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by

Delil Dölcü
Marcus Andersson

Master of Science Thesis TRITA-ITM-EX 2021:249
KTH Industrial Engineering and Management
Industrial Management
SE-100 44 STOCKHOLM

Stora Tekniska Systems Framtid

Trender och drivkrafter för vattenanvändning i svenska hushåll

av

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Abstract

Understanding the future of a Large Technical System (LTS) through a sociotechnical analysis is a complex notion. The authors will investigate the phenomenon by studying residential water consumption in Sweden. Although Sweden has great access to raw water, compared to many other countries, it does not justify the fact that consumption patterns have to be unsustainable. To perceive the future, one will need to have knowledge of history. Therefore, this thesis has identified 11 drivers that will affect future residential water consumption. From these 11 drivers, the authors have posed four future scenarios for residential water consumption. The top 3 identified drivers are connected to behaviour and awareness. Thus, implying individuals' responsibility and accountability will be of greater significance for the sustainable development of residential water consumption. For this research, the authors have adopted a framework based on the application of LTS, Multi-Level Perspective (MLP), Scenario building, PESTLE, and Multi-Criteria Analysis (MCA). The authors have conducted a qualitative study, gathering data through a literature study and semi-structured interviews. The 18 interviewees covered a broad spectrum of knowledge, experiences, and general interest in water. By understanding the dynamics of the system and drivers, the authors will be able to present the gathered knowledge to stakeholders for possible strategic decisions.

Keywords: Residential Water Consumption, Drivers, LTS, MLP, PESTLE, MCA

KTH Industrial Engineering and Management

Examensarbete TRITA-ITM-EX 2021:249

Utforska de icke-tekniska utmaningarna:

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Delil Dölcü & Marcus Andersson

Godkänt	Examinator	Handledare
26/05-2021	Jannis Angelis	Pernilla Ulfvengren
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Sammanfattning

Att förstå framtiden för ett stort tekniskt system (LTS) genom en socioteknisk analys innebär stor komplexitet. Detta kommer att undersökas genom att studera hushållens vattenförbrukning i Sverige. Även om Sverige har stor tillgång till råvatten, jämfört med många andra länder, berättigar det inte förekommandet av ohållbara konsumtionsmönster. För att öka förståelsen av framtiden måste en ha kunskap om historien. Därför har denna avhandling identifierat 11 drivkrafter som kommer att påverka den framtida hushållens vattenförbrukning. Från dessa 11 drivkrafter har författarna formulerat fyra framtida scenarier för hushållens vattenförbrukning. De tre högst rankade identifierade drivkrafterna är kopplade till beteende och medvetenhet. Detta antyder på att individens enskilda ansvar och skyldigheter är av större betydelse för en hållbar utveckling av hushållens vattenförbrukning. För denna forskning har författarna använt sig av ett teoretiskt ramverk som bygger på tillämpningen av LTS, Multi-Level Perspective (MLP), Scenario building, PESTLE and Multi-Criteria Analysis (MCA). Författarna har genomfört en kvalitativ studie, där insamling av data härstammar från den genomförda litteraturstudien och 18 semi-strukturerade intervjuer. De 18 intervjukandidaterna täckte ett brett spektrum av kunskap, erfarenhet och intresse av vatten. Genom att skapa ett samband och förstå dynamiken i systemet och drivkrafterna, kommer författarna att kunna presentera den samlade kunskapen till intressenter för eventuella strategiska beslut.

Nyckelord: Hushållens vattenanvändning, Drivkrafter, LTS, MLP, PESTLE, MCA

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Abbreviation and Acronyms	Name
IHC	Industrialised Housing Construction
LCA	Life cycle analysis
LTS	Large Technical System
MCA	Multi-Criteria Analysis
MDWC	Mean Daily Water Consumption per capita
MRQ	Main Research Question
MLP	Multi-Level Perspective
PDC	Peak Day Consumption per capita
PDF	Peak Daily Factor
PESTLE	Political, Economical, Sociological, Technological, Legislative, Environmental
RQ	Research Question
SOI	System of Interest
ST-system	Sociotechnical Systems
WTP	Willingness to Pay

IV Acknowledgement

First of all, we would like to thank Norrvatten for their supporting knowledge and trust. A special thank you goes out to Daniel Hellström for guiding us through this thesis and the opportunity given.

The industry has also been very welcoming, and without the interviewees' knowledge and experience, the accomplishment of this thesis would not be possible. I hope you will find our results and work highly valuable for the industry. Thank you for the time and knowledge you shared with us.

We would also like to thank Pernilla Ulfvengren for your support and insight throughout this thesis. Without your support, this thesis would not have reached the level of structure and content. Finally, a loving thank you is directed to family and friends for motivating and supporting us.

Stay safe.

Delil Dölcü & Marcus Andersson

Stockholm, June 2021

1. Introduction

Making decisions with less uncertainty of what the future beholds invites a great deal of potential for strategic decisions. However, conducting such a study introduces a vast number of complexities. Furthermore, acquiring knowledge of the future can be utilised to improve current decision support for large investments. A common approach is to build scenarios to plan for the future since the future is highly uncertain and depends on prior decisions and outcomes. Many organisations use this to develop their “roadmaps”. However, when it comes to systems of large scale and complexity, interwoven in society, other influences and external aspects need to be considered more than just internal aspects. Society is built on an infinite number of systems that interact, cooperate, and interchange, thus requiring system thinking to understand the complexities of technical and social systems. An aspect to study, which will be a significant theme in this thesis, is identifying drivers for consumption trends of natural resources in a Large Technical Systems (LTS). These drivers will act as Natural Resource Variables (NRV) within the LTS and have a degree of interchangeability depending on the studied system. This means that drivers, or NRV, can be excluded or new ones included based on the system.

Identifying drivers requires identifying and defining the limitations of the studied system by breaking it down to relevant system components (Hughes, 1983; Joerges, 1988). LTS is defined as systems containing “messy, complex, problem-solving components” (Hughes 1983, p.1), typically infrastructural and sociotechnical systems. These systems are socially constructed and shape core societal functions, like the supply of communication, transportation, energy, Functions with the overall goal to shape societies and enable individuals to live decent lives. Despite the name LTS, there are other aspects of importance than the technical. There is also the inclusion of legislative artefacts, regulatory, financial, and economic, political. Although all of these aspects are argued to be socially constructed and adapted in the system, it can be argued that there must be a driving reason for this. This presents an opportunity to investigate and partially attempt to understand what this will mean for the future. It may also enable opportunities to adjust functions and adapt to the system's dynamics. Previous literature regarding LTS stems from historical studies and primarily discusses change in past tense.

From this research, numerous modified models have been developed, for example, Multi-Level Perspective (MLP). MLP originates from studies of understanding transition and regime shifts, stemming from sociology in technology (Geels and Kemp, 2007). MLP will synthesise the perspectives of LTS in this thesis as it is a tool to comprehend the components of the LTS. Through these models, PESTLE analysis (Carruthers, 2009) has been identified as a complementing tool. The synthesis of LTS, MLP, PESTLE, and Multi-Criteria Analysis (MCA) will hopefully illuminate and educate the understanding of behavioural and consumption patterns. As the system shapes the individuals, the individuals shape the system itself. There is no random act of decision since individuals, functions and system owners make rational strategic decisions given the circumstances. However, if one does not understand the dynamics of the system, they could be perceived and interpreted as irrational and stochastic choices of act rather than rational decisions.

Natural resources are also qualified as system artefacts (Hughes,1987; Joerges, 1988). For example, water covers 71% of the globe's surface, making it a significant system artefact (Gleick, 1993). The System Of Interest (SOI) (Walden *et al.*, 2015) of this thesis is the household water consumption and supply. What drives the individual's consumption of natural resources in their everyday life will be of focus. Specific for this study is the residential water consumption and its relation to the urban water system in Sweden. Given that the residential water system achieves a majority of the criteria and characteristics of a LTS. The authors pose that SOI is equal to LTS, thus be approached accordingly in this thesis.

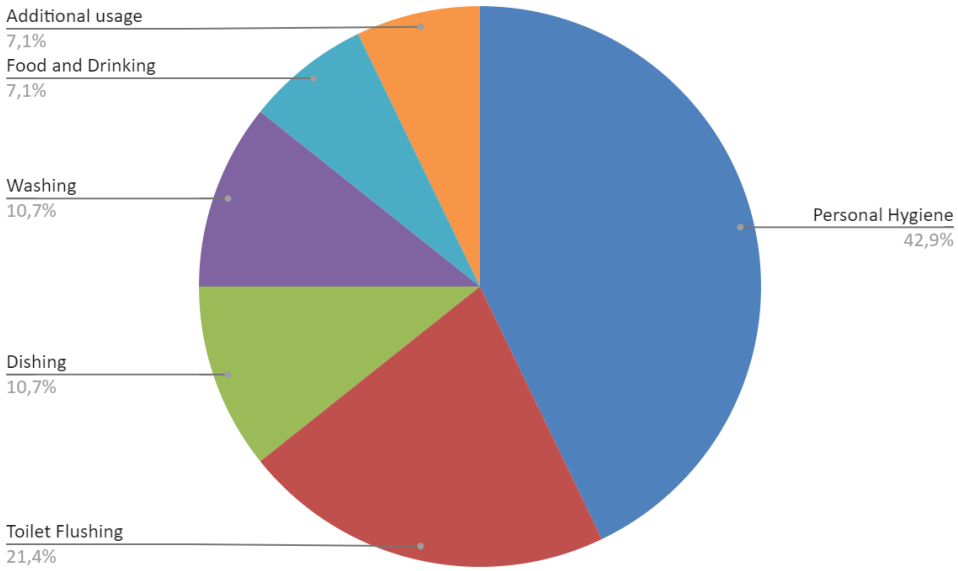

Figure 1: Distribution of water purposes/usage for households in Sweden. Data collected from Sydvatten (Sydvatten, 2020).

This study will observe residential water consumption as a system of the LTS of the water utility sector. Residential water usage is the consumption of indoor and outdoor water activities. It includes, for example, water for drinking, food preparation, washing clothes, dishing, flushing toilets, showering, gardening, outdoor swimming pool and washing vehicles (Holm and Schulte-Herbruggen, 2021). For distribution of water purposes in Swedish households. See Figure 1. Residential water consumption is usually presented in the format of water used in litres per day per capita. It is estimated to be approximately 140 litres per day in Sweden (Svenskt Vatten, 2020). Studies of forecasting within the water sector are usually built and compiled measurements of historical and statistical data. Two metrics commonly used are Mean Daily Water consumption per Capita (MDWC) and Peak Daily Factor (PDF). Collectively they give an understanding of the volume and intensity of water consumption. See Figure 2 for the correlation between the two equations. This thesis will aim to compile the existing knowledge of drivers through published literature and conducting interviews. Henceforth, the authors will build scenarios to understand the future to establish new perspectives through qualitative data rather than quantitative data (Schwartz, 1997).

$$Mean\ Daily\ Water\ Consumption\ per\ Capita\ = \frac{Volume\ Water\ Sold}{Number\ of\ Consumers}$$

$$Peak\ Daily\ Factor\ = \frac{Peak\ day\ consumption\ per\ Capita}{Mean\ daily\ water\ consumption\ per\ Capita}$$

Figure 2: Equations for Mean Daily Water Consumption per Capita and Peak Daily Factor.

