESL5201LO	2015	17
	ESL69200RO	2020	14.4
	ESZ89400UX	2022	12.2

Source: Respective product specification manual

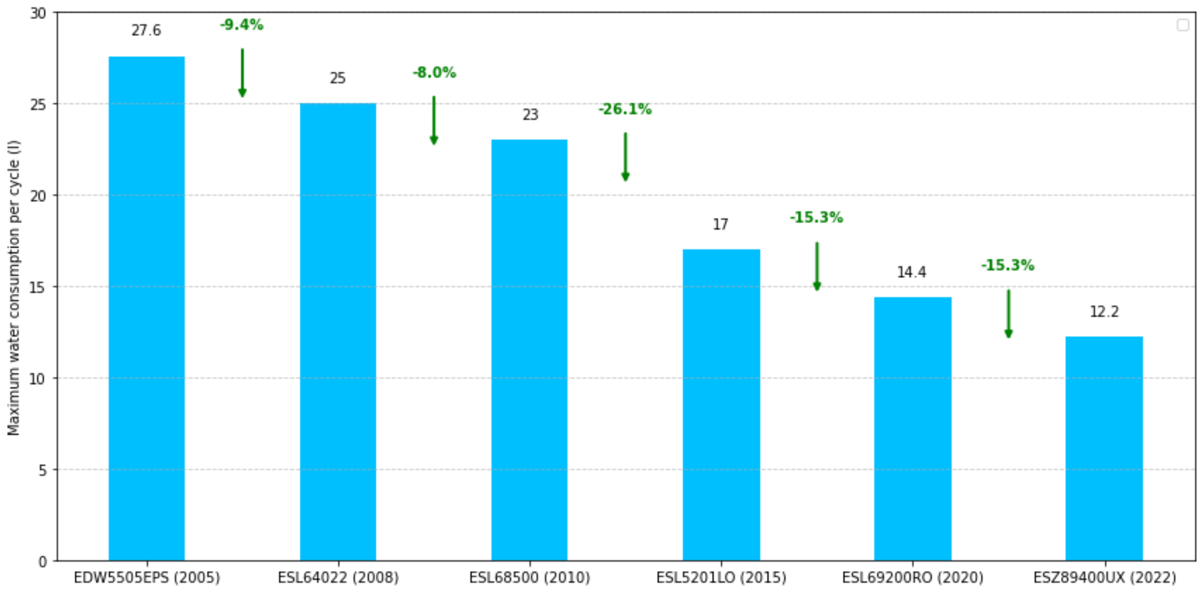

Figure 3.11 Evolution of water consumption in dishwashers per cycle since 2005

3.5 Enforcement of Regulatory Frameworks

In the recent decades, Europe and particularly Sweden has demonstrated growing recognition among scientists and policy makers regarding the importance of sustainable water governance, leading to the development of new legislations and recommendations (Dawson, Persson, Balfors, Mörtberg, & Jarsjö, 2018). The list of existing Swedish regulations, standards, European Union (EU) directives and green building certifications relevant to household water consumption is provided below, and the corresponding legal clauses are detailed in Appendix C. The timeline of these regulatory frameworks implemented by the Swedish government and European Union are illustrated in Figure 3.7.

Legislation/Certifications	Scale of effect	Interest of implementation	Reference
Planning and Building Act (SFS 2010:900)	Sweden	Mandatory	(Ministry of Rural Affairs and Infrastructure, 2010)
Boverket´s mandatory provisions and general recommendations (BFS 2011:6)	Sweden	Mandatory	(Boverket´s Building Regulations, 2011)
Method for determination of energy efficiency of mechanical basin and sink mixing valves – Single lever mixer (SS 820000:2020 Sanitary tapware)	Sweden	Voluntary	(Swedish Standard, 2020)
Sanitary tapware - Method for determination of energy efficiency of thermostatic mixing valves with shower (SS 820001:2010 Sanitary tapware)	Sweden	Voluntary	(Swedish Standard, 2010)
EU Water framework Directive (2000/60/EC)	Europe	Mandatory	(European Union, 2000)
EU Taxonomy Regulations *(Only regulation on limiting flow rate and consumption volume of various products)*	Europe	Mandatory	(European Commission, 2021)
Regulation on Eco-design requirements for household dishwashers (EU) 2019/2022	Europe	Mandatory	(European Union, 2019)
Regulation on Eco-design requirements for household washing machines and washer-dryers (EU) 2019/2023	Europe	Mandatory	(European Union, 2019)
LEED for Homes	Global	Voluntary	(LEED, 2019)
LEED for Building Design and Construction	Global	Voluntary	(LEED, 2025)
BREEAM International New Construction	Global	Voluntary	(BREEAM, 2021)
BREEAM In-Use International	Global	Voluntary	(BREEAM, 2020)
DGNB System – New buildings	Global	Voluntary	(DGNB System, 2023)

Although Sweden is often regarded as a leader in sustainability and resources conservation, its regulatory journey in water conservation measure began with the implementation of BFS 2011:6. This regulation mandated to design plumbing systems capable of detecting leaks, marking a significant step towards sustainable water management. In contrast, broader legal instruments such as SFS 2010:900 provided only general statements regarding the need for water conservation. Since 2010, Swedish standards on various categories of sanitary tapware have been established, with a primary focus on enhancing energy efficiency. While adherence to these standards remains voluntary, they have been widely adopted by manufacturers like Gustavsberg and FM Mattsson aiming to obtain energy classification certifications. These labels, include information such as energy ratings and flow rate, serve as marketing tools to encourage consumer preference for environmentally friendly options (an example is presented in Figure 3.12).

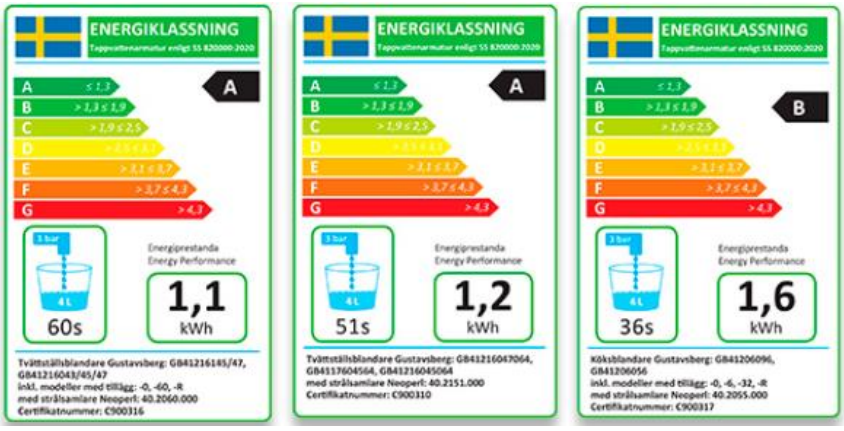

Figure 3.12 Swedish Standard energy performance labels for sanitary tapware

Despite the absence of comprehensive national legislation mandating water conservation, Sweden is bound by the EU Water Framework Directive (2000/60/EC), which has been legally binding for all EU member states since its inception in 2000. This directive emphasizes sustainable water use, recover cost for water services and promotion of water-efficient technologies. In addition, the EU's Taxonomy Regulations came into effect in 2021 have introduced requirements for limiting water flow rates in faucets to 6 l/min and showerheads to 8 l/min, toilets to have dual flush system with a maximum full flush volume of 6 litres and a half flush volume of 3.5 litres in all new buildings including residential. Further, EU has also set regulations for work plan on improving the efficiency of appliances such as washing machines and dishwashers to save 711 and 16 million m^3 by 2030.

Beyond statutory obligations, actors in real estate and construction sectors have increasingly sought to demonstrate environmental stewardship by voluntarily pursuing green building certifications. These certification schemes award points for the integration of water-saving features such as high-efficiency fixtures, water recycling, water metering, and mechanisms to detect and prevent leaks.

Collectively, these regulatory and voluntary initiatives have played a pivotal role in fostering a societal shift toward water conservation, aligning environmental objectives with building practices and technological advancement. Notably, the cumulative impact of these frameworks has possibly been a key driver in the decline of per capita water consumption in Gothenburg.

3.6 Behaviour and Awareness

To assess public awareness, attitudes, and behaviours towards water conservation, a bilingual online questionnaire (available in both Swedish and English) was prepared to ensure accessibility for a diverse respondent base. The developed questionnaire was published primarily through social media platforms, particularly in Facebook groups with more than 10,000 members. Additionally, printed posters with QR codes were placed across the university campus to broaden outreach and improve participation.

Despite being shared widely on online platforms, the response rate remained notably very low. To address this, a supplementary strategy was adopted involving direct engagement by solicitation of random strangers to fill out the survey form in a public setting. Although this approach increased the sample size, the ultimate number of responses yielded was only 44.

The limited number of responses restricted the ability to conduct detailed demographic-based analyses. Nevertheless, the data was still analysed for obtaining insights regarding water use behaviour and awareness. A summary of the responses obtained is given below and the detailed responses are attached in Appendix D.

Water Usage Behaviour

- A substantial proportion of participants lack awareness on quantity of water consumed as no individual metering for water was present.
- Despite the majority expressing an interest in water conservation, they still tend to take longer shower (≥6 min) contradicting their stated intentions. Furthermore, only 16% of the respondents reported having water efficient installations.
- About 82% of the respondents relied on communal washing machines and does not prefer to buy personal machines. Notably, 64% were unaware of the age of the laundry machines while 20% reported using more than 10-year-old machines.
- While only 43% of the respondents own a dishwasher, the remainder are not interested to buy such appliances. Among those with dishwashers, most are less than 10 years old.
- Encouragingly, 86% of the respondents reported to have dual flush system in their toilets which is widely recognized for water conservation.

Perceptions, Awareness & Attitudes

- Over half of the respondents expressed their willingness to use sustainable faucets which has reduced flow rate.
- Majority of the respondents supported water conservation with environmental concern being their primary motivator.
- A very large share of respondents reported either rarely or never encountering public campaigns focused on water conservation.
- When asked about the implementation of volume-based water taxation, 41% expressed support, whereas 25% opposed the idea.

Despite the scope of this study is constrained by its modest sample size, the findings provide preliminary understanding of the disjunction between awareness and behaviour in water conservation practices. While there is broad awareness of the importance of water conservation, the consistent implementation of conservation practices remains limited. The widespread use of communal washing machines and the prevalence of dual-flush toilets indicate that passive water conservation is taking place, despite inconsistencies in proactive behavioural change. These insights highlight the need for educational initiatives and policy measures to bridge the gap between awareness and sustainable actions.

3.7 Future Strategies

The transition towards sustainable water conservation practices requires a multi-faceted approach that does not solely rely on consumers. It requires the systematic integration of technological advancements, governance framework reforms, and behavioural influences (Dadvar, Mahapatra, & Forss, 2021). This section synthesises future-oriented strategies identified through literature review, online resources, and expert brainstorming

3.7.1 Technological Innovation

Role of technological innovations in water conservation can effectively minimise wastewater and enhance sustainable water management (Sustainability Media Lab). While conventional methods such as the adoption of low-flow fixtures and water monitoring remain valuable, emerging technologies offer more sophisticated and effective mechanisms. The table below presents selected water recycling technologies suitable for small-scale domestic applications.

Table 3.8 Overview of innovative water-saving technologies and their applications

Innovative Product	Application	Source
Orbital Shower	Closed loop shower system thereby minimizes water loss. About 90% of shower water is saved.	(Orbital, n.d.)
Hydraloop	Recycles water from showers, washing machines, hand basins and reuse it for gardens, toilets, laundry, and pool top-ups, reducing water usage by 25-45%.	(Hydraloop, n.d.)
Nubian Greywater Treatment Systems	Treats greywater with its new age slimline treatment unit.	(Nubian Water Systems, n.d.)
Graytec Blue Circle System	Uses advanced sensors to precisely identify and separate unusable water, ensuring only the cleanest, most reusable water is filtered and recirculated.	(Graytec, n.d.)
Vacuum toilets	Decrease water usage for flushing and enable recovery of macronutrients such as phosphorus, nitrogen, potassium and sulphur which are used to manufacture fertilizers.	(Smart City Sweden, n.d.)
Mimbox	Recycles water used in laundry.	(Mimbly, n.d.)

The implementation of such innovative technologies on decentralized greywater recycling systems and recirculating showers significantly reduces overall water consumption, thereby contributing to the 50-liter home when integrated with other water conservation measures. (50L Home & Arcadis, 2024). Despite the potential of such technologies, consumers may encounter resistance due to psychological discomfort associated with the reuse of water, particularly for showering (Kattenburg, 2021). Thus, use of recycled water for applications such as toilet flushing and irrigation are more socially acceptable. Additionally, the operational complexity and maintenance particularly with filter replacements pose practical challenges for many consumers. Therefore, the design of user-friendly, automated maintenance features is crucial for household adoption (Orbital shower and Mimbox are some examples).

A rough estimate of quantity of water saveable through the adoption of innovative water-saving technologies is presented in Table 3.9. The analysis is based on a daily per capita consumption of 131.9 lpcd for the year 2023 and projected daily per capita water consumption values derived using linear regression of ~73 lpcd for 2050. These projections reflect anticipated reductions due to behavioural and technological changes. The implementation of water-efficient systems such as recycling shower water, grey water reuse, and vacuum toilets demonstrates potential water savings ranging between 40% and 65% of total daily consumption. Specifically, on use of these technologies, the estimated quantity of water consumed ranges from 47 to 79 lpcd in 2023 and 35 to 44 litres in 2050, indicating a significant opportunity for water conservation through innovative domestic technologies.

Table 3.9 Estimated water savings through innovative technologies in 2023 and 2050

Product Type	Percentage of water saved (approx.)	Quantity of water saved (litres)		Description
		2023	2050	
Recycle shower	90%	58	23	8 min shower at 8 l/min is considered for 2023 while 5 min shower at 5 l/min is considered for 2050 due to positive behavioural changes
Reuse grey water	30%	25	14	Residential grey water generation is estimated to be ~64% of total water consumption (Seifu, 2022)
Vacuum toilet	100%	28	15	21% of water used for toilet flushing from Figure 3.6. Also average of 5 flushes per person is considered (DeOreo & Hodgins, 2016)
Total water saved (litres)		53-85	29-38	Approx. 40-65% of water can be saved

3.7.2 Change in Behaviour

As demonstrated by the survey results discussed in Section 3.6, there is a pressing need to enhance consumer awareness, particularly concerning water use during showering. The most common approach to make consumers more aware of water conservation and encouraging water saving behaviour is through knowledge transfer in the form of water conservation campaigns for instance (Salmon & Brouwer, 2025). Behavioural change remains one of the most cost-effective strategies for achieving water conservation. Last year KoV launched a campaign in Gothenburg encouraging residents to limit showers to three minutes, exemplified by campaign materials included in Appendix E (Vårt Göteborg, 2024).

Additional behavioural interventions include integrating water conservation awareness into school education and employing behavioural nudges, such as ‘mock billing’ strategies, which simulate water costs to raise awareness without actual financial implications.

3.7.3 Policy Reform

As explained in Section 3.5, there is currently a lack of robust legislation governing domestic water conservation in Sweden. Existing regulatory frameworks, such as the flow rate limits stipulated by the EU Taxonomy Regulations, are outdated, and many modern fixtures are already much better than these efficiency standards. To stimulate greater progress, policy reforms may include:

- Lowering the permissible flow rates for domestic water fixtures (faucets and showerheads).
- Mandating the integration of water-saving technologies in new residential developments.
- Providing fiscal incentives or subsidies for manufacturers and consumers adopting water-efficient innovations.

Such legislative initiatives can be enforced for progressive water conservation in households.