As is both stated in Joerges (1988) and Geels *et al.* (2018), LTS are often taken for granted and perceived as a non-compromised flow of products or services. However, its fundamental purpose and weight to the community are not tangible or even visible until disaster erupts (Joerges, 1988). In this research, the water system is expected to change in the future due to environmental factors and anthropogenic pressure (Gleick, 2003; Kiparsky *et al.*, 2013; Ercin and Hoekstra, 2014; McCarthy *et al.*, 2020). This incites to nurture the relationship between humans, technology and the environment. Digitalization and urbanization are also perceived to be contributing factors to future residential water consumption trends, adding additional layers of uncertainty and complexity (Gleick, 2003; Kiparsky *et al.*, 2013; Ercin and Hoekstra, 2014; McCarthy *et al.*, 2020). See Figure 3 for the development of Swedish residential water usage every five years from 1995 to 2015.

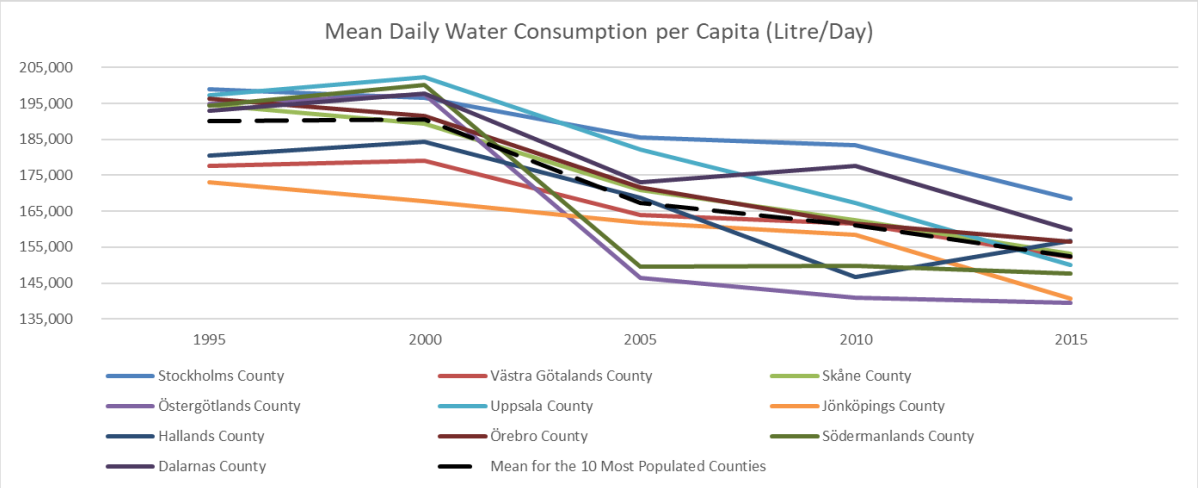

Figure 3: Mean Daily Consumption per Capita for the ten most inhabited counties in Sweden over 20 years (SCB, no date-a; SCB, no date-b).

1.1. Purpose & Research Question

The purpose of this thesis is to understand how the LTS, residential water consumption, will develop in the future. Furthermore, this research will attempt to investigate theories on sociotechnical analysis by applying them to residential water consumption.

The answering of (Research Question) RQ1-2 will aid in the attempt to answer (Main Research Question) MRQ:

MRQ: How is the development of LTS understood through a sociotechnical analysis?

RQ1: Which are the drivers for the development of MDWC and PDF?

RQ2: Which are the key drivers of significance for future residential water consumption?

1.2. Expected Contribution

This thesis is expected to contribute theoretically by adding layers to existing research of LTS and MLP. Expecting that this may be replicated and lead to additional developed knowledge contributing to theory and the potential application in the practical development of different systems. As this is an uncharted territory within the Swedish water sector, this can hopefully catapult the research for further development. Development that includes further investigation and analysis of complex systems and its many different components. This thesis should also be enacted as a blueprint of how to identify and map external factors on a sub-system.
Furthermore, the practical contribution of this thesis will hopefully illuminate and educate the whole spectrum of stakeholders, ranging from consumers to producers, authorities, and governments. Hopefully, the stakeholder will realize the consequences of their actions and initiatives on the future of a system and the SOI. Presenting the drivers which are extracted from the knowledge of scholars and industry professionals and compared and discussed through published literature in a comprehensible manner will be one way of achieving this. It is also expected that the thesis sponsor, Norrvatten, will be able to use the investigated drivers to more accurately focus on these drivers as factors of effect on the system. Also, it will hopefully give Norrvatten an understanding of which drivers have more significance on the system so that an appropriate amount of time and energy is placed on these.

1.3. Delimitations

The urban water system is large, and delimitations must be made to extract the most out of the knowledge and produce a report with valuable content to continue the research area. Although the initial focus of the thesis was on the individual level, it is vital to include all levels of the system perspective, including industrial and functional (Blomkvist and Hallin, 2015). The project is set to identify and understand future residential water consumption drivers and water trends in Sweden. This includes private houses and apartment buildings. It will focus only on the urban water system and the 90 % of Swedish inhabitants connected to the water and sewage system. The project will only focus on direct water consumption, i.e., consumption for hygiene, water used in faucets and water appliances such as dishwashers and washing machines, irrigation technology. It will not consider nor discuss virtual water consumption. See (e.g., Matthews, 2014) for further explanation.

The study will predominantly only consider and manage qualitative data from the empirical data collection. Therefore, simple figures and mathematical expressions are not excluded but limited in number. This is motivated partly because most previous published literature covers these areas and that data provided and circulated in the industry sector is sometimes deemed inaccurate (Mårtensson *et al.*, 2018; Hammarlund, Törneke and Siegwan, 2020). Thus, the report will not quantify the statistical implication or probability of the drivers for future water consumption since data will not be collected. Therefore, the authors cannot conclude nor quantify any probabilities for scenarios or trends to happen. However, based on a thoroughly

conducted literature review and interviews, an elaborated discussion will be completed discussing the implications and effects of different scenarios and drivers for the future.

1.4. Thesis sponsor

This thesis is sponsored by the municipal association Norrvatten. They are responsible for producing and delivering fresh drinking water to their 14 member municipalities in the Northern part of the Stockholm region. Each municipality is responsible for their water distribution network. Approximately 700 000 people rely on the vision and deliverance of Norrvatten, including large hospitals and the airport of Arlanda. Norrvatten is Sweden's fourth largest drink water producer in water volume production, with approximately 60 employees. Görvälnätverket gets its raw water from where it is located, in Mälaren, specifically in the municipality of Järfälla. The production site has the capacity to produce 1 600 litre water per second (*Norrvatten*, no date).

1.5. Disposition of Report

Introduction. An introductory chapter by framing the practical and academic context for the phenomenon to study with additional educational knowledge regarding the research area. The purpose to fulfil and research questions to be answered are followed. Lastly, the expected contribution of the thesis and the thesis sponsor is presented. *Theoretical Framework.* A comprehensive chapter where the theoretical foundation and framework is established. The theoretical perspectives of LTS, MLP, Scenario Building and PESTLE are introduced. *P(L)ESTE Review of the Water System.* This chapter is a thoroughly written and explored literature study originating from the dimensions of PESTLE individually and structured accordingly. However, the dimensions of Political and Legislative have been combined. *Methods.* A descriptive chapter of the methodologies chosen and applied in the study. It includes an overall description of the research design and structure, providing information for each. The processes of collecting and analysing literature and the empirical data is also described individually. A thorough description of methods applied and an explanation of MCA is also included. The chapter is ended with a complete presentation of the research's ethical stance and contribution. *Results and Analysis.* The completed MCA presents the empirical and literary findings of the study conducted. A summary score for each driver identified can be read with additional analysis motivating the scoring for each driver and criteria. *Discussion.* The chapter discusses the scientific implication of the empirical and literary findings and the entirety of the study. Answering the research questions of what drivers will be decisive for the future of residential water consumption and posing potential future scenarios and a discussion of the overarching research formulation and methods applied. *Conclusions.* The last chapter concludes the thesis by outlining the main arguments of discussion and answers to the proposed research questions. The drivers identified in the results will be concluded, and future development of the research is also presented.

2. Theoretical Framework

This chapter will lay the theoretical foundation and approach of this study. This section introduces the application LTS and MLP for this study. The often discussed dyad of LTS and MLP will further lead to a section focusing on scenario building, specifically for the future of a LTS. Ultimately it will lead to a section on the analytical method PESTLE. PESTLE will complement the prior perspective of LTS, MLP and Scenario Building to further and explicitly create a structure of potential and identified areas to investigate.

2.1 The Application of LTS

Joerges (1988) argues for LTS representing a societal dilemma, as this magnitude of a system cannot be perceived as a non-evolutionary black box. The system cannot be taken for granted despite the stable facade and the calm it emits since change usually happens incrementally and radical change happens sporadically and seldomly. This partly fraudulent natural state of mind cannot induce a satisfactory level of stability. This system of either physical or non-physical artefacts (Hughes, 1987) is a practical constellation of basic systems theory, “the whole is greater than the sum of the parts”. The parts can be substituted, disposed of or redesigned (Joerges 1988, p. 27). However, if characteristics or artefacts change in the system, the system will adjust accordingly (Hughes, 1987). Therefore, it is essential to consider aspects of system dynamics and change since the system has an “irreducible potential for controversy” (Joerges 1988, p. 27). The social base must remain precautious due to reasons of structural dependency. Failure to deliver or default tends to reproduce large scale conflicts (Joerges, 1988).

Besides the historical evidence of applying LTS and MLP in similar sectoral industries (e.g., Hughes, 1983; Gleick, 2003; Geels *et al.*, 2018) and specifically in the water industry (e.g., Kiparsky *et al.*, 2013; Blomkvist and Nilsson, 2017). The theories also have the advantage of being adaptable when studying dynamics and change (Geels, 2004). The configured approach by Geels (2004) also discusses and concludes the situational importance of distinctively analyse Socio-technical systems (ST-systems), actors and institutions. This argument can somewhat contradict the common practice in studies of science and technology, where conclusions usually emphasize “seamless webs” and the complexity of reality. However, this distinction allows exploration of the interaction between categories and entities according to (Geels, 2004; Geels and Kemp, 2007).

The LTS perspective is discussed to be particularly useful in analysing long-term dynamics. Creating a structured approach on how to map, understand and analyse a dynamic system. However, according to Geels (2004), it also enables the “black box of institutions”. It conceptualises dynamic sociological structures to understand humans’ actions while not confining space for intelligent perception and strategic action. Conclusively studies of LTS are complex, and the sociotechnical approach aids the process of understanding it better. It focuses on how innovation processes often create new sociotechnical systems by co-construction of multiple elements and technological changes. It also involves the changes in infrastructures, markets, regulations, user practices (Geels *et al.*, 2018).

2.2 The Application of MLP

In centrality, MLP is built on the claim that system changes are “governed by the interplay of factors and actors operating at different levels of aggregation and time scale” (Blomkvist and Nilsson 2017, p. 4). The analytically observed and examined levels are known as niches, regimes, and landscapes (Geels, 2004; Geels and Kemp, 2007; Geels *et al.*, 2018).

Niches refer to novelties that deviate or originate from one or more dimensions from the existing system. The novelties can be new behavioural practice, new business models or new technology or a combination of these. New radical innovation or technology may have difficulties competing in existing systems due to poor cost-efficiency or other characteristics. Meaning that specific applications, geographical areas, markets, and subsidy programs can act as a room for incubation, referred to as niches to compete against mainstream markets (Geels *et al.*, 2018).

The sociotechnical regime includes the interdependent selection of industries, consumption patterns, supply chains, policies, and infrastructure—tangible elements of the system which actors and social groups reproduce. The perception and action of these actors and social groups are the results of rules and institutions, routines, and social norms. Heuristic and rules-of-thumb are additional intangible elements referred to as socio-technical regimes, resulting in incremental change and path-dependent processes. Characteristically, lock-in effects are evident and a consequence of sunk investments in large infrastructure, skills, and factories. In addition, regulations could be perceived as favourable. They may shape all stakeholders' cognitive routines, social norms, and behavioural patterns (Geels *et al.*, 2018).

The sociotechnical landscape addresses the exogenous environment, which directly influences and implicates the niche and regime actors. What it will mean for the systems is not determined. It may implicate gradual changes through cultural preferences, demographic changes, or macro-political developments. Macro-economic recessions or natural resource depletion could also be a factor of short-term shock and could also be a source of exogenous factors implicating the sociotechnical landscape (Geels *et al.*, 2018).

These dimensions guide and orient activities of social groups. The key is understanding that the dimensions presented are interrelated dynamic dimensions and flow in all directions. The elements are co-structuring one and another. Geels and Kemp (2007) argue there is no autonomous act of actions in social groups. It is a consequence in the context of social structures and regulative, normative, and cognitive rules. The same way companies respond to problems within existing technology through engineering insights and managerial lessons. Products are embedded in consumption patterns through routines and cultural meanings (Geels and Kemp, 2007). Infrastructure largely determines the use of economics, and practices, in turn, are reproduced due to partly economics but also specific rules. The rules themselves consist of the search for heuristics and the possibility for including problem agendas, guiding principles, standards, and compliance with government regulation. It may also mean that companies and individuals acquire and feel a certain sense of attachment. It is shown that consumers develop certain lifestyles, routines and understandings which can be perceived as rules. These rules do not exist independently. They are linked together by a set of rules in a semi-coherent fashion and addressed as a regime (Geels and Kemp, 2007).

2.3 Understanding the Future Through Scenario Building

Humans are biologically built with the innate ability to perceive and partly foresee the future. The same part of the brain which controls speech is also involved with the part which governs human ballistic capabilities. I.e., the abilities to measure distances, and based on eye coordination and muscles, can launch a projectile on distance when hunting for food (Schwartz, 1997). This trait of perceiving the future has enabled humans' innumerable possibilities and opportunities. Building scenarios unconsciously or consciously enables individuals or organizations to perceive what will happen in the future to a certain degree. Thus, it will also pose possibilities to act accordingly or to respond in the best interest of the individual or organization (Ratcliffe, 2000). How one works to increase the understanding of the future will always be the question to ask oneself to have any clue or sight of the future. Despite the abundance of technology available today or the perceived knowledge of how the world's functions, one cannot with certainty claim nor predict the exact future, but individuals can build accurate scenarios, according to Schwartz (1997).

However, one of the most common way of works when attempting to understand the future is to "look backward to look forward" (Duarte, Pinilla and Serrano 2014, p. 220) or the phrase made by Deevey (1969, p.40) "Where time is required there is no substitute for history" However this poses difficulties of where to begin and what data or information shall be included. It also involves questioning whether or not prior data, knowledge, or perception of reality is adequate. Schwartz (1997) emphasizes that scenario planning is not the same as predicting the future, and complete accuracy is not the goal. Nevertheless, this still implies the concerns of Deevey (1969). At a specific time along the curve of knowledge or development, regardless of field, the present state is perceived as the absolute reality. However, one second later can be addressed as both history and ancient knowledge or technology. Hence, building scenarios will aid forecasters of the future to be flexible in the perspective of observing the present (Schwartz, 1997). Two worlds, facts and perception, constitute the process of scenario building. It explores facts but aims towards the perception of decision-makers. This process is often believed to be a process of collecting and presenting raw data from/in tables with numbers and statistics. According to Schwartz (1997), this perceived approach is discussed to lack psychological and cognitive aspects. This becomes apparent whilst communicating about the future. Conventional language of business and science are too precise to narrate the complexity of the future. Thus, enabling the need to include storytelling allows the perspective of meaning and why things happen in a certain way. Stories give order and meaning to events, which according to Schwartz (1997), are a crucial element of understanding the possibilities of the future. The scenario building process implies for the practitioner to search information narrowly to pursue and investigate facts for a specific scenario. It also poses new questions which will ultimately hone one's ability to acquire a new perception of reality. The flexibility of perspectives is critical, but it also requires the scenario planner to be aware and continually readjust one's filter not to be overwhelmed with facts, perceptions, and impressions of the world (Schwartz, 1997).

According to Schwartz (1997, p. 108), it is about "looking for driving forces, the forces that influence the outcome of events". A driving force is often highly individual, and individuals perceive and interpret driving forces based on what one knows and what one cares about. Thus, it is also sufficient for scenario planners to work in a broad context, acquiring multiple

perspectives on the posed dilemma. However, there are a few fundamental areas and dimensions of finding driving forces. Society, Technology, Economics, Politics, Environment are the five areas that could be practical starting grounds for the scenario building processes. Once driving forces are identified, the disconfirming of evidence completed, the works of uncovering the “predetermined elements” and the “critical uncertainties” are to begin. It is essential not to assume these are three separate and individual categories. They work together. However, the purpose of each has its characteristic traits. Without getting stuck in the definitions, predetermined elements do not depend on any particular chain of events. If it seems specific, no matter which scenario divulges, it can be labelled as a predetermined element, i.e., “what we know, we know” (Schwartz 1997, p. 114). The fearfulness of predetermined elements is that individuals tend to deny them (Schwartz, 1997).

Critical uncertainties exist in every plan, and scenario planners attempt to be prepared for the situation that the scenario poses. Critical uncertainties are, as mentioned previously, intimately related to the predetermined elements as they often question the assumptions about the predetermined elements. What will happen to the opposite of the most certain plausible scenario and what will the reaction be, is commonly asked when examining and identifying critical uncertainties (Schwartz, 1997). By exploring and composing the driving forces, predetermined elements and critical uncertainties, a structure can be established for building scenarios of potential futures. Establishing the long view will help individuals choose wisely since one better knows where it is heading (Schwartz, 1997).

2.4 PESTLE

PEST analysis is a management method used to investigate an organization's major external factors that can affect its profitability (Kenton, 2020). By utilizing PEST analysis, there is also the possibility to break down factors that affect the system (Carruthers, 2009). PEST is an acronym for Political, Economic, Social and Technological. Due to increased environmental awareness and lack of regulatory frameworks, two additional dimensions have been added: legislation and Environment. Thus, creating the new and extended acronym PESTLE (Kenton, 2020).

PEST analysis enables an in-depth analysis method for organisations to develop effective strategic planning (Carruthers, 2009; Kenton, 2020). In doing so, strategic planning will enable the planner to maximize the organisations’ ability to thrive under the conditions that are in place. As well it allows the organisation to be prepared for any changes that can lead to adverse outcomes. Thus, making the organisation prepared for multiple scenarios. The political dimensions of the analysis process aim to investigate the area in which governmental policies influence the organisation in question. The economic dimension of the analysis includes factors such as economic growth, supply and demand. In contrast, the social dimension of the analysis investigates factors such as age, cultural attitudes and lifestyle (Kenton, 2020). The fourth dimension of PEST analysis, technological, explores technology’s role and development in the sector or organisation. As mentioned earlier, the extension of PEST to PESTLE has a fifth and sixth dimension. The fifth dimension, legal or legislative, focuses on different legal instruments such as taxes, policies and subsidies. While the sixth dimension, environmental, focuses on areas related to nature and ecosystem, such as climate change (Carruthers, 2009; Zalengera *et al.*, 2014).

2.5 The Developed Framework

The model illustrated in figure 4 is an attempt by the authors to graphically present the theoretical and practical approach to the SOI and how the authors have perceived the system. The model could be described as a model with two overarching theoretical concepts, which is illustrated with two levels of boxes distinguished with the colours light grey and white. *Large Technical System* is the concept that defines the system characteristics and determines if the SOI is suitable for the application of the theoretical framework. *The Multi-Level Perspective* will highlight and support how system dynamics occur and the processes of change. Two rectangular-shaped and vertically located boxes are found within the large white box with a third much smaller and cubic shaped figure. The first one to the left, *LTS Dimensions, determines the more significant dimensions to investigate* to determine and identify *Natural Resource Variables* and categorize/structure accordingly. This model suggests that LTS dimensions will remain static, but NRV's are dynamic and can be substituted depending on the SOI. However, a separation of Political and Legislative is possible if the chosen SOI requires it given other system variables. Hence, through the LTS dimension, NRV's are identified. NRV's are identified by the convergence of theory and empirical data. The NRV's posed in the model could be a start or source of inspiration to initiate similar studies. With the option to add or exclude new NRV giving the specific SOI. Based on the literature findings and the empirical interview study, the compiled qualitative data will then be analysed and translated into quantitative data to understand better and categorise the specific NRV. In this study, four criteria have been chosen and formulated as following (1) Driving Effect; (2) Urgency; (3) Plausibility; (4) Evolution. Once all of the scores are summarised, the investigator/s based on the outcome. Through reasoning, given the data collected and quantified, determine which NRV will be of significance for the future and build scenarios accordingly. The criteria, Urgency, will overview and partly determine the time frame of change to happen within the system. The criteria Plausibility will determine the plausibility in implementing the option in the current system and seen as a viable option to substitute prior NRV. The criteria Evolution will be to uncover how much the NRV has progressed in terms of development and implementation in the SO.