3.7.4 Water Taxing Reform

Article 9 of the EU Water framework Directive (2000/60/EC) obliges member states to adopt water-pricing policies to use water resources efficiently, and thereby contribute to the environmental objectives. In Sweden, however, the cost charged to consumers for their water use is set below the marginal cost of providing water leading to municipalities underinvesting in the water infrastructures (Westling, Stromberg, & Swain, 2020).

Volumetric fees fail to reflect actual household consumption, as individual metering devices (IMDs) are rare in Gothenburg and KoV imposes a fixed charge. As a result, a fixed fee for water consumption is measured from 14.55 SEK/m^3 for an assumed usage of 100 m^3/year for small houses and 1500 m^3/year for other properties (Kretslopp och vatten, 2025). Based on the pricing, a small house in Gothenburg City pays 1455 SEK for about 274 l/day/HH whereas about 54% of the Swedish HH have more than 1 person which means 137 lpcd for a 2 person HH, 91 lpcd for a 3 person HH and so on, thereby charging so low. The volumetric fee was considered to be low even for the household with particularly small economical means (Köhler, 2017). Moreover, there are also statements against introducing volumetric billing in Sweden by many citizens, especially due to inequal billing and making it unfair for people that are already struggling (Mangold, Morrison, Harder, Hagbert, & Rauch, 2014).

To counter this, a potentially equitable solution can be found in the telescopic pricing model piloted in Coimbatore Smart City, India. Under this system, a base allocation calculated from census data (e.g., 135 lpcd base allocation x no. of person in that HH x 30 days → monthly allocated quantity) is provided at a subsidised rate. Consumption beyond this allocation incurs exponentially increasing charges. This model has successfully incentivised water conservation without penalising basic needs. Its effectiveness was further enhanced through the deployment of IoT-enabled smart meters and Automated Meter Reading (AMR) systems, which provide real-time consumption data and enforce usage limits through prepaid mechanisms. Details of the tariff structure are included in Appendix F.

4 Discussion

4.1 Interpretation of the Results

The primary objective of this study was to identify and analyse the key factors contributing to the declining per capita household water consumption trend in Gothenburg, Sweden, despite a growing population and stable water production levels. Though this population should raise concerns over managing water resources, the data states otherwise. The findings from the study, triangulated across quantitative data, technological insights, regulatory frameworks, and behavioural assessments, provided a comprehensive understanding of this trend.

RQ1: Primary Factors Contributing to Declining Water Consumption

The results highlight the wide spread adaptation of technological advancements, as the consumers increasingly integrate water efficient fixtures and appliances. This shift played a key role in contributing to the declining trend, confirmed by reduction in residential water usage following the retrofitting of modern water efficient faucets as well as significant drops in water consumption by advancement of washing machines and dishwashers. Another key driver, such as the enforcement of regulatory policies, has also played a role in influencing manufacturers to design more sustainable products thereby reducing the water consumption.

RQ2: Influence of Consumer Behaviour

The survey responses revealed a gap between awareness and consistent practice. While most residents expressed their willingness to conserve water, behaviours such as taking long showers persisted highly. However, the high adoption rates of dual-flush toilets and the use of communal washing machines reflect passive conservation behaviours driven by design rather than individual choices.

RQ3: Role of New Technologies and Infrastructure

Modern washing machines and dishwashers have achieved significant leaps in terms of water efficiency, saving 54% water in washing machines and 44% in dishwashers. Both these technological advancements, alongside water-efficient sanitary tapware, have substantially curbed the water use without necessitating behavioural change.

RQ4: Demographic and Socioeconomic Correlations

Although limited by sample size, the study suggests that apartments had higher per capita consumption than the detached houses, due to possibly differing infrastructure or communal habits. Variations by day and season, such as higher winter use and weekend spikes, further reflect consumption patterns tied to lifestyle in different type of residential buildings.

RQ5: Effective Strategies and Systematic Applications

Technological retrofits and voluntary corporate efforts towards sustainability emerged as the most effective, scalable strategies. The passive nature of such interventions assures uniform impact across the population irrespective of their demographic profiles.

4.2 Implications of Findings on Water Conservation Strategies

The implications of these findings are multifaceted and offer real-world guidance for sustainable urban water management:

Technological Adoption is Crucial: The water reductions from fixture retrofits and appliance efficiency imply that citywide upgrades can serve as the backbone of future conservation initiative. Such renovation should be incentivized or subsidized with high priority.

Regulation and Standards: While Sweden lacks stringent national regulations on water efficiency, adherence to EU directives and voluntary efforts by the manufacturers have been effective. Updating the maximum flow rates standard and policies favouring removal of inefficient appliances beyond projected lifespan can enhance impact.

Behavioural Interventions Need Strengthening: Awareness campaigns, educational programs, and behavioural nudges (e.g., mock billing, real-time feedback) should complement technological efforts. The disconnect between stated concern and actual practices underlines the need for persistent and creative public engagement.

Economic Tools Have Untapped Potential: Fixed tariffs currently in practice in Gothenburg, conceal the real cost of consumption and do not encourage water savings. The telescopic tariff system tested in Coimbatore presents a socially equitable and operationally feasible alternative, especially when paired with smart metering technologies.

Urban Planning and Housing Design: Differences in water consumption across different housing types suggest that urban form impacts sustainability. Future developments should incorporate design elements that naturally limit high-consumption behaviours (e.g., compact spaces, efficient communal facilities).

Policy Formulation for the 50L Goal: Achieving a 50 lpcd standard without compromising quality of life through a multi-faceted approach is an achievable target by combining technological advancements especially in recycling grey water, improved infrastructure, regulatory reforms, economic incentives, and awareness. The Gothenburg case proves this can be achieved without draconian measures.

4.3 Water Budget for 50L Home

A calculation was performed from an optimistic perspective to emphasize the potential for maximum efficiency in water usage. This analysis aims to achieve the goal of reducing the current per capita water consumption to 50 lpcd through behavioural changes, adoption of high efficiency appliances and recycling of greywater. The anticipated reduction in personal behaviour is expected to be driven by awareness and water taxing with telescopic charges. The table below presents comparison of daily water use between current, efficient and 50L Home model.

Table 4.1 Daily Water Use Comparison: Current vs Efficient vs 50L Home Model

Common water uses	Frequency	Current estimate		Efficient use		Much efficient use (50L Home)	
		Assumption	Qty.	Assumption	Qty.	Assumption	Qty.
Bath/shower	Once per day	6 min by 7/min faucet	42.0	5 min by 6 l/min faucet	30.0	4 min by 6 l/min faucet	24.0
Toilet full flush	Once per day	6 l tank	6.0	6 l tank	6.0	4 l tank	4.0
Toilet half flush	4 times per day	5.5 l tank	22.0	3.5 l tank	14.0	2 l tank	8.0
Hand wash	4 times per day	35 s per wash by 6 l/min faucet	14.0	-	14.0	4 l/min faucet	9.3
Dish washing	1.9 times per week	No dishwasher	14.0	12.2 l water consumption per cycle	3.3	Maxed efficiency	3.3
Laundry	1.3 times per week	Multiple times in half load	14.0	49 l water consumption per cycle	9.1	Maxed efficiency	9.1
Direct intake	-	3.5 l by intake and 5.5 l for kitchen use	9.0	1 litre reduction in kitchen use	8.0	Another half-litre reduction in kitchen use	7.5
Other		miscellaneous	9.0	1 litre reduction in other uses	8.0	Another 1 litre reduction in other uses	7.0
		Total water consumption	**130.0**	**Total water consumption**	**92.4**	**Total water consumption**	**72.2**
						Greywater generated (except shower)	19.7
						30% of recycled greywater (ex. Hydraloop)	-5.9
						75% of recycled shower water (ex. Orbit Shower)	-18.0
						Total water consumption utilising recycled water	**48.3**

All quantity of water is estimated in lpcd.

5 Recommendations

To emphasise the need for water conservation effective strategies must integrate technological innovation, behavioural change, economic instruments, and public engagement to ensure sustainable water management. The following recommendations outline practical and policy-oriented measures that can contribute to long-term water sustainability at the household and community levels.

- Installation of water-efficient fixtures, such as low-flow bathroom and kitchen faucets and showerheads with aerators to reduce household water consumption. Furthermore, policy interventions should mandate manufacturers to limit the production of faucets with excessive flow rates and require builders to incorporate water-efficient systems in all new developments.

- Volumetric pricing system should be established with the incorporation of telescopic tariff scheme by the municipality (water service provider) to incentivize responsible water users.

- Prioritize widespread adoption of greywater recycling systems to reduce water consumption significantly and make the 50L home achievable.

- Educational initiatives should focus particularly on the younger generation, fostering long-term awareness and commitment to water conservation practices.

- Sustained efforts in technological research and development of fresh, innovative technologies for water saving is crucial for increased water efficiency. This can also be achieved by organising competitive events offering monetary prizes and prestigious awards thereby encouraging university students and manufacturers of appliances and fixtures to participate.

- A greater level of awareness campaigns over wide public exposure should be conducted to promote behavioural change and community engagement in water conservation efforts.

- Internet of Things (IoT) based smart water management systems attached to IMD should be enabled in all households, facilitating real-time monitoring and user engagement via mobile applications and digital platforms.

6 Conclusion

This study aimed to investigate and identify the key drivers of per capita water consumption decline in Gothenburg, despite ongoing population growth and urban expansion. Through triangulating quantitative data, technical analysis, policy regulations, and behaviour-based surveys, a comprehensive understanding has been gained.

The findings indicate that this trend cannot be attributed to an individual factor but rather is a result of interactions between technological advancements, passive infrastructural improvements, regulatory reforms, and nuanced behavioural shifts. While consumer awareness and intentional conservation efforts exhibit variability, the widespread integration of water-efficient fixtures and appliances often driven by voluntary commitments to sustainability exceeding industry standards has had a profound effect on household water usage patterns. Moreover, the integration of modern technologies and new policy approaches, such as the introduction of volumetric tariffs and IoT-based smart metering, holds great potential for further reductions. Regulatory changes, in coordination with EU policy, have complemented those developments by pressuring manufacturers to adopt higher efficiency standards, many of which have been voluntarily surpassed by large brands. Although Sweden lacks binding national mandates for household water conservation, EU-mandated regulation has clearly been impactful.

Although behavioural influences are considered to remain secondary, they still hold considerable significance. Survey responses showed a discrepancy between practice and awareness, indicating the need for continuous public engagement and targeted educational initiatives. The prevalence of dual-flush toilet systems and communal laundry facilities underscores how infrastructure design can facilitate conservation independently of deliberate consumer behaviour.

Significantly, the findings also infer that strategic policy interventions, such as volumetric pricing reforms introduced and individual metering systems implemented, would additionally enhance conservation efforts and influence behavioural change. The case study of Coimbatore’s telescopic tariff model provides an economically viable as well as socially fair model that may be adapted in the Gothenburg context.

Notably, this decline in water consumption trend has not resulted in a diminished quality of life, suggesting that conservation should be framed not merely as a technical or behavioural challenge but as an opportunity for innovative design and governance. The Gothenburg case study emphasizes that sustainable consumption can be achieved by means of systems-level thinking, passive efficiency solutions, and supportive policies, rather than through restrictive regulations. Consequently, it provides a replicable framework for other urban regions aiming to balance water demand with the challenges posed by climate change and water scarcity. Although, the target of 50 lpcd is more ambitious, it appears attainable by the combined efforts of technological innovation, regulatory systems, and public engagement.

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Appendix A: Daily Per Capita Water Consumption