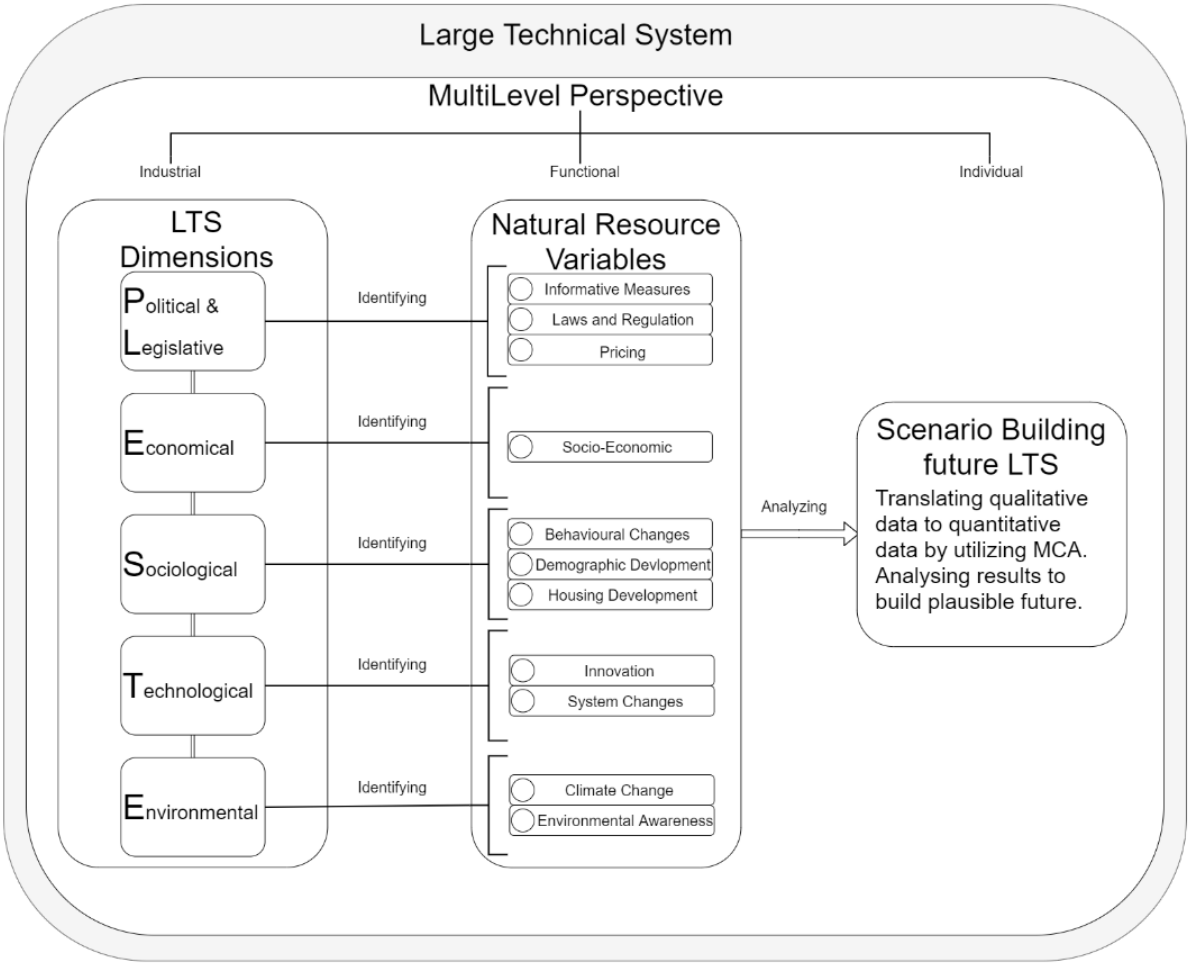

Figure 4: Illustration of the theoretical and practical approach to the SOI.

3. P(L)ESTE Review of the Water System

The chapter of this report is a review of published literature of the five dimensions of P(L)ESTE, Political & Legislative, Economical, Sociological, Technological and Environmental. By writing and proceeding from the five dimensions of P(L)ESTE, this section intends to present and discuss current and potential trends in the sector and industry of water in relation to how households use and consume water. It will also acquire a theoretical approach and present how societies have reacted to change within the water industry and in regard to each of the five dimensions. Noticeable, according to Figure 4, is the merge of the two dimensions, Political and Legislative. The authors have decided to merge the two because the authors concluded it was challenging to identify what separates the two dimensions in this specifically chosen context.

3.1 Political and Legislative

3.1.1 Pricing

Swedish producers and suppliers of water services have big societal responsibility while acting on slim marginal costs. Thus, creating a limbo of effectively price water and simultaneously secure the supply of future water consumption. The price of water is regulated based on the "Lag (2006:412) om allmänna vattentjänster" as it states that the price of water should be reasonable and fairly set while covering the cost of production and distribution. In short, the cost of principle should be applied. However, the law itself is criticized for partly being too versatile and too open for individual interpretation (Svenskt Vatten, 2006). In Sweden, the price for water and sewage taxation is a compiled sum of the cost of actual water usage, fees for using the infrastructure and the service of water utilities. In addition, there is a fee if one wants to be connected to the municipal water distribution network when building a new house, for example. However, this is a fixed cost and one-time payments, but it can vary heavily depending on regional differences (Svenskt Vatten, 2020).

In 2013 the European Environment Agency initiated a project to examine water pricing and cost recovery to ecological and infrastructural systems (Dige *et al.*, 2013). EEA itself defines Water pricing as "Applying monetary rate or value at which water can be bought or sold" according to its glossary (*European Environment Agency*, 2021, p16). However, this definition is revised and broaden in the project (Dige *et al.*, 2013). Water pricing is discussed according to the definition of Bogaert *et al.* (2012, p16) as "water pricing refers to monetising the abstraction, use or pollution of water".

In 1984 Millerd (1984) published an article discussing that the price of water is the best method to manage water demand, but it is rarely used. Something that, e.g. Sibly (2006); Ayoo and Horbuyluk (2008) years later confirms. However, the conclusion of Millerd (1984) is based upon multiple studies conducted in Canadian municipalities. Millerd (1984, p. 8) states that "price performs two essential roles in a market system, rationing and production motivation". Due to the scarcity of freshwater globally and the fact that there is only a given amount, the role of rationing is far more tangible in the context of freshwater. Thus, scarcity precludes both unlimited production of goods and services but also the satisfying of all needs. Hence, goods

and services must be rationed to consumers, and producers must oblige to the factors of production. Therefore, the price system allows bids for scarce goods, services, and production factors, thereby ensuring that goods and services are allocated to the highest bidders. The use of production factors is allocated where the return is the largest. Hence, the price has the role of motivating and indicating what consumers are willing to pay for a service or a good. The producers then react to this and direct their production towards where the return is the largest and products most profitable (Millerd, 1984).

Additionally, Millerd (1984) also addresses the relevance of the suggested four principles for effective pricing structure earlier stated by Mann and Lefrancois (1983). Firstly, prices should be equal for all customers. Secondly, beneficiaries of publicly produced goods and services shall pay all the cost of producing the goods and services. Thus, it will aid in restricting increased consumption and overinvestments. Thirdly is marginal cost pricing, meaning that if an individual or group would impose an extra cost on the system, the individual or group should be held accountable for the additional cost. Lastly, the prices should reflect the cost of all inputs consumed for producing the good or service, both the cost imposed by the market, labour, and material and the external cost to the market, for example, pollution. This system would accurately reflect the reality of costs and seasonal variations, meaning that customers/beneficiaries would be accountable and increasingly more involved in the market and actions and consequences are far more visible, according to Mann and Lefrancois (1983) and Millerd (1984).

However, the practical implication and applications were not yet administered in the mid-1980s (Mann and Lefrancois, 1983; Millerd, 1984). In the articles of Mann and Lefrancois (1983) and Millerd (1984), it is not explicitly stated if water should have a monetary value and be traded as an economic good like most natural resources. Based on the market fundamentalistic belief that the market will set a fair price of water. Alternatively, that the current pricing system itself did not effectively price the water for the consumer. As a result, producers were financially bleeding while consumers got great discounts on water (Food & Water Watch, 2010). The latter system, where prices are set to cover production and distribution cost, is often referred to as administered prices (Ayoo and Horbuyluk, 2008).

Hence, trading water as an economic good raises a polarised debate. One side promises great potential in coping with demand based on the market fundamentalistic belief (Mann and Lefrancois, 1983; Millerd, 1984) that the market will set a fair price of water and regulate demand (e.g., Zarnikau, 1994; Sibly, 2006; Ayoo and Horbuyluk, 2008; Savenije and Van Der Zaag, 2009). It will also encourage consumers and producers to invest in water-efficient technology to reduce consumption since water price saving marginals increase (Libecap *et al.*, 2012). The other side claims that it will lead to price dispersion and discrimination (e.g., Adams, 1997; Yoskowitz, 2002; Food & Water Watch, 2010). Food & Water Watch (2010) claims that water pricing is a mirage and cannot solely reduce residential water usage. The assumption that households will reduce consumption when faced with increased prices is falsely presented. Concluding that strategies for managing demand are more effective than price adjustments while not excluding those negative incentives for consuming unsustainably. Restricting water usage during droughts, positive incentives to encourage adaptation of new efficient technology and water fixtures are proposed as better and more effective water management measures to reduce water consumption compared to increasing the price of water (Adams, 1997; Food & Water Watch, 2010).

Yoskowitz (2002) shows, based on evidence from Texas, that trading a homogeneous product do results in price dispersion and price discrimination, puncturing some of the early arguments raised by Mann and Lefrancois (1983) and Millerd (1984) of creating a fair market. The study by Yoskowitz (2002) also confirms the previous research conducted by Adams (1997). Both authors raise the concerns of the indifference in information supply and the skewed distribution of information which can be advantageous for someone. Hence, regardless of the product being homogenous, firms explicitly discriminate, and for consumers to understand the market much resources must be invested for both learning the market and to search for lower purchase prices meaning that the final cost could eventually exceed the initial price (Adams, 1997; Yoskowitz, 2002; Food & Water Watch, 2010).

Some publications oppose the evidence of Yoskowitz (2002) and Smart *et al.* (2017), meaning that spot market pricing of water has increased farm productivity and the financial gains in the markets of the Murray-Darling Basin of Australia and the Western U.S. are substantial (Libecap *et al.*, 2012; Wheeler *et al.*, 2013). Important to note is the two terms agriculture and farming, a big consumer of freshwater and industry which have for long not fully understood the value of water (Yoskowitz, 2002). However, the water market has effectively relocated water among users without negative environmental consequences and increased the awareness of water scarcity in the Murray-Darling Basin. Achieve a majority of the purpose. Still, the system also requires adjustments to fulfil its full potential. There are the implications of strategic trade issues that can lead to market failures. The system itself must be more flexible and adaptive, and policy changes to better support the sustainable aspiration of Murray-Darling Basin (Wheeler *et al.*, 2013). Tisdell (2001) agrees that the future of water markets must be revised to achieve its full potential. The system has also aided the relocation and purpose of water extraction, and where farming has adapted its production accordingly. However, Tisdell (2001) opposes the environmental impact which this system has caused, to note the gap of 12 years between the publication of the article by Tisdell (2001) and Wheeler *et al.* (2013).

Observing international literature, there are implemented examples of new pricing structures for water management and demand control. For example, there is the strategy of Willingness to pay-principle, which has been applied and studied in the Ethiopian city of Godey. Compared to the old structure where the government manages the taxes and transfers, the new pay structure enabled regional management of cost recovery and better allocation of water pots. In addition, it was predominantly preferred as it allows consumers to only pay for water which they are consuming and according to welfare status. At the same time, it also enabled local decision making (Kayaga *et al.*, 2018).

In China, where water resources per capita are continuously becoming scarcer by day, Jiang et al. (2010) proposed that urban water resource quota management will be a core strategy. According to Jiang et al. (2010), the strategy has made remarkable contributions in transforming the pattern of water mode. While also strengthening the water management initiatives and integrating new and various management methods for water-saving incentives and pollution prevention. The index quota system considers several factors such as quantified quota indicators, a definition of a user's reasonable scale of water usage calculated from factors as water intake per capita, or per area, or per product in unit time while also including factors of water-saving measures. According to Jiang *et al.* (2010), the most optimal and perfect water quota system is composed of six essential elements.

1. A multi-tiered system
2. The category
3. Grades
4. Type of water sources
5. Accounting factors
6. Accounting units.

The implementation of such a quota system has proved beneficial in both industrial and domestic sectors. However, regarding the domestic sector, most of the cities have instead chosen the path of the “ladder water price” as a preparatory stage before implementing the more meticulous water quota system (Jiang *et al.*, 2010).

Determining which pricing structure will be the most optimal and implemented will be difficult. However, economists have concluded that water demand is relatively price inelastic. Thus, making a complex case of water. Price inelasticity refers to water demand responding disproportionately to price changes (Inman and Jeffrey, 2006). In practical terms, the decrease of demand is lower than the increase in price (Corbella and Pujol, 2009). Hence, the conclusion which Inman and Jeffrey (2006); Corbella and Pujol (2009) draws mean that price mechanism in the context of water pricing will not results and correspond as anticipated if consumed water is close or equivalent to the perceived quantity of water necessary for fulfilling basic and essential needs (Corbella and Pujol, 2009). However, there is an additional perspective of this, according to Corbella and Pujol (2009). Suppose prices do not target consumption for basic and essential needs. Instead, it is targeted towards additional consumption, for example, outdoor use, i.e. filling pools. In that case, water gardening tends to be more price elastic and could be a potential area of importance when structuring new water pricing structures (Corbella and Pujol, 2009). These examples are collected from international literature and originate predominantly from Australia and the united state of America, where drought is an increasing nationwide problem and consumption trends are increasing (Food & Water Watch, 2010).

Many argue that the price of water is too cheap in Sweden and the Nordics (Mahmoudi, 2017; Rohrdrommel, 2017; Holm and Schulte-Herbruggen, 2021; IVA, 2021) and globally (Maxwell, 2010; Dige *et al.*, 2013; Donnelly, Christian-Smith and Cooley, 2013). Essentially there is a need to effectively price water better for it to reflect its actual value. Hence, in most free markets, the price reflects the value of the commodity (Maxwell, 2010). This is not the case with water. However, it can with a high certainty be declared that the future price of water will increase and specifically in areas where water becomes scarce as populations grow and consumption per capita does not change drastically. Hence, the conclusion by Maxwell (2010) despite the modest data and genuine interest in past and future water price trends, the price of water will most certainly increase in the future partly based on the fact that water as a commodity is heavily undervalued but also the fundamentalistic trinity that demand and supply will adjust the price (Maxwell, 2010). Whether the price will adjust the consumption of water per capita is highly uncertain, and net consumption will naturally increase. The potential efforts in improved access to water as in efficiency, storage, and infrastructure will likely increase demand and production and pressure freshwater sources (Ercin and Hoekstra, 2014).

3.1.2 Laws and Regulations

Changing human behaviour and perception of water can be done through many different measures. One way may be through policy change, which could be either locally or regionally. As policies change, they can restrict individuals in that the boundaries can be narrower (Abbott *et al.*, 2019). Thus, creating restrictions on how individuals can behave and consume water.

In 2013 a case study in Spain was initiated to understand the effectiveness of environmental taxation and industrial water use further (Giménez and Zárate-Marco, 2013). The study itself was influenced by the pilot study conducted by European Environment Agency in (2005). According to the authors of the report, the sample size of Denmark, Estonia, France, Netherlands, Spain, and Poland was deemed representable. Motivated by two of them did largely comply with the directive, two that did not and two that must comply by the year 2010, as they have only recently joined the E.U. at the time.

What could be concluded by the report by Dige et al. (2013) are plentiful, one being that relatively few E.U. member states have implemented a transparent recovery of environmental and resource cost. Which states they are referring to is not explicitly stated. There are member states which have implemented environmental charges/taxes on abstraction/pollution to internalize parts of current environmental and resource costs. However, most are financial instruments that are instigated to generate revenue to support water policy implementation and grid expansion. Overall, the need for growing awareness for cost recovery and incentive pricing to harmonise. As well as create a functional concept of cost recovery implemented in the water policy of European members state is yet unachieved. Regardless, the efforts of Article 9 and Water framework directive to oversee and support member states to declare KPI:s and indicators for benchmarking transparently. In the attempts to increase educational knowledge and exhibit the importance of water as a resource and the unsustainable approach of today (Dige *et al.,* 2013).

Giménez and Zárate-Marco (2013) report suggest that economic instruments and specifically environmental tax on industrial discharges were the most optimal option for protecting the environment. It was observed that the economic instrument was superior to the command-and-control instruments. This was also suggested and consider in the studies of (e.g., Stavins, 2001; Kraemer *et al.*, 2003; Mattheiss, Mat and Strosser, 2009; Strosser *et al.*, 2009; Lago and Möller-Gulland, 2012). They were concluding that economic instruments contra command-and-control instruments in the water industry is far more effective. Since they internalise externalities by introducing a fee or additional costs in the price of output and emissions (Giménez and Zárate-Marco, 2013), it statues the principles of The polluter pays which was first introduced in 1975 by OECD (OECD, 1992) and updated and revised in recent years (OECD, 2008).

Economic instruments are more effective in the industrial setting of water use and wastewater removal based on the arguments and data raised by Kraemer *et al.* (2003); Lago & Möller-Gulland, (2012); Mattheiss *et al.,* (2009); Stavins, (2001); Strosser *et al.,* (2009). However, the same principle of behaviour may not be applicable in residential water usage, which Giménez & Zárate-Marco (2013) highlights in their study. Giménez and Zárate-Marco (2013, p. 134) discuss that environmental management strategies should be “utilised in a harmonized manner”, meaning that there is not one solution that fits all and requires multiple tools

instruments to achieve a sustainable living, consumption, and production. Each having strengths and weaknesses and depending on the surrounding economic, social, and institutional circumstances and welfare. For example, the availability of monetary funds, the status of the internal market and citizen awareness over environmental issues (Giménez and Zárate-Marco, 2013).

Giménez & Zárate-Marco (2013) also raises a necessary differentiation between economic and financial instruments in the context of water use. The authors utilise the previous work of Horbulyk (2005) and Cantin, Shrubsole and Aït-Ouyahia, (2005) to distinguish between the two instruments, economic and financial. Economic instruments, in broad, provide the incentive to change behavioural patterns, in contrast to the orientation of financial instruments, which are to recover cost and can therefore not significantly influence the actions and choice of water consumers (Giménez and Zárate-Marco, 2013). Hence, Horbulyk (2005) emphasizes the significance of differentiating between the goals behind different pricing strategies, which means that cost recovery and efficient pricing are two objectives and may require different types of instruments.

As there has been a rising tide of knowledge on sustainability, so has the need to affect positive environmental outcomes directly. For water consumption, this has meant a reduction in consumption through green buildings. There is also the incentive to build green housings as evidence suggests greater financial returns (Devine and Kok, 2015). In the U.S., a home certification called WaterSense is put on products to indicate that they are water-efficient (*US EPA*, no date-a). Someone trained and skilled must evaluate and verify that the home can get the verification to get a certificate. There are also updates done to the WaterSense Home specification that the home verifier must be aware of to offer a certification(*US EPA*, no date-b).

3.2.3 Informative Measures

The idea to inform the public on correct action and accountability in everyday water consumption must be rooted in social and psychological aspects to be successful, according to Seyranian, Sinatra and Polikoff (2015). Societal entities must understand why the different societal patterns are in a certain way to implement appropriate informative measures for effects. The primary strategy to communicate with consumers is through various outreach programs. The main goal is water conservation by informing individuals of the water scarcities and encouraging them to act sustainably. It could be sufficient to declare the difference between water conservation and water efficiency in this section (Water Footprint, 2018; Waterless, 2019). Water conservation is the beneficial reduction in water loss, waste, or use (Vickers, 2001). An action that is often imposed and requested by governments or governing bodies during droughts. However, the action is often criticized for only being applied and utilised in short-term perspectives, but it does perform effectively in its short-term purpose (Waterless, 2019). Water efficiency is the minimization of the amount of water used to accomplish a function, task, or result (Vickers, 2001). Oppositely to water conservation, water efficiency often seems as the long-term strategy of reducing water. Previously discussed in this study, as the most applied and performance-oriented approach (Linkola, Andrews and Schuetze, 2013; Yang *et al.*, 2017; Water Footprint, 2018; Waterless, 2019).