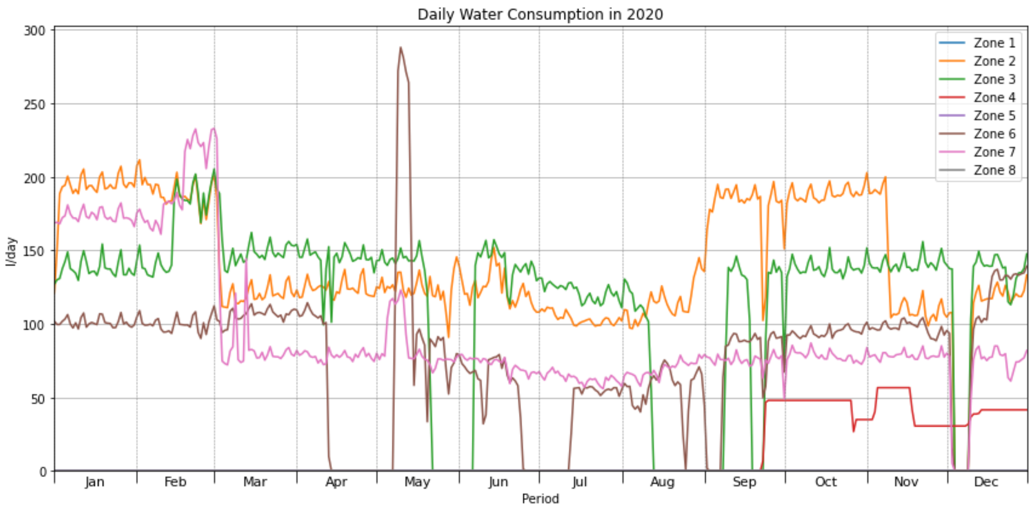


Figure A.1 Daily per capita water consumption across all zones for the year 2020

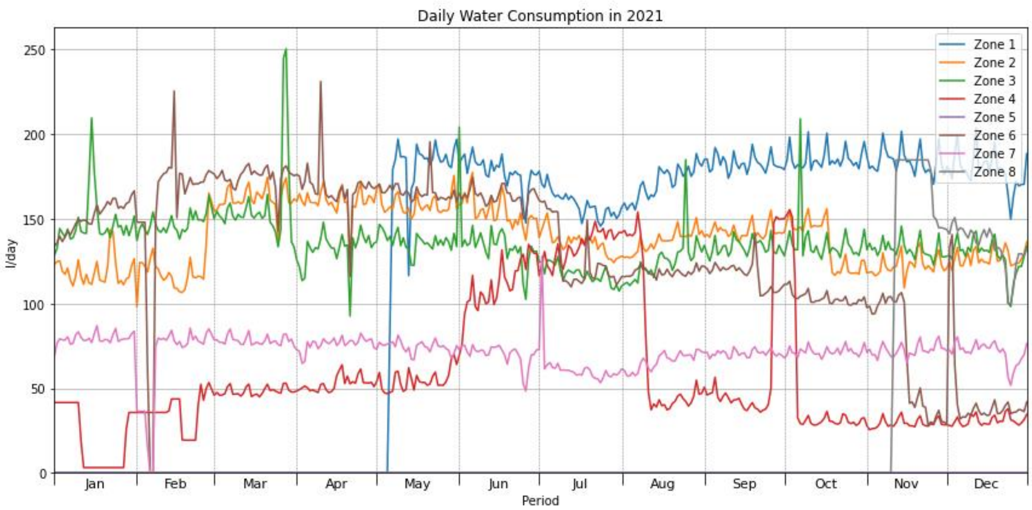


Figure A.2 Daily per capita water consumption across all zones for the year 2021

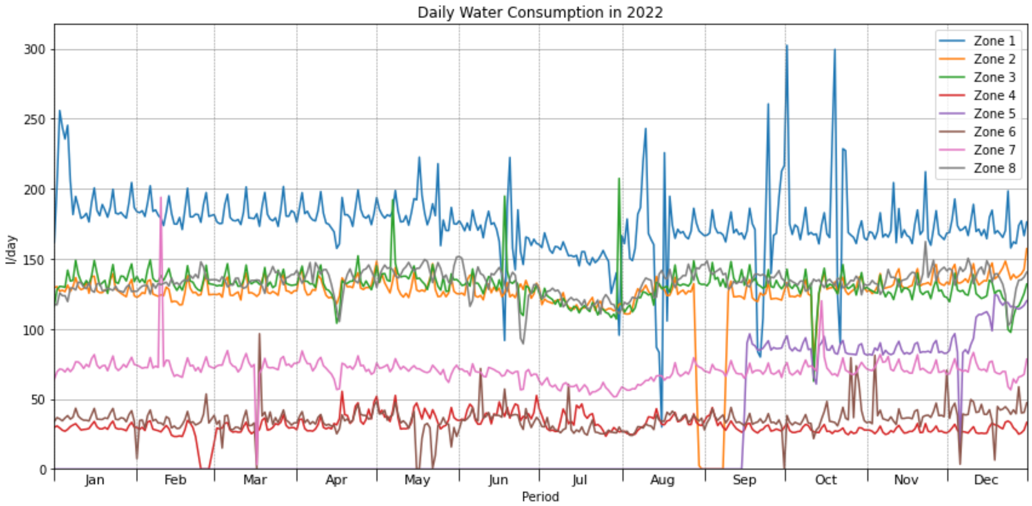


Figure A.3 Daily per capita water consumption across all zones for the year 2022

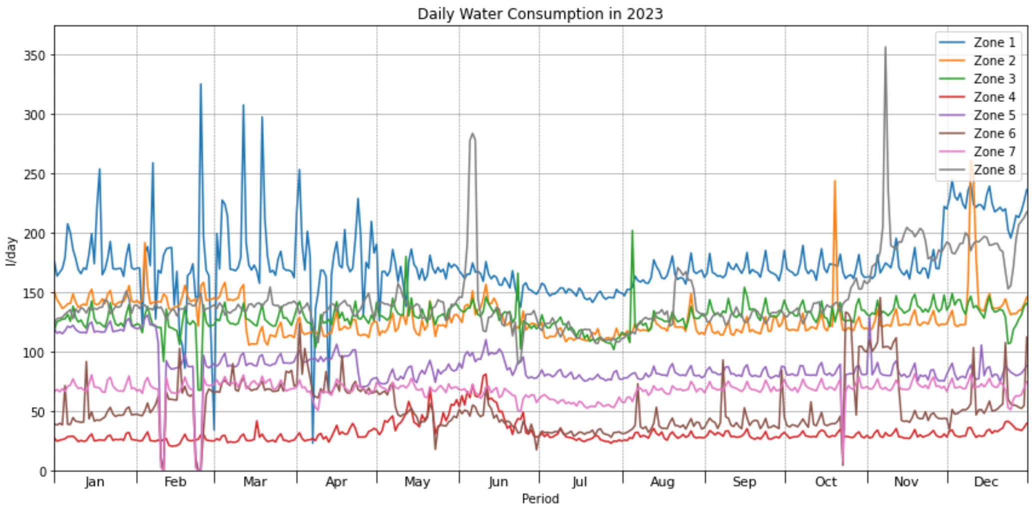


Figure A.4 Daily per capita water consumption across all zones for the year 2023

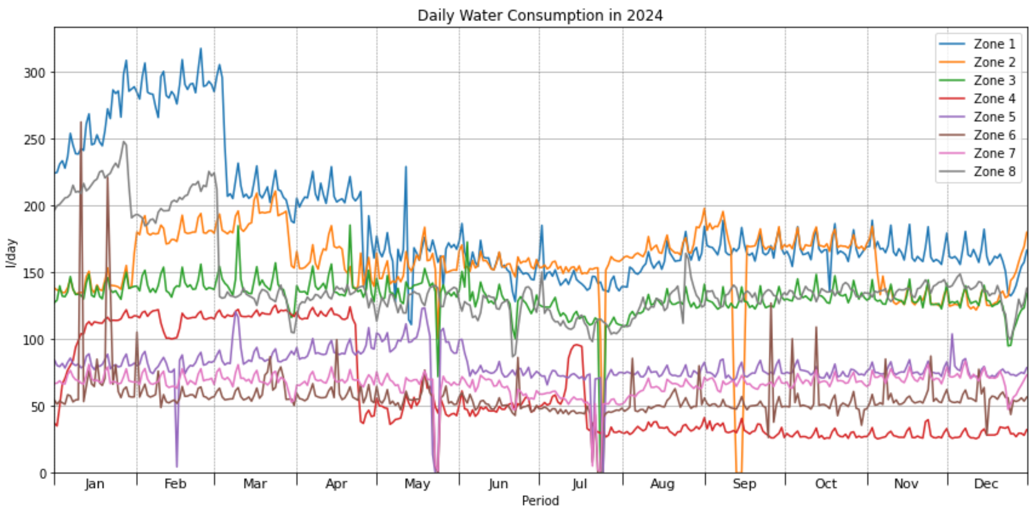


Figure A.5 Daily per capita water consumption across all zones for the year 2024

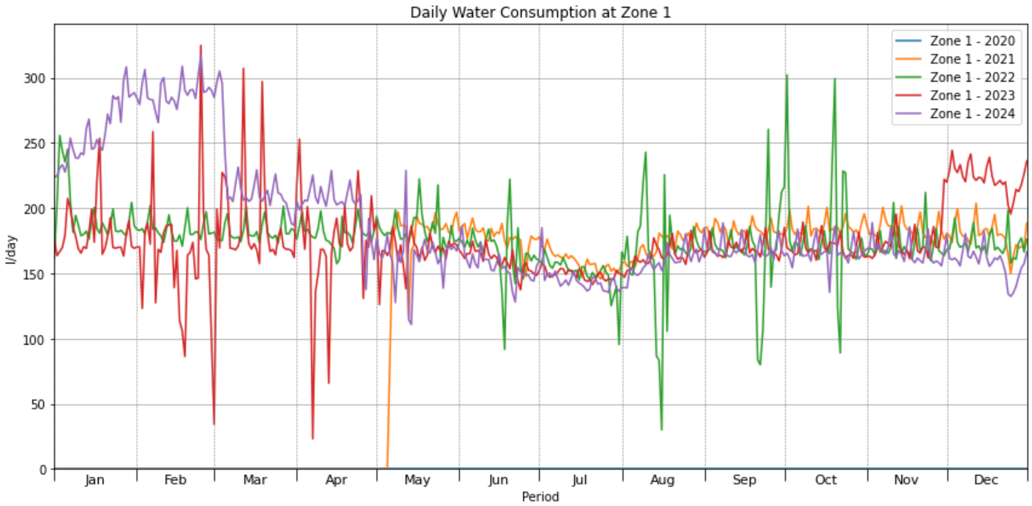


Figure A.6 Daily per capita water consumption for all years of Zone 1

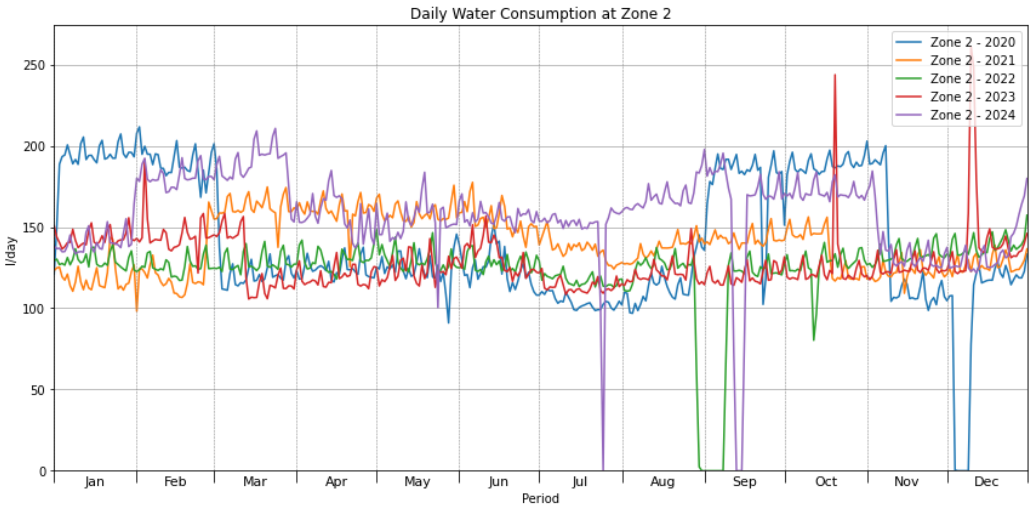


Figure A.7 Daily per capita water consumption for all years of Zone 2

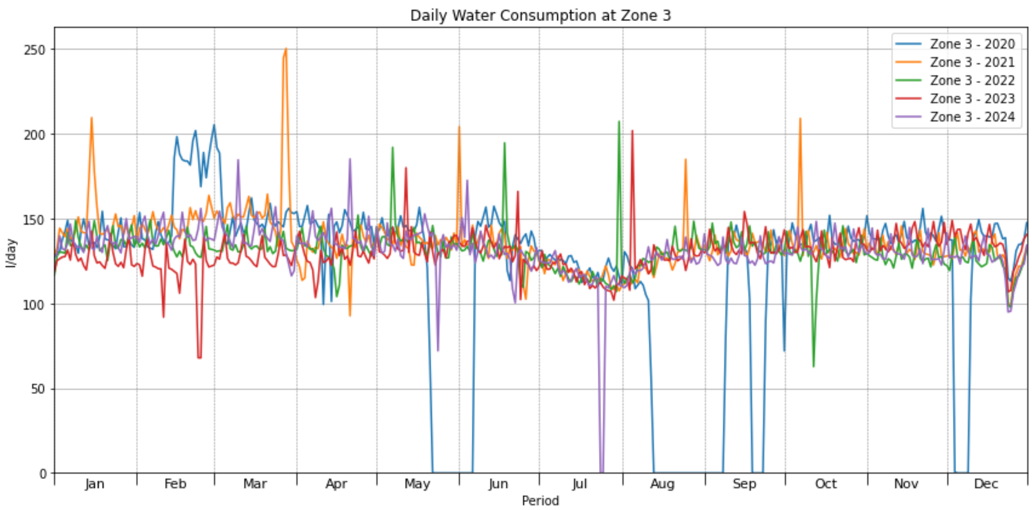


Figure A.8 Daily per capita water consumption for all years of Zone 3

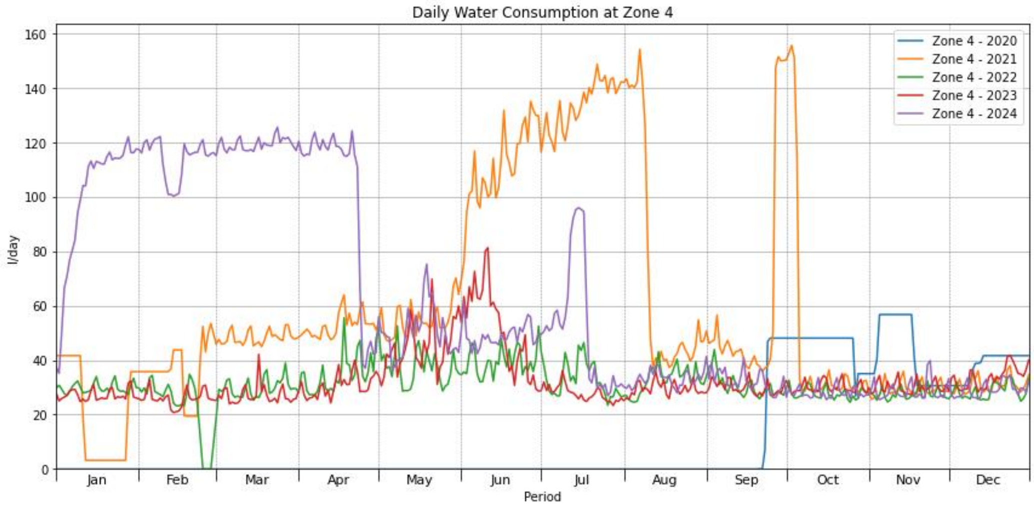


Figure A.9 Daily per capita water consumption for all years of Zone 4

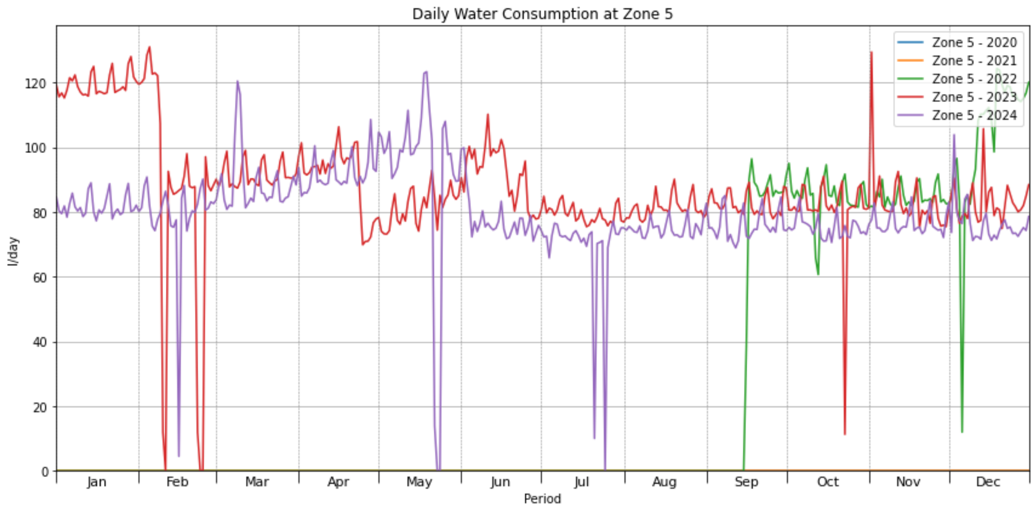


Figure A.10 Daily per capita water consumption for all years of Zone 5

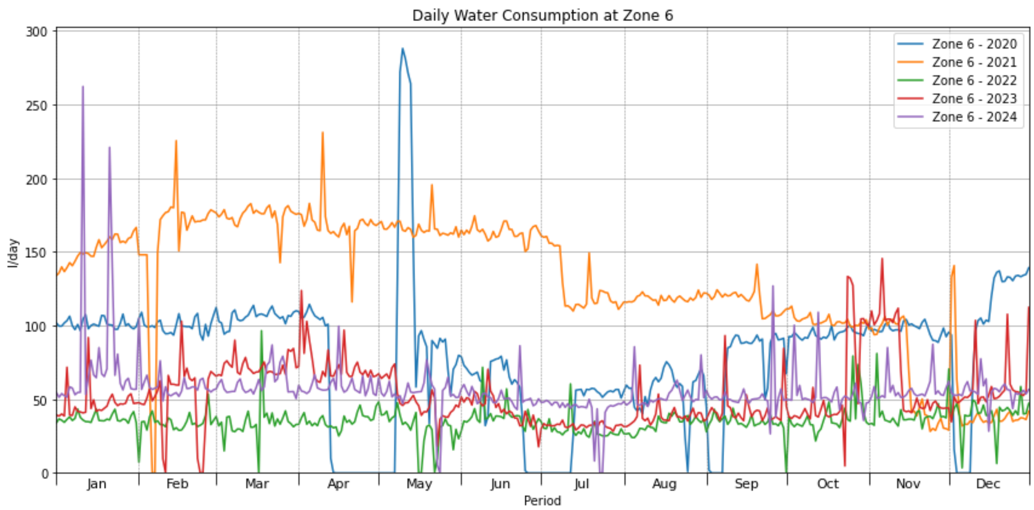


Figure A.11 Daily per capita water consumption for all years of Zone 6

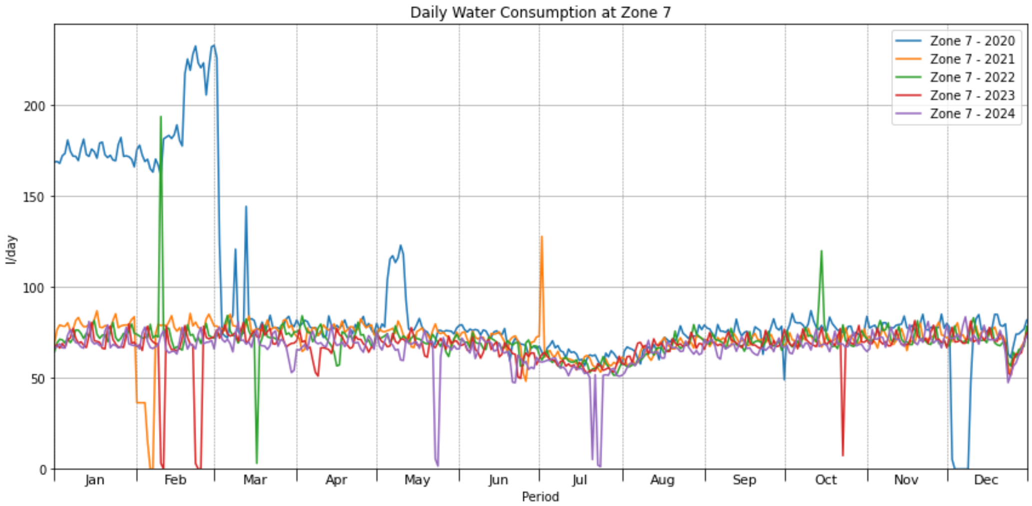


Figure A.12 Daily per capita water consumption for all years of Zone 7

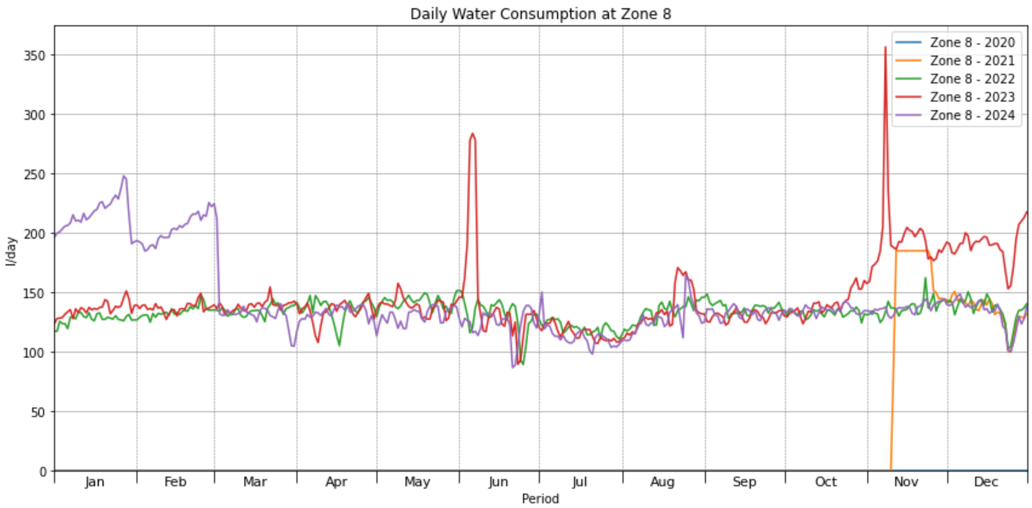


Figure A.13 Daily per capita water consumption for all years of Zone 8

Appendix B: Monthly Eater Consumption Data from Bostadsbolaget

Bostad_Bolaget.xlsx

Monthly water consumption data and calculation for average percentage of water saved is available in this spreadsheet.

Appendix C: Regulations and Certifications in Regard to Water Conservation

Planning and Building Act (SFS 2010:900), *Sweden (Mandatory)*

- **Chapter 2**: Public and private interests, **Section 3**
  Planning under this Act shall, with regard to natural and cultural values, environmental and climate aspects, and inter-municipal and regional conditions, promote **(3)** *a long-term good management of land, water, energy and raw materials, as well as good environmental conditions in general.*
- **Chapter 2**: Public and private interests, **Section 6**
  In the case of planning, in matters relating to building permits and in measures relating to buildings that do not require a permit under this Act, buildings and structures shall be designed and placed on the intended land in a manner that is appropriate with regard to **(4)** *the need for energy and water conservation, and for good climate and hygiene conditions.*

Boverket's Building Regulations (BBR 2011:6), *Sweden (Mandatory)*

- **Section 6:623** Tapwater flow
  Water outlets shall be designed in such a way that water flows remain adequate without causing interfering noise or corrosion due to high water velocity. The design shall also minimise the risk of dangerous surge pressure. Hot tap water at the correct temperature shall be provided without having to wait an inconvenient amount of time.
  - For dwellings, the requirement of the mandatory provision for water flow at the water outlet for both hot and cold water is met if the draw-off flow is 0.1 l/s for wash basin and bidet, 0.3 l/s for bath tubs and 0.2 l/s for other water outlets. For water outlets in dwellings with cold water only, the requirement of the mandatory provision is met if the draw-off flow is 0.1 l/s for toilet and wash basin and 0.2 l/s for other water outlets.
  - For the tap water system as a whole, the requirement of the provisions is met if at least 70 % of each water draw-off flow-rate can be achieved when a likely percentage of connected water outlets are opened simultaneously.
  - A water heater, which only serves a one dwelling house should be designed to ensure for a maximum period of 6 hours, it can heat cold tap water at 10°C to ensure two water draw-offs can each maintain a 140l flow of mixed hot and cold tap water at 40 °C in one hour.
- **Section 6:625** Design,
  Tap water installations shall be designed and made of such material that they have adequate durability against the external and internal mechanical, chemical and microbial processes to which they are likely to be exposed.
  - Tap water pipes and joints on such pipes should be designed and positioned so that any water leaking from the pipes or joints can be quickly detected and so that the water does not cause damage. Tap water installations that are hidden and cannot be inspected, e.g. in shafts, walls, floors or behind fixed fittings, should be carried out without joints.

    - Shafts for tap water pipes should be easily accessible and designed with leakage indication, e.g. pipes with sufficient capacity that open into rooms with floor drains or with waterproof floors.

Swedish Standard SS 820000:2020 Sanitary tapware, ***Sweden (Voluntary)***

Method for determination of energy efficiency of mechanical basin and sink mixing valves – Single lever mixer

- **Section 6.3** Energy use of a mixer: **(Table 1)** Energy classification levels of wash basin and kitchen mixer taps.
- **Section 7** Contents of test report: Time required to fill a 4-litre vessel.
- Older version - SS 820000:2010

Swedish standard SS 820001:2010 Sanitary tapware, ***Sweden (Voluntary)***

Method for determination of energy efficiency of thermostatic mixing valves with shower.

- **Annexure B** Energy classification: **(Table B.1)** Examples of energy classification levels for thermostatic shower mixers
- **Annexure C** Model form of energy class certificate **(Figure C.1)** An example of an energy class certificate's content and appearance

Water framework Directive (2000/60/EC), ***EU (Mandatory)***

- **Article 1** Purpose: **(b)** promotes sustainable water use based on a long-term protection of available water resources.
- **Article 9** Recovery of costs for water services **(1)** Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs. Member States shall ensure by 2010
  - that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,
  - an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Annex III and taking account of the polluter pays principle.
- **Annex VI** Lists of measures to be included within the programmes of measures: **Part B (x)** efficiency and reuse measures, inter alia, promotion of water-efficient technologies in industry and water-saving irrigation techniques.

EU Taxonomy Regulation, ***EU (Mandatory)***

- **Section 7.1** Construction of new buildings: **(3)** Sustainable use and protection of water and marine resources
  Where installed, except for installations in residential building units, the specified water use for the following water appliances are attested by product datasheets, a

building certification or an existing product label in the Union, in accordance with the technical specifications laid down in Appendix E to this Annex:

- wash hand basin taps and kitchen taps have a maximum water flow of 6 litres/min;
- showers have a maximum water flow of 8 litres/min;
- WCs, including suites, bowls and flushing cisterns, have a full flush volume of a maximum of 6 litres and a maximum average flush volume of 3,5 litres;
- urinals use a maximum of 2 litres/bowl/hour. Flushing urinals have a maximum full flush volume of 1 litre.

To avoid impact from the construction site, the activity complies with the criteria set out in Appendix B to this Annex.

- **Section 7.2** Renovation of existing buildings: **(3)** Sustainable use and protection of water and marine resources
  Where installed as part of the renovation works, except for renovation works in residential building units, the specified water use for the following water appliances is attested by product datasheets, a building certification or an existing product label in the Union, in accordance with the technical specifications laid down in Appendix E to this Annex:
  - wash hand basin taps and kitchen taps have a maximum water flow of 6 litres/min;
  - showers have a maximum water flow of 8 litres/min;
  - WCs, including suites, bowls and flushing cisterns, have a full flush volume of a maximum of 6 litres and a maximum average flush volume of 3,5 litres;
  - urinals use a maximum of 2 litres/bowl/hour. Flushing urinals have a maximum full flush volume of 1 litre.

  To avoid impact from the construction site, the activity complies with the criteria set out in Appendix B to this Annex.

Regulation on Ecodesign requirements for household dishwashers (EU) 2019/2022, ***EU (Mandatory)***

- Measures from the ecodesign working plan have an estimated potential to deliver a total in excess of 260 TWh of annual final energy savings in 2030, which is equivalent to reducing greenhouse gas emissions by approxi mately 100 million tonnes per year in 2030. Household dishwashers is one of the product groups listed in the working plan, with estimated annual electricity savings of 2,1 TWh, leading to GHG emission reductions of 0,7 Mt CO2 eq/year, and estimated water savings of 16 million m3 in 2030.

Regulation on Ecodesign requirements for household washing machines and washer-dryers (EU) 2019/2023, ***EU (Mandatory)***

- Measures from the Working Plan have an estimated potential to deliver a total in excess of 260 TWh of annual final energy savings in 2030, which is equivalent to reducing greenhouse gas emissions by approximately 100 million tonnes per year in 2030. Household washing machines and household washer-dryers are among the product groups listed in the Working Plan, with estimated annual electricity savings of 2,5 TWh, leading to GHG emission reductions of 0,8 Mt CO2 eq/year, and estimated water savings of 711 million m3 in 2030.

<u>LEED for Homes</u> Certification, *Global (Voluntary)*

For mid-rise buildings and houses

- Implementation of the following measures to reduce total water use – 12 points
  - Install smart scheduling technology
  - Use captured rainwater
  - Use reclaimed water
  - Use water treated on site
- Installation of high-efficiency fixtures and fittings to minimize indoor demand for water – 6 points
- Efficient landscaping practices to reduce outdoor water consumption – 4 points
- Scoring is done through either total water use (12 pts) or indoor & outdoor water consumption together (6+4 pts)
- Minimum of 3 pts is required.

<u>LEED for Building Design and Construction</u> certification, *Global (Voluntary)*

For high rise building

- Water Metering and Reporting – Required
- Minimum Water Efficiency – Required
- Water Metering and Leak Detection – 1
- Enhanced Water Efficiency – 8

<u>BREEAM International New Construction</u> certification, *Global (Voluntary)*

- Water consumption – 5 Credits
  To reduce the consumption of potable water for sanitary use in new buildings from all sources through the use of water efficient components and water recycling systems.
- Water monitoring – 1 Credit
  To ensure water consumption can be monitored and managed, and therefore encourage reductions in consumption.
- Water leak detection and prevention – 2 Credits (Leak detection system & Leak isolation)
  To reduce the impact of water leaks that may otherwise go undetected.
- Water efficient equipment – 1 Credit
  To reduce water consumption by encouraging specification of water efficient equipment.

<u>BREEAM In-Use International</u> certification, *Global (Voluntary)*

- Water consumption – 4 credits
  To ensure management are aware of annual consumption from utility-supplied water sources.

- Water recycling – 2 credits
  To encourage the use of alternative water supplies in order to reduce the demand for utility supplied fresh water.
- Water consumption reporting – 2 credits
  To facilitate the structured and systematic provision of reporting on water consumption to encourage building users to understand and set efficiency improvement targets.
- Water strategy – 6 credits
  To promote reduced utility-supplied water consumption through encouraging strategies that focus on water-efficiency and reduction of wastage.

DGNB System – New buildings certification, *Global (Voluntary)*

- Water utilisation concept – 10 pts
- Potable water demand and waste water volume – 80 pts
- Watering and retention – 6 pts
- Integration into district infrastructure – 4 pts
- Contribution to the sponge city – 10 pts (Bonus)

Appendix D: Survey Questionnaire with Responses

Survey Questionnaire - Water Conservation

44 responses

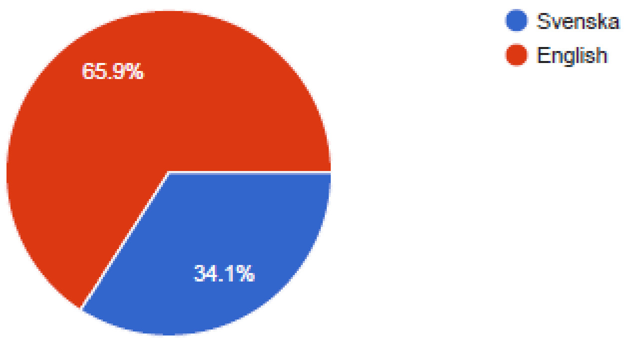
Publish analytics

Språk / Language

Välj språk / Select language

Copy

44 responses

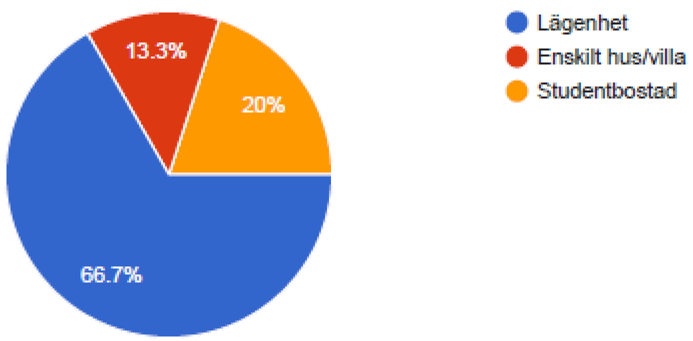


Avsnitt A: Demografisk information

Vilken typ av bostad bor du i?

Copy

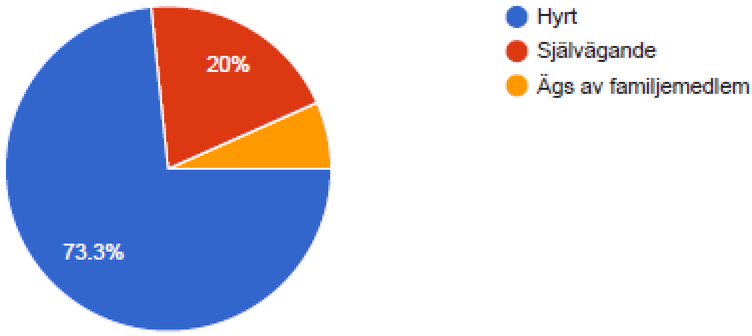
15 responses



Avsnitt A: Demografisk information

Är platsen du bor i ägd eller uthyrd?