However, there is also a gap that is occupied with mistrust between individuals in society and governmental entities (Burgess, Harrison and Filius, 1998). This mistrust towards political decisions and agendas regarding environmental politics is often interfered with and replaced with suspicion through mass media coverage. Burgess, Harrison and Filius (1998) claim that this can be counteracted through a higher knowledge of the environmental dilemma at hand, grounded in a more profound knowledge and uncompromised coverage of what is required to act sustainably. Thus, creating a higher understanding of the effects of water scarcities and unsustainable daily water activities. The individuals of the society will understand the importance of the measures communicated by governmental entities. The proper channels of communications have to be implemented independently and accordingly to the current environmental situation. As there are periods when water consumption is higher or higher relative to available water, there have to be informative measures to deal accordingly because of several factors such as higher temperature and increased risks of water depletion. There also has to be proactive work of informative measures to prevent similar situations to occur in the future (Burgess, Harrison and Filius, 1998). The study by Seyranian, Sinatra and Polikoff (2015) also concluded similar thoughts as Burgess, Harrison and Filius (1998). That informative measure alone is not sufficient for a positive effect if there is a deficit in knowledge by the inhabitants. However, Seyranian, Sinatra and Polikoff, (2015) argue for this to be a globally chronic misconception in how to work and approach individuals and is suggested by the authors to be counterproductive (Seyranian, Sinatra and Polikoff, 2015). There have to be the proper information channels to create awareness for young and older people alike. Water Research Foundation made a study of how social media can be a channel for information about water and wastewater utilities (The Water Research Foundation, 2017). The research showed how social media could be used for different purposes, such as crisis communication and the opportunities to reach consumers instantly.

Furthermore, the study by Linkola, Andrews and Schuetze (2013) showed that the agents simulated in their research have a minimum level of consumption based on their current habits and the technology available. The introduction of campaigns for water-saving did not show a significant difference in consumption. To make a difference, the agents have to reduce their showering by taking shorter ones which could be an informative measure. However, it requires individuals to act according to the information at hand. This means that the lower the water usage level is, relative change will decrease while it will increase the effects of the individual's behaviour. Another factor that affects an individual's behaviour is technology. The technology put in place can enable the user to consume less or more water. It gives the users a set of parameters to work within. It is essential that the water-efficient technology also appeals to the consumer. If not, information should be communicated to shift and establish new perceptions of default (Linkola, Andrews and Schuetze, 2013).

Another dimension of value is the reuse of wastewater and the perception of using and consuming purified wastewater. Wastewater purification is a critical factor in conserving water in the future while also minimising pollution. Making individuals realize that water, even if it is waste, has some value and is an asset. With the right initiatives to include the social dimension of the water usage problem, there can be a great outcome. The social relationship between water and waste can be improved. It is essential to create that connection between the two entities that is nature and mankind (Stuart, 2007). To understand that water in all forms and sources is of value, such as rainfall or purified wastewater. If there is an evolution in the water

infrastructure, there can be a better understanding of how water should be treated for the better. This, in the term, could lead to defamiliarization of infrastructure and new defaults. To ensure this is to make society realize what the infrastructure looks like and functions, like how wind turbines are known. It is proposing new ways of communicating with consumers and understanding the value of the system and infrastructure. To make this familiar, information must be available to society to devour (Svenskt Vatten, 2007). This can be enabled through education and informative strategic measure rooting in a long-term perspective on shifting societies perception. Education itself can be enacted as a tool for overall recognition of the state of the water sector (Stuart, 2007; Svenskt Vatten, 2007). By increasing the education about the state of the water sector, there can be a possibility of decentralisation and a higher awareness of how to positively contribute (Stuart, 2007).

3.2 Economy

3.2.1 Socio-Economic

Duarte, Pinilla and Serrano, (2014) identifies multiple reasons or as he refers to, as effects coupled to increase water usage and overall exploitation. The two most economically prominent effects of the intensification of residential water usage. Firstly, the rapid development of urbanization, which have increased the facilities and amenities that people enjoy. Secondly, the increased water demand has logically and gradually increased water provision, increasing the water consumption itself. Besides presenting this cause and impact, Duarte, Pinilla and Serrano (2014) also explain why economic growth is a central explanation in understanding increased water consumption trends by geographical and temporal differences. Something observable in developed countries in Europe during the first half of the twentieth century when industrialization was pioneering, and economic growth was distinctive. Shifting a focus to Asia, it was not until the second half of the twentieth century when per capita income was more decisive than population growth (Duarte, Pinilla and Serrano, 2014). Duarte, Pinilla and Serrano (2014) also present an observation of system change in the European industrial sector during the 1990s when capital resources were abundant. The adoption rate of recirculating water systems showed reducing effects on water consumption. Collard *et al.* (1988); Jänicke *et al.* (1997) continues this perspective and reasoning of Duarte, Pinilla and Serrano (2014, p. 219) *"Looking backwards to look forward"*. However, they do not discuss the resource of water, but parallels can be drawn between the energy sector. They suggest that the economy's composition is an essential factor when examining historical patterns, addressing structural changes in new cost structures and policy changes, and technological developments. Hence, Duarte (2014) raises the thought that the intensification of water consumption due to urbanization may be a phase before the latent power of efficiency is implemented, and water consumption per capita is reduced.

Duarte, Pinilla and Serrano (2014, p. 218) present the *Income effect,* and wrote *"*increase in per capita income has been one of the most important economic facts during the last two centuries". After the 1980s water withdrawal rate slowed down after years of sharp rise. Reasons being the rapid upturn of population growth and GDP combined with the intensification of agriculture and industrialization. A gradual increase in living standard could also be one reason, according to Duarte (2014), while concluding that it is reasonable to expect that the economic development and its effect or efficiency improvements can have

exerted influence on water use. However, Beckerman (1992) also raises the dilemma of developed countries in the early1990s having difficulties adapting to the rapid change caused by urbanization and exceeding population growth. Something that can be observed in today's developing countries, according to Duarte (2014).

Beckerman (1992) was early in discussing a positive correlation in the medium to long term time frame of increased income and increased access to water supplies. Hence, the weight of which water has to the economic development of nations is indisputably immense (Beckerman, 1992; Duarte, 2014). Climate change is estimated to cost the global economy up to 20 % yearly in the worst case. However, if a more moderate estimation of risk and impact is considered, the annual loss due to global climate change is estimated to be 5 % of GDP (Nordhaus *et al.*, 2006). In a report made and published by Stockholm International Water Institution, SIWI confirmed the positive correlation between increased national income and the proportion of the population with access to the improved water supply. Quantifying it by a 0.3 % increase in investment in household access to safe water associated with a 1 % increase in GDP (Sanctuary, Tropp and Haller, 2005).

However, according to multiple studies in Sweden, the big residential consumers are individuals with good socioeconomic belonging (Nikell, 1994; Mahmoudi, 2017; Hammarlund, Törneke and Siegwan, 2020). A Dutch study partly opposes these findings. Individuals with a stable economic situation tend to work more, spend less time at home, eat out, or eat takeaway while also using bathroom utilities up to 50 % less. These findings are based on the results of Agent-based modelling, thus highly dependent on input variables and data collection points (Linkola, Andrews and Schuetze, 2013).

3.3 Sociology

3.3.1 Housing Development

Depending on what type of house, e.g., townhouses, apartments or detached houses, combined with the demographic dispersion of individuals that live on the property and building year, certain assumptions can be made on how they affect water consumption. A study made by the Market Transformation Programme (2008) in the United Kingdom concluded that the water consumption per household in newer houses was lower compared to older houses. The difference in consumption is discussed due to available technology and general building techniques for resource-efficient housing (MTP, 2008).

A detached house often implies using water in a greater range and for external purposes. External purposes are usually defined as watering gardens or lawns, car washing, refiling and maintaining swimming pools (Randolph and Troy, 2008). Thus, giving the owners more rationale to consume water and, therefore, habitually increase water consumption. However, the research done by Randolph and Troy (2008) in Sydney, Australia, showed that per capita. Therefore, there is little influence on the individual average water use depending on if the individual lives in a house or an apartment. Another similar study made by Domene and Saurí (2006) in the metropolitan region of Barcelona is contradictory to the one made by Randolph and Troy (2008), as it concludes two factors having an effect on water consumption. One being household size and the other being housing type (Domene and Saurí, 2006). The study

concluded that in this region, smaller families consume more per capita than bigger families. The different conclusion can well be based on the difference in geographical location and cultural differences where the study took place. Furthermore, the study made by Linkola, Andrews and Schuetze (2013) showed a relatively clear pattern of how the household consumes water depending on factors such as how many people live in the residence and time spent at home. The study showed that individuals who spend 50% less time in their house would use 50 % less water in their kitchen and bathroom. Regarding how many people who live in the residence, it is often discussed that the consumption per capita usually decreases with increased residents. This is an effect of consumption being divided between more individuals. However, total consumption volumes are often higher (Linkola, Andrews and Schuetze, 2013).

It is also discussed in the literature that the determination of water change patterns can be a result of how the individuals relate to their own household and water consumption. A green and thriving lawn, a clean house facade and windows indicate that you take care of your property. It also increases consumption, thus requiring saving water in other instances. The communities the individuals live in will also be a determining factor of water consumption. The perceived and constructed social norms and how society around the individual treats water consumption issues will affect consumption since the risk of moving from the norms and creating feuds is not attractive. The neighbourly feeling of belonging to a community is perceived as necessary. This relationship and community may not be duplicated in areas where most housing consists of apartments, where it is perceived that everybody minds their own business and little insight is offered in one's life compared to a detached house with a garden, for example (Gilg and Barr, 2006; Randolph and Troy, 2008).

As the population grows and urbanisation expands, adequate housing and strategically planned urban areas combined with a supportive infrastructure will be essential (Kedir and Hall, 2021). Life cycle analysis (LCA) is a commonly applied tool for assessing the environmental impact of housing projects. Studies are starting to incorporate measures of resource efficiency once the housing is established and not only during construction (Lavagna *et al.*, 2018; Kedir and Hall, 2021). General perceptions are that residential buildings require more resources and space compared to commercial ones. Apartments are seen to be one of the solutions of building more residents requiring lesser space while increasing the economies of scale for pilot projects of sustainable and green buildings (Kedir and Hall, 2021). This has invited many potential possibilities in Industrialized Housing Construction (IHC) concepts, where resource efficiency is a top priority during the construction phase and through the usage phase. The study by Kedir and Hall (2021) concluded that customers' Willingness to Pay (WTP) is based on what the customer is paying for. Green building, i.e. building with LED lights, water-saving technology, and general materials selected based on their sustainable features, increases the WTP compared to prefabricated elements, which tends to lower the WTP. Thus, it was concluded by Kedir and Hall (2016) that customers do not value resource efficiency in the shape of industrialized production methods. Still, customers perceive value in resource efficiency in the finished product where it is more visible. Hence, the potential of better visualising impact and contribution through the choice of products for the end-consumer will be an essential part of creating value for the customer (Kedir and Hall, 2021). In Sweden, during the last 20 years, on average, two times as many apartments are built compared to detached houses. Over the previous five years, the number has risen to approximately three times as many apartments compared to detached houses (SCB, 2021). Hence, the concerns

and conclusions of Kedir and Hall (2021) are adequate to consider since it is indicated in studies (e.g. Domene and Saurí, 2006; Randolph and Troy, 2008) that individuals living in apartments usually have a higher per capita consumption that individuals are living in detached houses. The MDWC difference between a single household and a four-person household could be as high as 75% (Mudgal *et al.*, 2009).