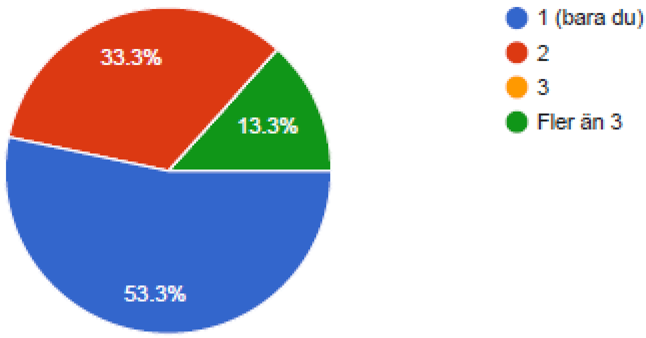
15 responses



Avsnitt A: Demografisk information

Hur många vuxna (18+) bor i huset?

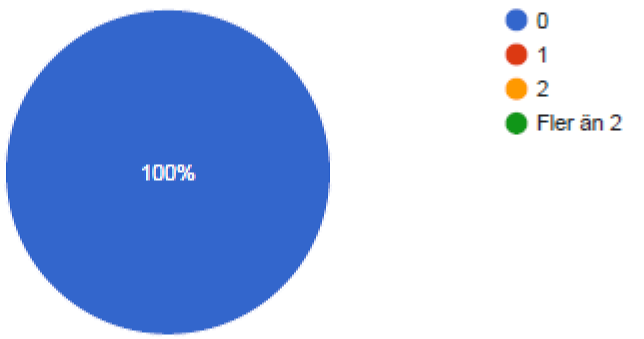
15 responses



Avsnitt A: Demografisk information

Hur många barn (<18) bor i huset?

15 responses

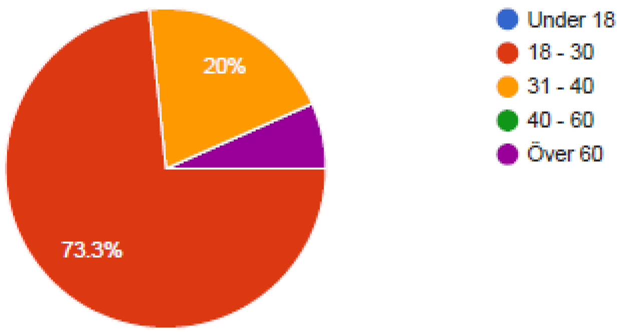


Avsnitt A: Demografisk information

Vilken åldersgrupp tillhör du?

Copy

15 responses

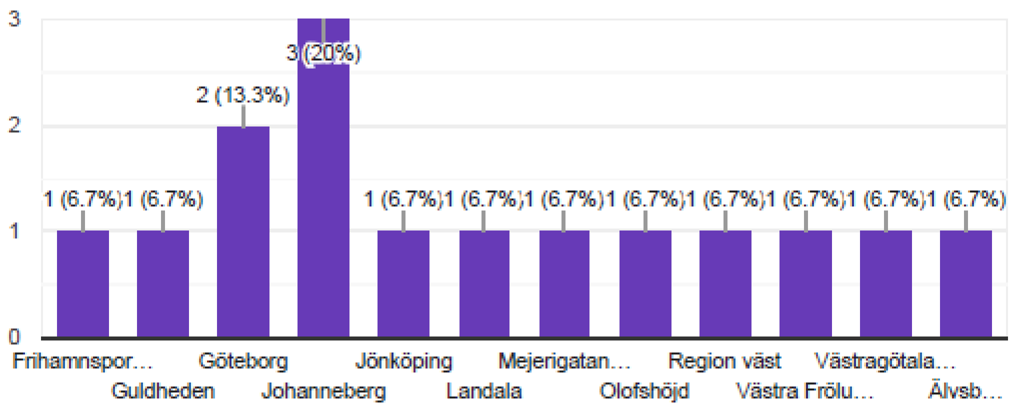


Avsnitt A: Demografisk information

Vad heter regionen du bor i?

Copy

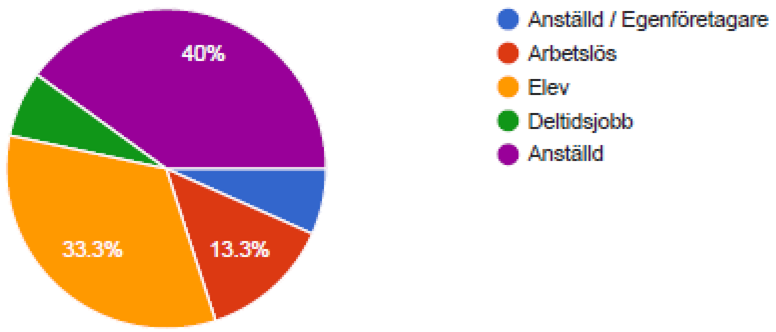
15 responses



Avsnitt A: Demografisk information

Vad är din anställningsstatus?

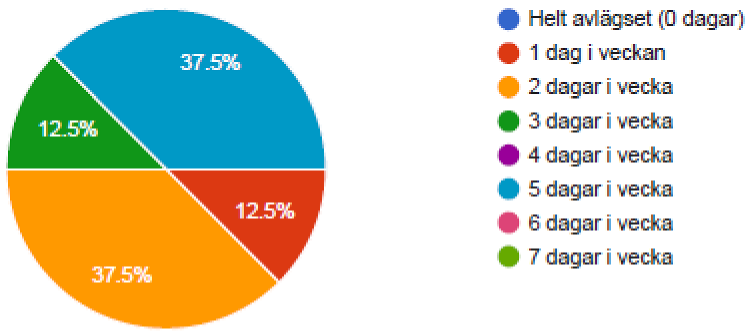
15 responses



Avsnitt A: Demografisk information

Hur många dagar i veckan är du på din arbetsplats?

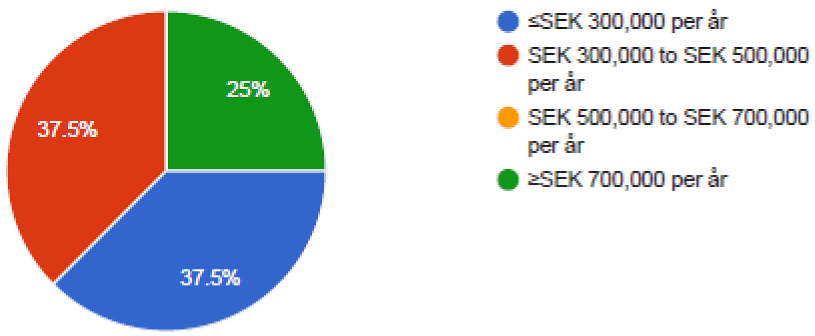
8 responses



Avsnitt A: Demografisk information

Vad är din genomsnittliga inkomst?

8 responses

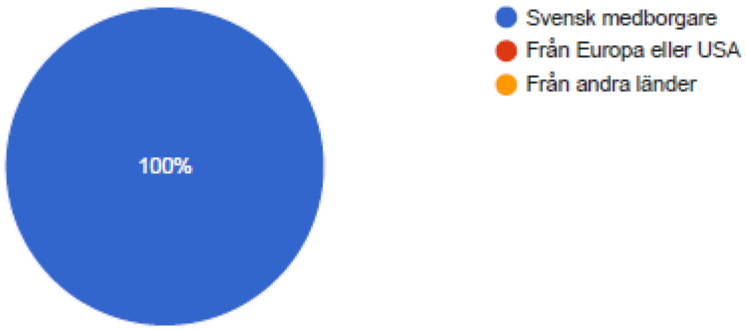


Avsnitt A: Demografisk information

Vad är din status när det kommer till din bosättning?

15 responses

Copy

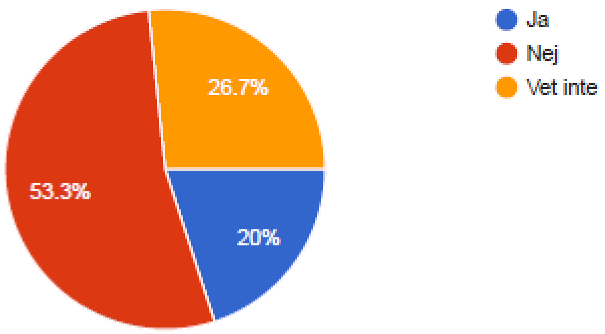


Avsnitt B: Vattenanvändningsbeteende

Har du individuell vattenmätning installerad i ditt hus?

15 responses

Copy

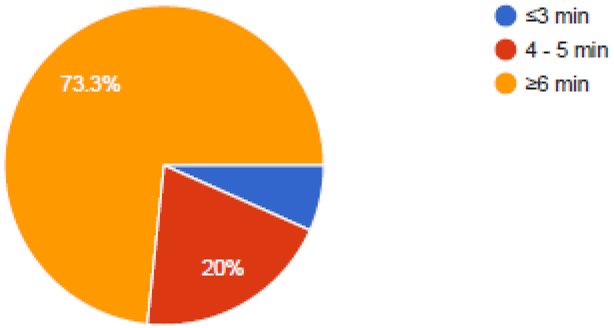


Avsnitt B: Vattenanvändningsbeteende

Hur mycket tid brukar du ta för att duscha?

Copy

15 responses

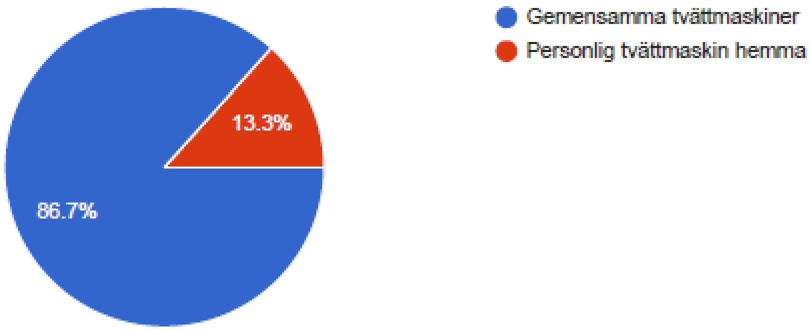


Avsnitt B: Vattenanvändningsbeteende

Var tvättar du din tvätt?

Copy

15 responses

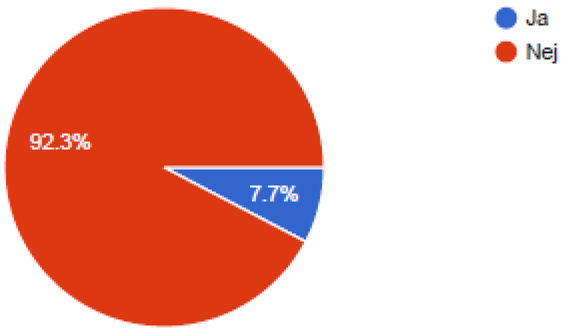


Avsnitt B: Vattenanvändningsbeteende

Planerar du att köpa en personlig tvättmaskin?

Copy

13 responses



Hur gammal är tvättmaskinen du använder?

12 responses

Ca 3 år

10 år

Har ej

Kanske 10+ år inte helt säker

1 år

4 år

ca 12 år

More than 10 years

Över 5 år

10

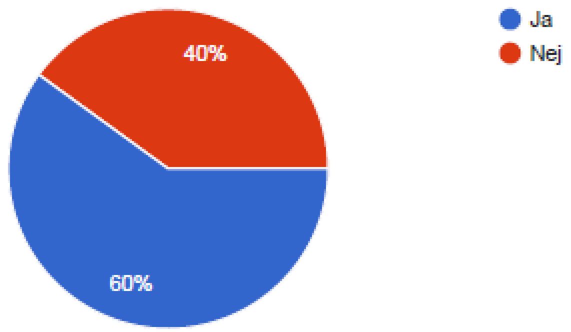
Vet inte

Vetvej

Avsnitt B: Vattenanvändningsbeteende

Har du en diskmaskin hemma hos dig?

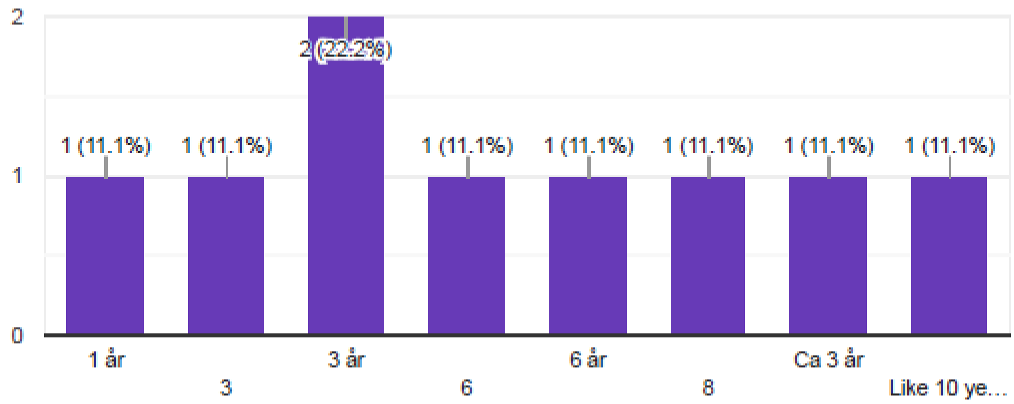
15 responses



Avsnitt B: Vattenanvändningsbeteende

Vad är diskmaskinens ålder?

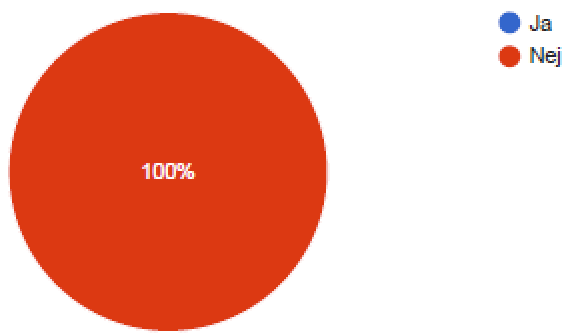
9 responses



Avsnitt B: Vattenanvändningsbeteende

Planerar du att köpa en diskmaskin

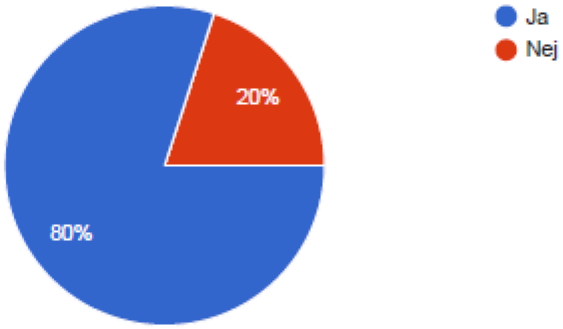
6 responses



Avsnitt B: Vattenanvändningsbeteende

Har din toalett dubbla spolsystem? Copy

15 responses



Avsnitt B: Vattenanvändningsbeteende

Har du någon typ av installation för att minska förbrukningen av vatten?

13 responses

Nej

Snålspolande duschmunstycke

Snålspolande kranar.

Inte vad jag vet. Bor i ett privatägt "kollektiv" Det skulle väl vara att det är unga personer som bor i huset och alla är miljömedvetna och tänker på vattenkonsumtionen på det sättet.

Munstycke på kranen i köket

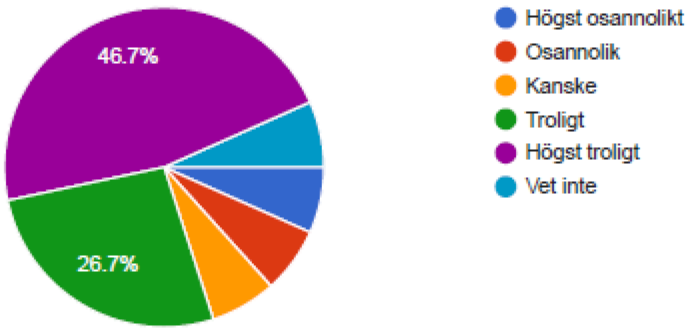
I don't know

Avsnitt C: Uppfattningar, medvetenhet och attityder

Vill du använda hållbara kranar som har minskat flöde?

Copy

15 responses

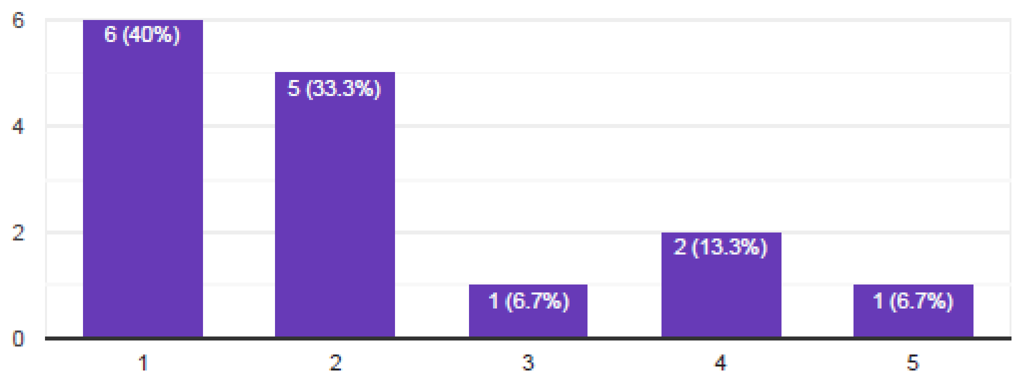


Avsnitt C: Uppfattningar, medvetenhet och attityder

Tycker du att det är viktigt att spara på vatten?

Copy

15 responses

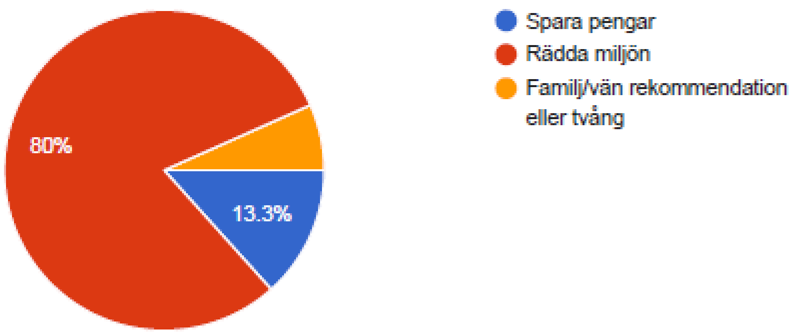


Avsnitt C: Uppfattningar, medvetenhet och attityder

Vilken anledning får dig att spara vatten?

Copy

15 responses

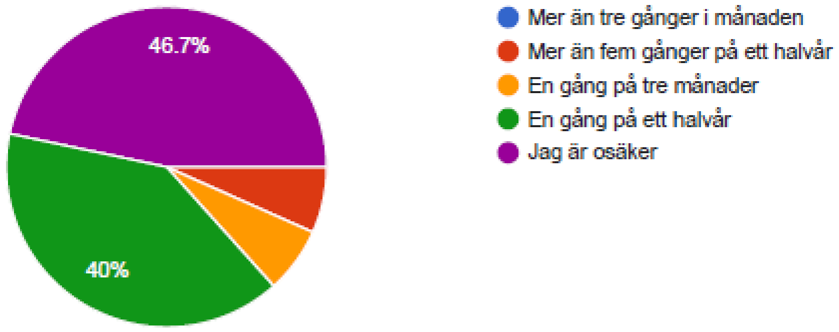


Avsnitt C: Uppfattningar, medvetenhet och attityder

Hur ofta har du lagt märke till vattenbesparingskampanjer av kommunen, inlägg eller annonser på sociala medier?

Copy

15 responses

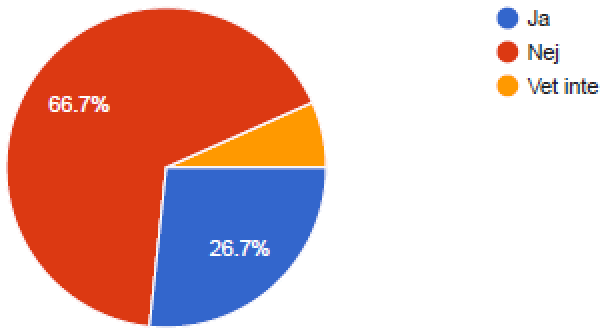


Avsnitt C: Uppfattningar, medvetenhet och attityder

Arbetar du eller någon i din nära krets (familj/vän) inom vatten industrin antingen direkt eller indirekt?

Copy

15 responses

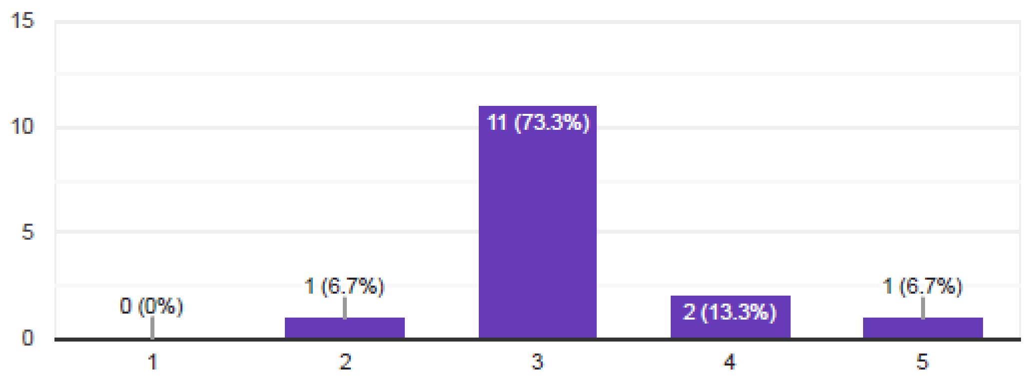


Avsnitt C: Uppfattningar, medvetenhet och attityder

Tror du att det nuvarande vattenpriset i Göteborg speglar vattnets verkliga värde?

Copy

15 responses

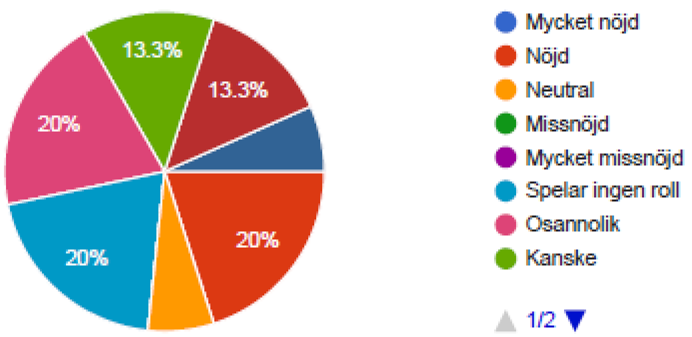


Avsnitt C: Uppfattningar, medvetenhet och attityder

Hur nöjd skulle du vara om kommunen gick över från en fast vattenavgift till ett system där du betalar baserat på hur mycket vatten du använder?

Copy

15 responses



Avsnitt C: Uppfattningar, medvetenhet och attityder

Har du några idéer eller förslag för att spara på vatten hemma eller i samhället?

9 responses

Erbjuda skatteavdrag om man kan påvisa att man håller miljökrav i hushållet

Att ha toaletter som använder vattnet från t.ex handfat och dusch till spolning istället för rent vatten.

Jag har inte mycket vetskap om kostnader på vatten i Göteborgs stad och är osäker på hur mycket vatten olika maskiner konsumerar. Men jag tror att en vattenbov med att bo i ett kollektiv utan diskmaskin är att alla diskar på olika tider och låter vattnet rinna från kranen samtidigt som man diskar. Tror att en diskmaskin hade sparat på onödigt spillt vatten. Men generellt tänka på att fylla tvättmaskinen ordentligt, ta kortare duschar och stänga av vattnet mellan schamponering osv, koka vatten med lock, använda en diskbalja istället för att låta vattnet rinna direkt ut i rören.

Diskmaskiner.
Urinoar sparar mycket vatten.
Man skulle kunna spola med vatten ifrån havet istället för kranvatten. Tror man gör det i Taiwan.

Använd regnvatten till att bevattna gröna ytor

No

-

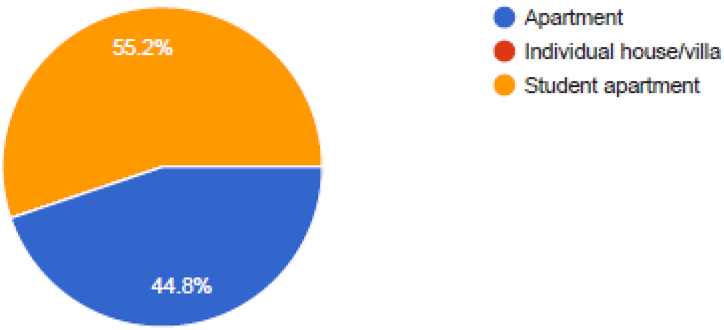
Duscha mindre

Nej

Section A: Demographic Information

What type of housing do you live in?

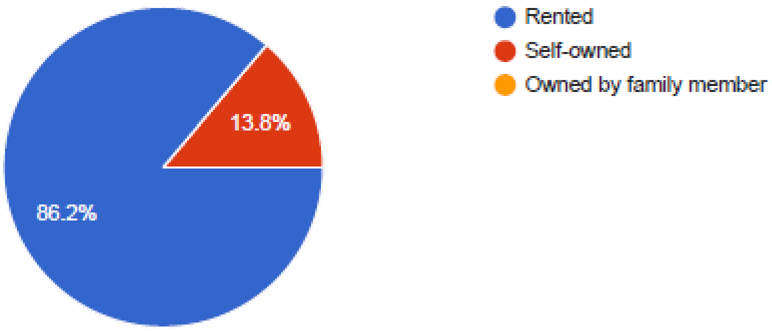
29 responses



Section A: Demographic Information

Is the place you live in owned or rented?

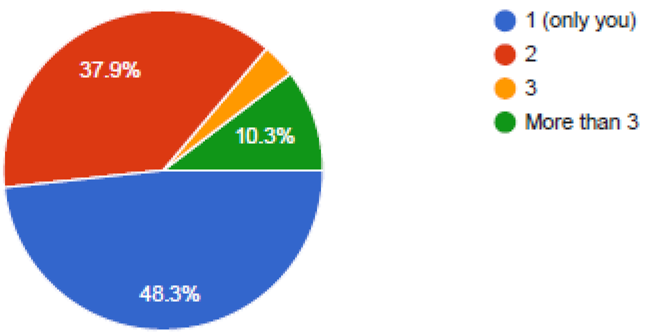
29 responses



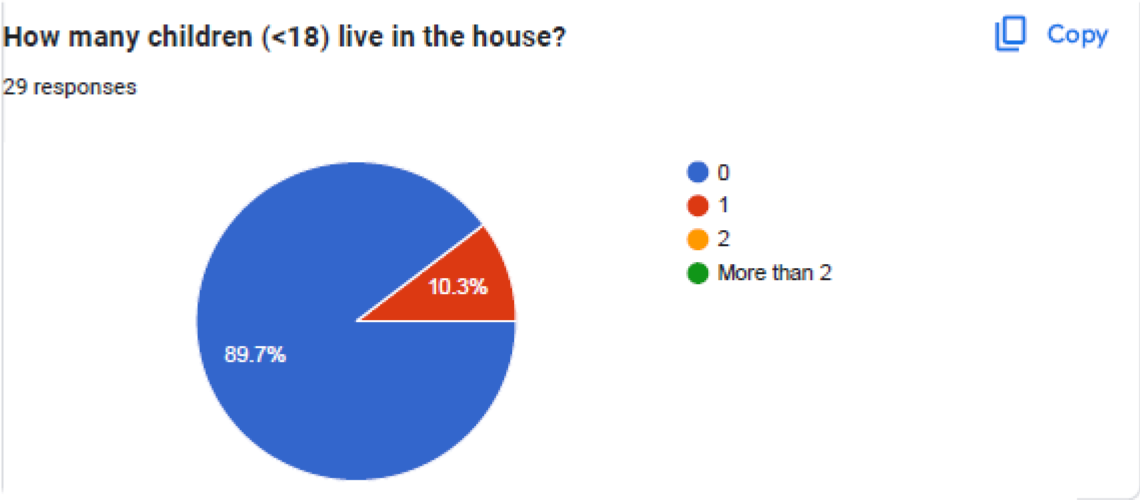
Section A: Demographic Information

How many adults (18+) live in the house?

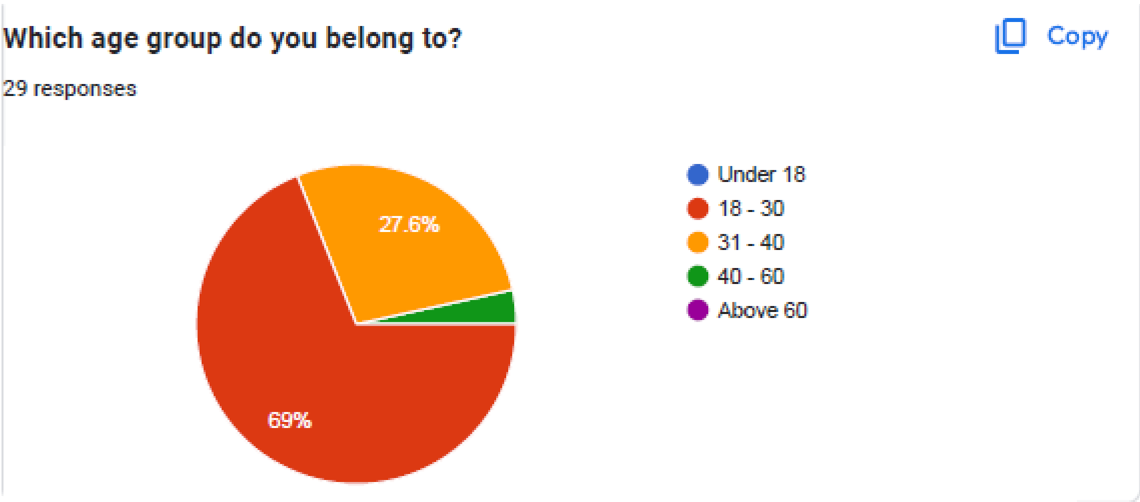
29 responses



Section A: Demographic Information



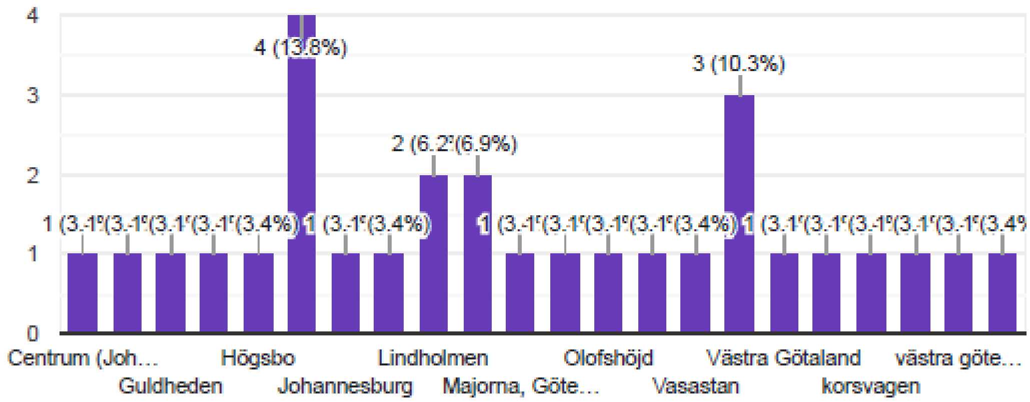
Section A: Demographic Information



Section A: Demographic Information

What is the name of the region you live in?