3.3.2 Demographic Development

There is reason to believe that the changes of a population and an ageing society will influence water consumption (Schleich and Hillenbrand, 2009). This means that the older the age of individuals in society becomes, there is reason to believe that individual water consumption increases. It relates to retirement and how these older individuals are busy gardening, increasing consumption, health reasons increasing consumption and their impaired ability to move agile (Schleich and Hillenbrand, 2009). According to Bates et al. (2008), population growth, which is one of the current stressors of water consumption, will be worse with climate change. Another stressor will be urbanization, and its already damaging impact will be even worse with climate change (Russell and Fielding, 2010). The study made by Russell and Fielding (2010) suggests conflicting results in the literature. Some research indicates that older people conserve water, while there is also research that presents the opposite. Some research could not find any statistical correlation between water consumption and age, while others referred to different age groups water consumption levels, according to Russell and Fielding (2010). The various research suggests that identifying a clear correlation between a person's age and water consumption is complex. It is suggested in the study by Russell and Fielding (2010) that the relationship between age and water conservation can not be characterized linearly, but rather a function of demand of a person's stage in life, its experiences within its generation as they can vary depending on generation. Different generations may consume water based on how they perceive technology in relation to their needs (Russell and Fielding, 2010).

3.3.3 Behavioural Changes in Water Usage

The sociological aspect of water consumption in households would mean studying human behaviour regarding the consumption and usage of water within their households (Linkola, Andrews and Schuetze, 2013). High water consumption within a household can be the result of a multitude of factors, factors that can enable both positive and negative behaviour. If there is an imbalance between the economic incentives, technological and socio-cultural, it can lead to wasteful water consumption (Linkola, Andrews and Schuetze, 2013). The current water infrastructure in developed countries has made it simple for individuals to take water for granted (Stuart, 2007). People in developed countries expect drinkable water in an instant. However, there is an overall consensus and recognition of global water scarcity (Distefano and Kelly, 2017; Stuart, 2007). The hidden infrastructure may be the reason for this since it conceals most of the value chain and processes from raw to drinkable water. The concealment of the infrastructure also makes it difficult for the human eye to trace, understand and grasp the volumes consumed. Furthermore, to uphold society's well-being and ensure that everything runs smoothly, access to water is a prerequisite. Not only for consumption but also for additional activities, making individuals maintain a particular lifestyle (Stuart, 2007).

A study made by John W. Cary (2008) in Australia suggested that demand management has become critical for water scarcity. A way to minimize consumption is through the act of voluntary choices (Cary, 2008). For involuntary choices, it is the opposite where individuals have to comply with some prerequisites made by the government or other institutions. Thus, regulating individual's behaviours through different policies and laws. However, voluntary choices are primarily enabled through different informational campaigns for educational purposes on the subject. Change in choices means a change in behaviour towards the water (Cary, 2008).

There have been two broad models on human behaviour used to promote conservation in the environmental sector (McKenzie-Mohr *et al.*, 1995; Cary, 2008). The first being the rational-economic model or the rational choices model as it is called. This model has the assumption that to influence natural resource conservation decisions. In addition, there must be an incentive of financial or performance gain. The second model, the attitude-behaviour model, is that the attitude towards a subject affects an individual's behaviour. Therefore, there must be an influence and change on the individual's attitude (McKenzie-Mohr *et al.*, 1995; Cary, 2008). The understanding of water conservation influence can be through dividing it into internal and external influences. Internal influences can be attitudes, values, habits, personal norms, psychological motivation, emotion and need for status and identity. External influences can be incentives, financial and regulatory, institutional constraints, and social practices (Cary, 2008). According to John W. Cary (2008), there are many variables that the water industry must focus on for a reduction in residential water consumption behaviour. The variables are the environment of the water delivery, the individual's behavioural intention, the individual's capacity to act and respond, what the water industry anticipate the outcome will be of the changed behaviour, the attitude toward water conservation, the norms of the community towards water conservation, the amount of strength and social support for the current habits as well getting a positive emotional response from the individuals (Cary, 2008).

Furthermore, there is a need to raise awareness and act accordingly, i.e. being resourceful towards natural resources. Water usage can be a product of socio-economic placement since there is a correlation between water usage and culture. The dilemma of water usage is looked at from the perspective of living situation, the number of individuals in the household, the individuals' occupation, and their behaviour towards water (Linkola, Andrews and Schuetze, 2013). The idea of socio-economic status places individuals in different socio-economic categories. If individuals are in a similar category, they often act similarly. However, an individual's action is determined by their experiences and therefore connected to, among other things, to their culture. Culture and economics in this context are similar. However, they have a different perspective regarding this issue (Oosterbeek, Scheunemann and Santos, 2013). It must be recognised that individuals act after their cultural understanding of the environment and economics. An individual's adaptation to different circumstances regarding the environment is based on their acquired knowledge of which culture also affects (Oosterbeek, Scheunemann and Santos, 2013).

3.4 Technology

3.4.1 Household Innovations

Technological advancements for the consumers and residents can be labelled both vast and improving. The two most notable trends in technological adoption are the installation of water-efficient appliances and faucets, explicitly resulting in lower consumption since daily needs and activities require less water consumed (Linkola, Andrews and Schuetze, 2013; Holm and Schulte-Herbruggen, 2021). The second trend is the increasing adoption rate of intelligent watering metering, which may not explicitly reduce water consumption. However, it has shown a strong connection between awareness of water consumption and reduced consumption (Beal and Stewart, 2014; Gurung *et al.*, 2015; Yang *et al.*, 2017).

Stuart (2007) reflects on humankind's perception of "technological fixes" highlighting the active choice of the consumer when determining which efficient product to purchase and install. However, once installed, little reflection of its impacts when utilizing the product is reflected upon by the consumer. On the one hand, Stuart (2007) reflects upon this topic as these appliances have a "tendency to automate environmental improvements" (p. 422). In contrast, Stuart (2007) highlights that the consumer did take the active choice of choosing a specific technology over another one. These types of suboptimization are often happening across multiple industries where the root cause is not directly addressed. However, the implementation is partly adequate for the results and required efforts (Hitch, 1953).

Technology is mainly discussed to help humanity reduce consumption. However, it is essential to consider the rebound effects of new technology and initiatives of the government. Examples can be withdrawn from the agricultural industry, where water conservation has always been a topic of discussion (e.g., Beckerman, 1992; Bogaert *et al.*, 2012; EurEau, 2017; McCarthy *et al.*, 2020). Ward and Pulido-Velazquez (2008) proposed that water-efficient irrigation technology within the agricultural industry and the constant urging matter of water conservation may have been a zero-sum game or even having opposite effects. Meaning that water consumption as a result of active implementation of new technology to reduce water consumption has increased. Farmers identify new business opportunities to sow and reap more water-intensive crops while increasing water consumption and financial returns. Water is used more efficiently, but overall consumption increases. Same conclusions are drawn by Berbel *et al.*, (2015); Freire-González, (2019); Paul *et al.*, (2019). The subject is justified to be discussed since what would happen if similar effects of residential water consumption are repeated. Consumers take the active choice of purchasing and installing water-efficient appliances and faucets which consume less water per minute or water per usage. However, it also induces and justifies in the eye of the consumer to take longer showers, being more wasteful and reckless in the way they consume and use water. Imprinting the false delusion that every time the consumer uses water-efficient technology, the world becomes a better place (Stuart, 2007).

However, existing literature discussing potential rebound effects coupled with residential water usage is non-existing despite the selection of published literature discussing water pricing and the modest selection of how new technology will aid the management and reduction of water consumption. In general, much innovation and technological development have been

introduced and adopted within the energy sector and in households. Contrary to the more modest technological development and adoption rate within the residential water sector (Potts, 2009; Kiparsky *et al.*, 2013; Spiller *et al.*, 2015). The enormous sectoral and long-term transformation of the electricity system is mainly based on renewables, and the fact that the system capacity has reached thresholds and demand is increasing (Smith, Voß and Grin, 2010; Markard, Raven and Truffer, 2012). However, these symptoms are not industry-specific, and the same symptoms are shown in the urban water system, but fewer initiatives are taken in the urban water system (Gleick, 2003; Kiparsky *et al.*, 2013).

3.4.2 System Changes

The article by Stuart (2007) claims that water is seen as a vehicle to transport waste by consumers, as it transports domestic, industrial and agricultural waste into the sewage system. In doing so, the water becomes viewed as waste in certain circumstances and perspectives. As society evolves at the current pace, the need for water becomes increasingly more significant while the amount of raw water availability. There are also ideas to achieve a sustainable water balance, a unity between thinking ecological, local decision-making and having the right technology (Stuart, 2007). To enable resource awareness, one must be in touch with the current technology and understand its relationship with nature. How one can affect the other becomes a central theme for sustainability, it can encourage ecological consciousness. With the correct infrastructure and technology, there can be changes in the urban consuming patterns and industrial epistemology (Danielopol *et al.*, 2003; Stuart, 2007).

Nevertheless, it is also addressed in sparse literature that a system change will induce additional behaviours towards economic water consumption. Besides the savings in overall water usage, wastewater is more efficiently treated in a circular system, increasing overall societal sustainable thinking (Stuart, 2007; Linkola, Andrews and Schuetze, 2013). Stuart (2007) and Linkola, Andrews and Schuetze (2013) propose that practical acts of system owners will highlight the system's inefficiency and hopefully increase sustainable awareness and behaviours of consumers. Leakage has been a major talking point within the Swedish water utility sector and the public awareness of water as a good. Arguments as such, since producers and distributors do not take responsibility for fixing leaking pipes. Reducing the amount of pure drinking water discharging into the soil due to broken pipes contributes to the unwillingness of the consumers to take their responsibility (Jernberg, 2007; SVT, 2009; Brantemo, 2017; Ringqvist, 2021).