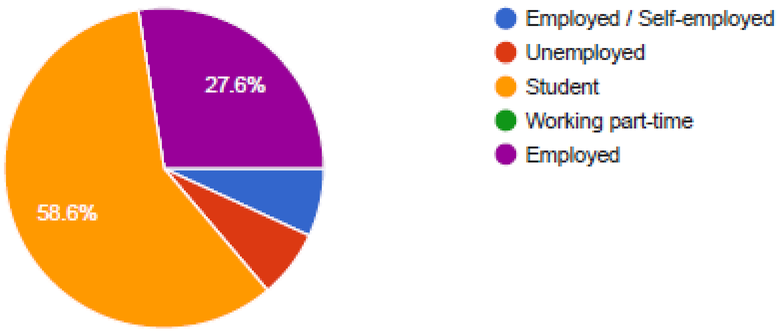
29 responses



Section A: Demographic Information

Employment status

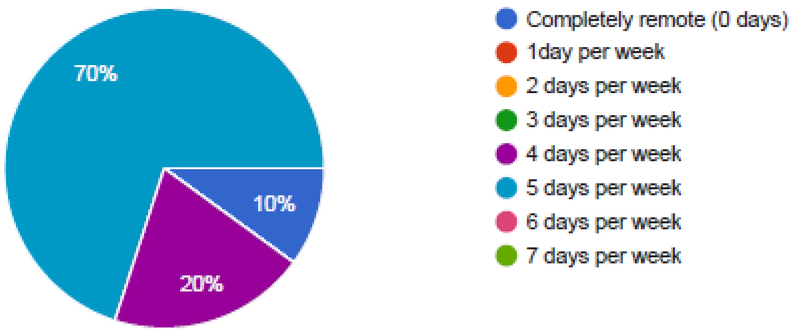
29 responses



Section A: Demographic Information

How many days a week do you physically go to your workplace?

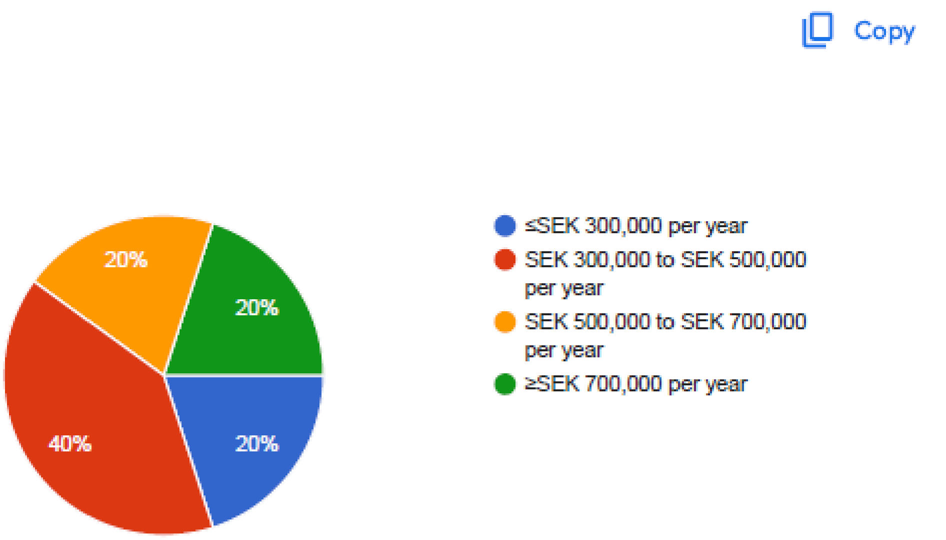
10 responses



Section A: Demographic Information

Income range

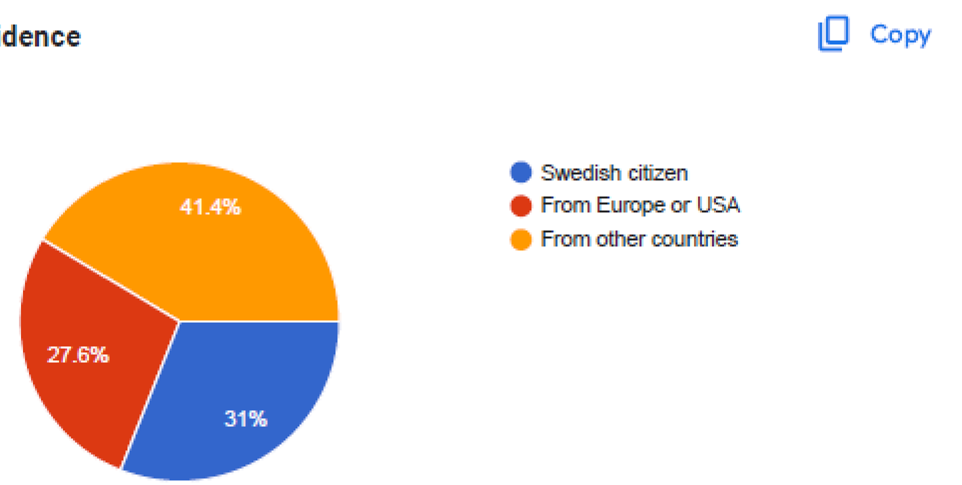
10 responses



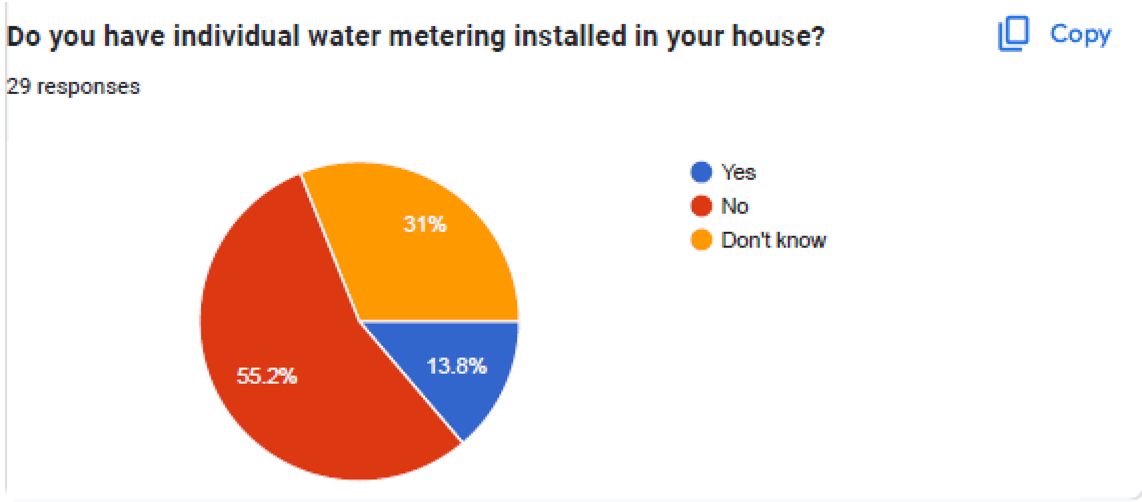
Section A: Demographic Information

Status of residence

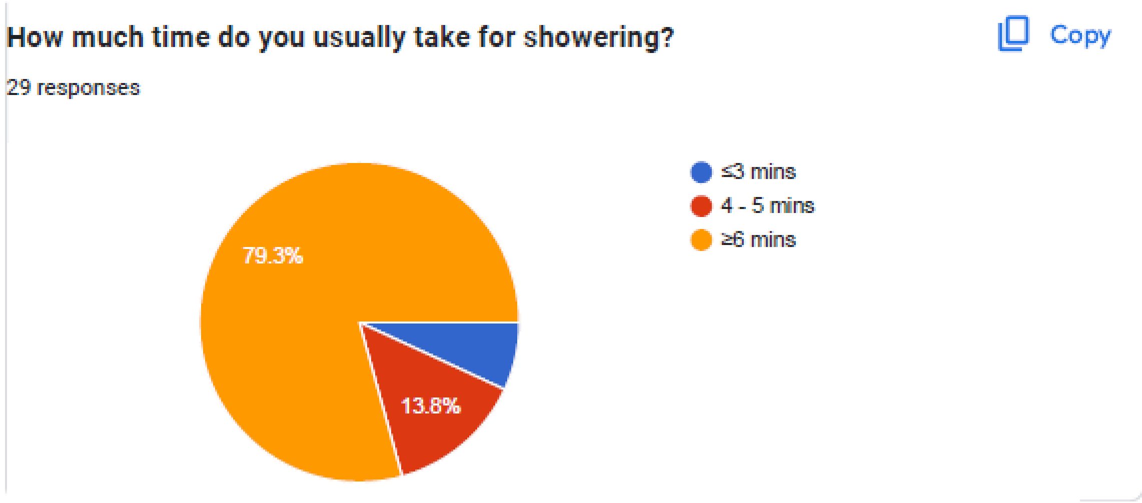
29 responses



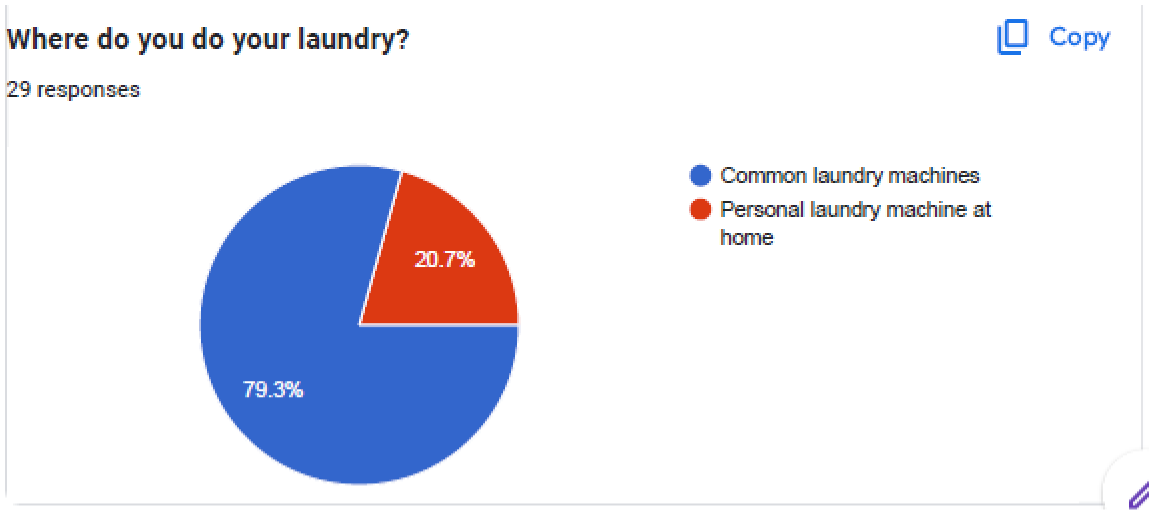
Section B: Water Usage Behavior



Section B: Water Usage Behavior



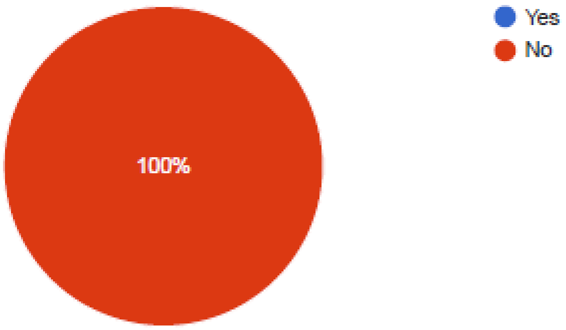
Section B: Water Usage Behavior



Section B: Water Usage Behavior

Are you planning to buy a personal laundry machine?

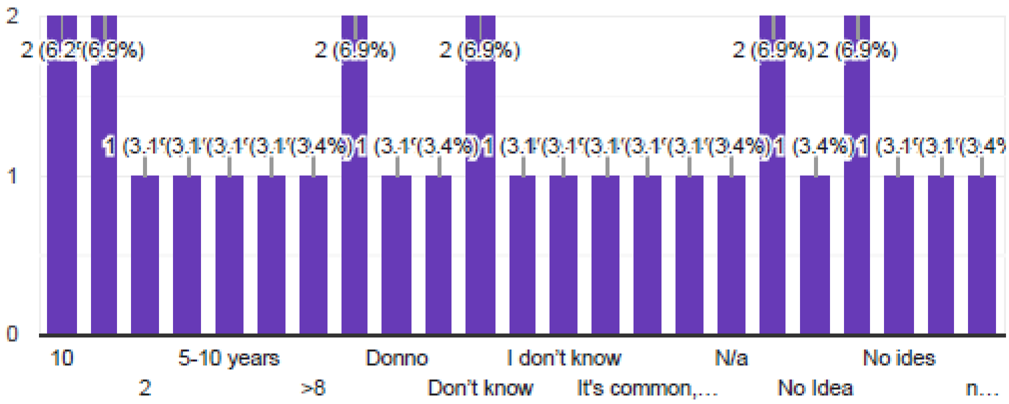
23 responses



Section B: Water Usage Behavior

How old is the laundry machine you are using?

29 responses

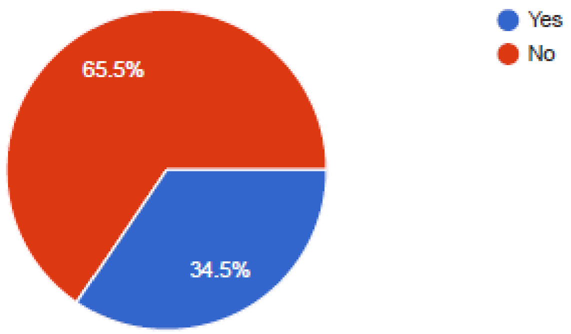


Section B: Water Usage Behavior

Copy

Do you have a dishwasher at your home?

29 responses



Section B: Water Usage Behavior

What is the age of the dishwasher?

10 responses

Don't know

fairly new I would say, average in age, does not seem old

5

1 month

Dont know

More than 10 years

2

>8 yr

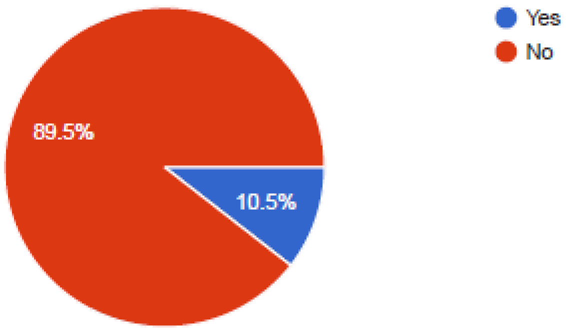
5-10 years

New

Section B: Water Usage Behavior

Are you planning to buy a dishwasher

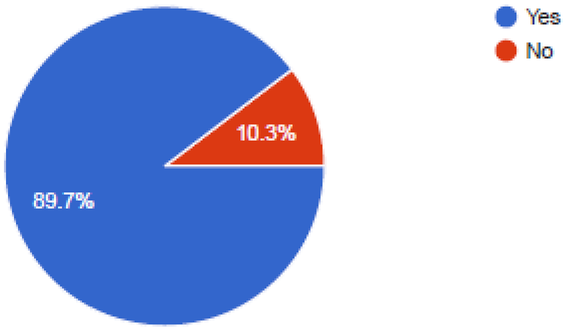
19 responses



Section B: Water Usage Behavior

Does your toilet have dual flushing system?

29 responses



Section B: Water Usage Behavior

Do you have any type of installation (fittings/fixtures/devices) to reduce the consumption of water?

25 responses

No

Yes

Yes, taps that reduce water consumption

no

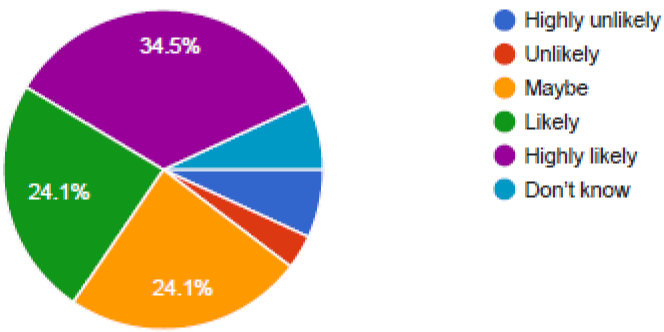
do not know

Not sure but maybe not

Section C: Perceptions, Awareness & Attitudes

Would you like to use sustainable faucets which has reduced flow? Copy

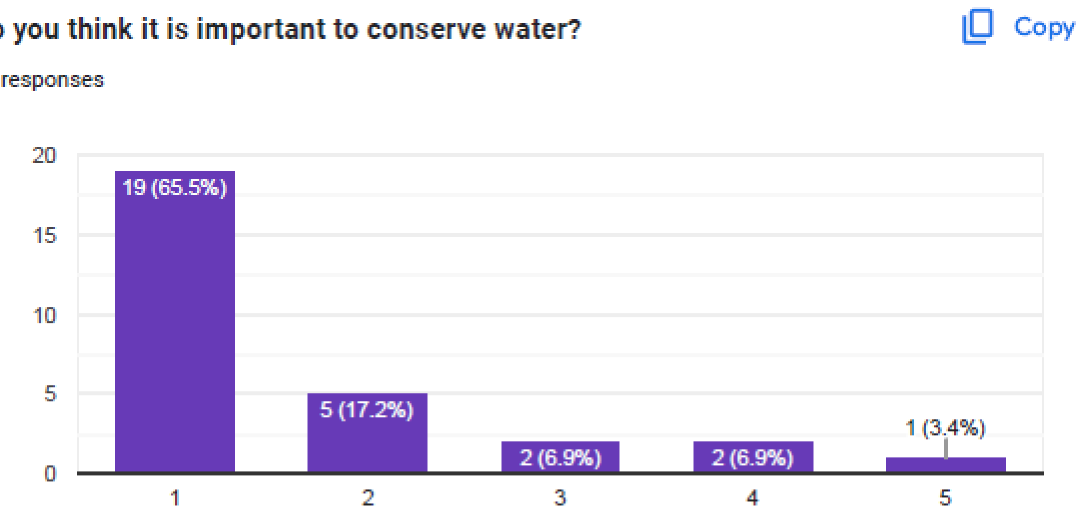
29 responses



Section C: Perceptions, Awareness & Attitudes

Do you think it is important to conserve water?

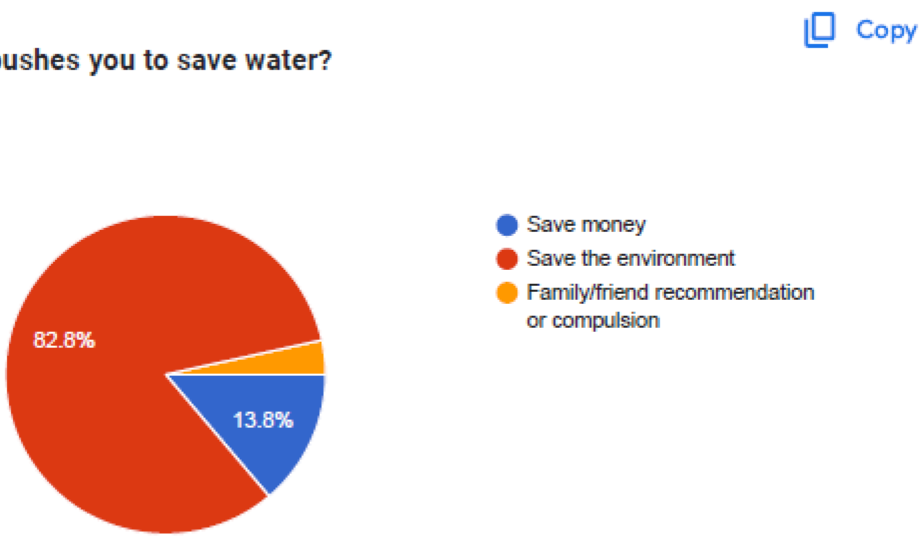
29 responses



Section C: Perceptions, Awareness & Attitudes

Which factor pushes you to save water?

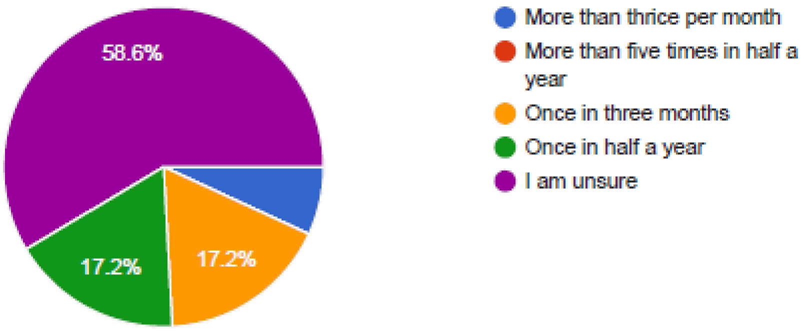
29 responses



Section C: Perceptions, Awareness & Attitudes

How frequent have you noticed water conservation campaigns by the municipality or through social media posts or advertisements?

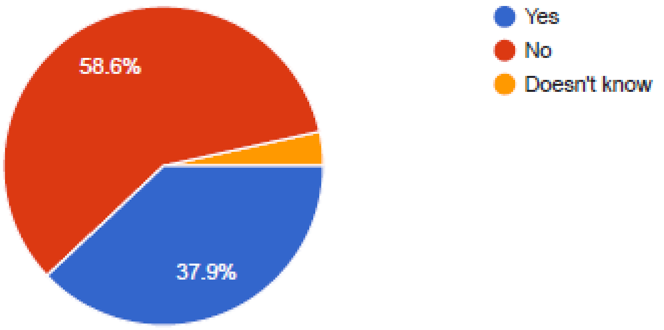
29 responses



Section C: Perceptions, Awareness & Attitudes

Do you or any one in your close circle (family/friend) works in water industry either directly or indirectly?

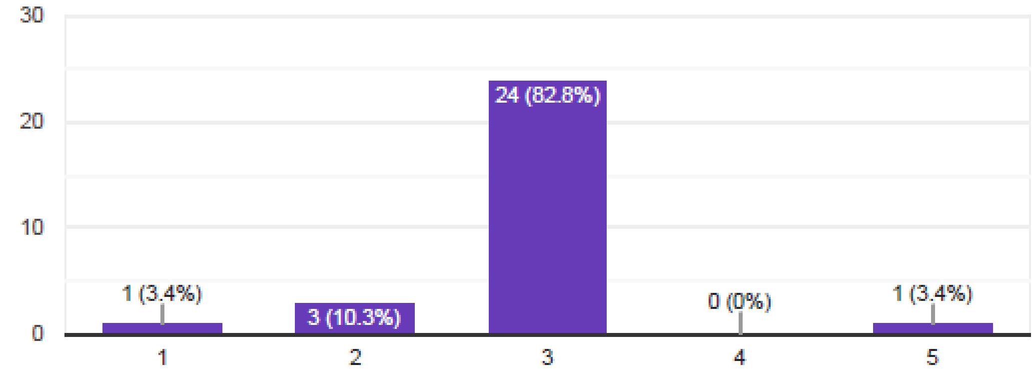
29 responses



Section C: Perceptions, Awareness & Attitudes

Do you think the current water price in Gothenburg reflects the true value of water? Copy

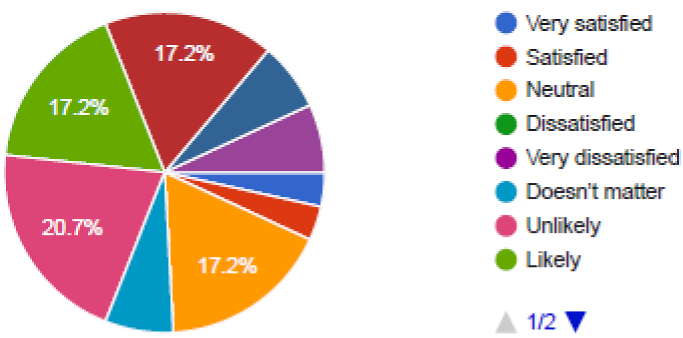
29 responses



Section C: Perceptions, Awareness & Attitudes

How satisfied would you be if the municipality switched from a fixed water fee to a system where you pay based on how much water you use? Copy

29 responses



Section C: Perceptions, Awareness & Attitudes

Do you have any ideas or suggestions for saving water at home or in the community?

13 responses

No

reusable water, for example connecting the bathroom faucet with the water source of the toilet, or mainly using echo mode for the dishwasher when there is a big event and a lot of dishes but hand-washing otherwise, turning off water in the shower when soaping up, etc.

Education and informing the population

Education, Awareness, pay by consumption like electrictity (or at least regulate the price over certain amount of l/person,day for example that we would start paying when consuming over 80-100 l/p,day), campaign for shorter showers, incentivize installation of water reuse in villas (storage of rain water, installing a connection between sink and toilet to use reused water instead of drinking water to flush the toilet), sending (fake) bills to the citizens showing how much the consumption for the year per household would have costed to increase awareness.

Save water at home by fixing leaks, using water-efficient appliances, turning off taps when not in use, and collecting rainwater for outdoor uses. Replace lawns with drought-resistant plants and water gardens during cooler hours to reduce evaporation. In the community, promote water-saving awareness, advocate for efficient public systems, and support policies encouraging conservation. Engage schools in projects like rain gardens and report leaks in public areas promptly.

Placing shower kind of structure in taps of kitchen sink. The water gets spread over the vessel jnctead of pointed washing. And people will also use less water because more the force the water scatter who use the tap.

need awareness campaign rather to increase fee

Water saving shower heads maybe

Water consumption metering

I don't know how and how well they clean the sewage water before releasing it back to the environment, but maybe installation of additional water filters at home, that would clear the water straight after being used, could ensure that water is definitely being cleaned properly and pollutants (microplastics, chemical pollutants and so on) wouldn't reach relatively clean groundwater and water bodies, because freshwater resources are not infinite so in order to save water we need to keep it clean. Furthermore, education is usually the most important thing when one wants to raise awareness, thus, more talking, advertising about water resourses in schools, workplaces, common spaces could help to make people understand stuff, because no matter how easy it is to save water a person won't do it if they don't know why. Also, water usage in private homes makes up only a small part of globally significant water resources, hence for individuals it could be even better to give up some produce that require large amounts of water to be made (which over time could have effect on how industries use natural resources).

Higher price for high water consumption

More percolation areas and less concrete, reusing cold water for garden while waiting for warm water, ban on household pools

Appendix A: Water Conservation Campaign Poster by Kretslopp och Vatten

Appendix B: Coimbatore City Pilot Project Tariff Sheet

(இ) வீட்டின் உரிமையாளர் ... வேண்டும். பழுது பார்த்தல் ...
செலவில் அளவுமானியை பழுதுபார்க்க ஏற்பாடு செய்ய வேண்டும். பழுது பார்த்தல் ... அவ்வாறு செய்யத் தவறும் தருவாயில் குடிநீர்க் குழாய் இணைப்பு துண்டிக்கப்படும். இரண்டு மாத காலத்திற்குள் செய்தல் வேண்டும்.

12. ஒவ்வொரு குடிநீர் குழாய் இணைப்பு பெறுவதற்கும் வைப்புத்தொகை செலுத்த வேண்டும். வைப்புத்தொகை மற்றும் குடிநீர் கட்டண விகிதங்கள் கீழ்க்கண்டவாறு செலுத்தப்பட வேண்டும்.

(அ) வீட்டு உபயோக முறையில் வழங்கப்படும் குடிநீர் இணைப்புக்கு உண்டான குடிநீர் கட்டண விவரம்.

வரிசை எண்.	குடிநீர் விநியோக முறை ஒருமாத உபயோக அளவு	வீட்டு உபயோக குழாய் இணைப்பிற்கு ஒவ்வொரு 1000 லிட்டருக்கும் அதன் பாகத்திற்கும்
அ.		
1)	15,000 லிட்டர் வரை	ரூ.100.00 (குறைந்தபட்ச மாதாந்திர கட்டணம்)
2)	15,001 முதல் 20,000 லிட்டர் வரை	ரூ.6.00
3)	20,001 முதல் 1,50,000 லிட்டர் வரை	ரூ.8.00
4)	1,50,000 லிட்டருக்கும் மேல்	ரூ.10.00
	ஒருமாத குறைந்தபட்ச கட்டணம்	ரூ.100.00
	குடிநீர் கட்டண வைப்புத் தொகை	ரூ.5,000.00

வரிசை எண்.	குடிநீர் விநியோக முறை ஒருமாத உபயோக அளவு	வீட்டு உபயோக முறையில் மொத்த விநியோகம் 20 எம்.எம்,விட்டத்திற்கு அதிக அளவிலான குழாய் இணைப்புகளுக்கு ஒவ்வொரு 1000 லிட்டருக்கும் அதன் பாகத்திற்கும்
ஆ		
1)	7500 லிட்டர் வரை	ரூ.5.25
2)	7501 முதல் 10,000 லிட்டர் வரை	ரூ.6.00
3)	10,001 முதல் 1,50,000 லிட்டர் வரை	ரூ.8.00
4)	1,50,000 லிட்டருக்கும் மேல்	ரூ.11.00
	ஒருமாத குறைந்தபட்ச கட்டணம்	ரூ.900.00
	குடிநீர் கட்டண வைப்புத் தொகை	ரூ.10,000.00

(ஆ) வீட்டு உபயோகம் அல்லாத முறையில் வழங்கப்படும் குடிநீர் கட்டண விவரம்.

வரிசை எண்	குடிநீர் விநியோக முறை வீட்டு உபயோகம் அல்லாத பிற உபயோகத்திற்கு ஒருமாத உபயோக அளவு	வீட்டு உபயோக குழாய் இணைப்பிற்கு 20 எம்.எம். ஒவ்வொரு 1000 லிட்டருக்கும் அதன் பாகத்திற்கும்	பொது நிறுவனங்கள் முதலியவற்றிற்கு மொத்த விநியோகம் 20 எம்.எம். விட்டத்திற்கு அதிக அளவிலான குழாய் இணைப்புகளுக்கு
1.	7,500 லிட்டர் வரை	ரூ. 10.50	ரூ. 10.50
2.	7,501 – 10000 லிட்டர் வரை	ரூ. 13.50	ரூ. 13.50
3.	10,001 – 150000 லிட்டர் வரை	ரூ. 18.00	ரூ. 18.00
4.	1,50,001 லிட்டருக்கு மேல்	ரூ. 22.50	ரூ. 22.50
	ஒருமாத குறைந்த பட்ச கட்டணம்	ரூ.525.00	ரூ.1,350.00
	குடிநீர் கட்டண வைப்புத் தொகை	ரூ10,000.00	ரூ.15,000.00