Kiparsky *et al.* (2013) argue that this innovation deficit in urban water systems results from multiple reasons. The inherent inertia of not wanting to change, creating a difficult path ahead due to increased awareness of the environmental impact and distressing watermarks. The urban water systems ability to adapt to the change is argued for only being sufficient to a certain point. Furthermore, urbanization and increased expectations of the system will put significant pressure on the infrastructure. According to Kiparsky *et al.* (2013), novel concepts have been proposed to enable radical change in urban water systems. However, the response of such action has historically been reluctant (Gleick, 2003; Kiparsky et al., 2013). Gleick (2003) was the first to advocate the “soft path” solution as the proposed superior solution for handling future demand and ecosystem changes. After the publication of Gleick (2003), multiple authors have continued and developed the arguments (e.g., Potts, 2009; Kiparsky *et al.,* 2013; Spiller *et al.*, 2015)

“Soft path” solutions propose a conceptual shift towards a focus of water-related services, transitioning from the “hard path” of massive, centralized infrastructures as dams, aqueducts, pipelines, and complex treatment plants. This infrastructure is arguably and evidently a fundamental reason for the welfare development of the world. However, it has also caused detrimental damage to ecosystems and unquantified economic and social costs (Gleick, 2003). This long and historical focus of the “hard path” has led to systemic damage, i.e., over-dimensioning and overestimating consumption trends. The consequences of these have yet not shown their true colours since the over capacity of the urban water infrastructure is abundant. No direct problems until the millennial shift, problems started to divulge, and matters became urgent and actual due to increased climate awareness and exponential growth in population and social welfare. The supply and production of water could not meet the demand (Gleick, 1998; Kiparsky *et al.*, 2013; Spiller *et al.*, 2015).

The ideas sparked by Gleick (2003) of a carefully planned and managed centralized infrastructure is essential, but it must be complemented with small-scale decentralized facilities. In order to not only meet quantitative needs but rather matching the quality and user’s needs. Markets and pricing will be critical economic tools for encouraging efficient use and equitable distribution of resources nationally and locally. Kiparsky *et al.* (2013) agree upon the concerns and arguments raised by Gleick (2003). However, the theory is not fully developed and understanding the response of such innovative ideas must be declared. Urban water systems can change in two ways, through innovation and institutions, according to Kiparsky *et* al. (2013). Innovation, in turn, can appear in three contexts. Firstly, new technology as (e.g., energy recovery from wastewater, desalination). Secondly, new approaches to management (e.g., rate structure, new business models, regional coordination). Thirdly, efficient techniques increase the efficiency of existing systems (e.g., sensors and controls, better understanding of system dynamics and precise models). Institutions in broad terms can be defined as the rules, norms and practices that govern decision-making. In this definition, formal institutions can also be included, including regulations and laws while also acknowledging the multiplicity of factors that shape water systems as behaviour and cultural factors (Kiparsky *et* al., 2013)

The case of the urban water system and other large conservative sectors has without any doubt difficulties to adopt and transition, and solely trusting technological merits alone will not be sufficient. A set of multiple radical technological innovations must be incorporated to cause disruptive innovation within an industry. One core element is new industry structures emerging from the institutional level. According to Kiparsky *et al.* (2013), much of the hurdles originate from the institutional level. Uncertainties in performance and costs are challenging the development. Resulting in risk-aversion and choosing a proven mediocre technology compared to a potentially superior technology. This argument is partly contradictory towards the general conception of niche markets where actors are usually willing to accept higher costs related to improving the system's new technology and overall functionality (Markard and Truffer, 2008).

Spiller *et al.* (2015) partly continue the arguments raised by both Gleick (2003) and Kiparsky *et al.* (2013), meaning that besides the inherent inertia of adopting new technology and structures. There is also a gap in understanding and identifying the actual problem. The technical and non-technical implications are factors that will determine the trajectory and success of implementing the technology. Risk aversion is a common threat to the water industry. Spiller *et al.* (2015) raise much concern regardless of the industry. However, explicitly

urban water systems since difficulties in identifying the problem and initiating the innovation process and understanding the path to successful implementation are absent. Spiller *et al.* (2015) also conclude that direct regulation best stimulates innovation in drink water and environmental standards. Regulation that requires and supports information gathering has also shown results and, more importantly, helped identify performance gaps. Economic regulation may not trigger innovation explicitly, but they alter the type of innovation adopted. Influencing the choice of innovation will also be required to change historical patterns and induce industrial transformation. Flexible regulation or frameworks have been proven effective in guiding change towards the desired direction. Encouraging riskier projects over more proven and traditional technological solutions to redefine old standards are essential. Ultimately, the adaptation and configuration of innovation will be crucial for implementation regardless of organizational or environmental circumstances. Here, institutional environment, organization knowledge and natural physical factors will be essential and decisive influencing factors (Spiller *et al.*, 2015).

3.5 Environmental

3.5.1 Climate Change

Ecology is discussed to be an essential concern when it comes to water demand and usage but also in general when discussing both the man-made systems and natural ecosystems of our planet and its inhabitant's health (Beckerman, 2013). Human and nature are both relying upon the welfare and prosperity of the earth. Currently, the trajectory of the world is discussed to be increasingly unsustainable, including individuals' perception of water (Beckerman, 2013). However, this is not the case in Sweden as there are sufficient volumes of water in many areas of Sweden. It is a matter of resource efficiency rather than water scarcity. (*Svenskt Vatten*, 2019). It has to be recognised that the exertion of the world's resources is reaching its limits, and this includes raw water, which encourages action to withstand the water demand (Beckerman, 2013). It is important to recognize the importance of a stable water supply since it relates to general public health and welfare. Improved water quality improves general health, to which the general life quality can be improved. The significance of this is that there is a correlation between economic growth and access to safe drinking water, and health improvements (Beckerman, 2013; Distefano and Kelly, 2017).

There is a direct linkage between water scarcity and the climate. The multitude of climate change impacts will have a toll on the system that is beneficial for future water necessities (Distefano and Kelly, 2017). Specifically, there are predictions that climate change will affect hydrological cycles to affect and shift global precipitation patterns. There will also be a higher frequency of extreme weather events. However, it is discussed that areas that are already wet will get wetter while dry areas will get dryer. Contributing to water reliability will lessen with a higher frequency of precipitation over large areas. It is predicted that the consequence would be increased flooded areas, which would affect the whole system of infrastructure and water marks. Infrastructure that enables water storage and other facilities can be seriously damaged. In addition, a warmer climate will ultimately result in extended summer periods, where biological life will require more water during longer seasons. The summer season will start earlier and shorten the spring season, while the autumn will also be shortened since summer will be extended. The winter season is expected to be affected by the lesser precipitation and

will consequently mean that water reservoirs and water marks will have difficulties replenishing. It creates a negative spiral of water scarcity and water depletion (Distefano and Kelly, 2017). The preservation of the groundwater system will also be an essential factor to create a stable and sustainable supply of raw water. Humans have had a costly impact on the groundwater with its depletion lifestyle of water. One cannot elude from the fact that the raw water quality will also lessen due to changes in the ecosystem as a whole and specifically the groundwater (Danielopol *et al.*, 2003). It is difficult not to include man-made interaction with the ecology, thus human's impact on nature and water accessibility. The interaction between man-made creations such as local water infrastructure, i.e. surface water reservoirs, will affect the access to water in the future as they are designed to withstand climate extremes (Mehran *et al.*, 2017). These systems must be built with a level of resilience to withstand the pressure of different climate pressures caused by climate change. An example of this is the water supply catchment in Melbourne. The water system is highly regulated as its reservoirs can withstand climatic pressure with the help of its water storage and redistribution, despite being located in an area highly affected by climate change (Mehran *et al.*, 2017). However, the increased temperature will severely decrease water resource availability, and it is estimated that 35 % of the global population will live in areas where water stress is a fact (Schewe *et al.*, 2014).

3.5.2 Environmental Awareness

Over the past couple of years, there has been a greater awareness of water and environmental issues among the public (Oosterbeek, Scheunemann and Santos, 2013). However, it is difficult for all stakeholders, the abstract "battle of sustainability" and convincing all of the nations on earth that focus on the environmental aspects should shift and accelerate, even if it can cause negative economic effects in the short term. Additionally, the complexity of the change is increasing while time is sparse. Convincing people seems to be a difficult task as it requires people to realize and understand the long-term perspective. Thus, recognizing the improvement in life quality that this will bring in the future. However, this realization includes sacrifices in minor everyday choices that can be met with resistance. These sacrifices could potentially lead to an accumulation of greater prosperity as it will minimize the risk of depleting natural resources (Beckerman, 2013; Distefano and Kelly, 2017).

During the last 50 years, there have been both ecological and socioeconomic changes that have affected the groundwater systems. This is the result of environmental effects occurring from anthropogenic pressures. The effects have been detrimental as changes in both the quality and quantity of the groundwater have developed. It is forecasted that the impact will continue until 2025 (Danielopol *et al.*, 2003). A way to change this negative trajectory of trends would be through new environmental policies. The new trajectory in water demand has become a greater environmental issue, especially for developing countries. Changes in climate have become a real factor in countries not susceptible, which means that in countries where people rely on a specific type of climate and weather. Changes in seasonal and natural irrigation are essential for farming, and change can interfere with overall health. In order to create policies which, have an impact on the three dimensions of sustainability, i.e. Ecology, Sociology and Economy, all three dimensions must be included in policy creation and implementation (Danielopol *et al.*, 2003; Mehran *et al.*, 2017).

A study made by Anderson *et al.* (2007) in South Africa concluded that the perception of environmental problems is related to a post-materialistic perspective. Individuals most likely

to be affected by water pollution would primarily see it as a problem (Anderson *et al.*, 2007). Suggesting that if one lives in dire environmental circumstances, they would have a greater sense of awareness. It is suggested that education is a determinant of solving these environmental problems in the household, also being directly linked to awareness (Anderson *et al.*, 2007). Moreover, the study conducted by Straughan and Roberts (1999) pointed out that environmental awareness is higher amongst women and younger individuals. When education rises among individuals, environmental awareness and behaviour will increase (Straughan and Roberts, 1999).

Furthermore, the study by Li *et al.* (2021) on Chinese households concluded that an awareness-behaviour gap exists, where the economic factors are the ones contributing households to take pro-environmental consumption attitudes (Li *et al.*, 2021). Thus, the higher degree of environmental awareness that the consumer has will ultimately affect the willingness to pay for eco-friendly products (Liu, Anderson and Cruz, 2012). This implies that environmental awareness of the consumers will be a contributing factor for companies in their launch of products. Companies' understanding of the level of environmental awareness amongst their consumers will be a competitive factor in the market and contribute to the success of companies (Liu, Anderson and Cruz, 2012). A study made by Bülbül *et al.* (2020) concluded that most households in Turkey believed that companies were the most significant contributors of environmental problems, shifting accountability. The study highlighted the ignorance these individuals had toward their household consumption (Bülbül *et al.*, 2020).

4. Methods

This section of the report will shortly describe and motivate the choice of a single case research study design. The methodological approach is presented in chronological order, from the early drafts of the pre-study and communication with stakeholders and thesis sponsors to the final steps of the study. It will be followed by a description of the main study and building the theoretical framework and empirical data set. It will also include how the analysis is structured, outlining the ethics of the research process the quality of the research.

4.1 Research Design

4.1.1. The choice of a Single Case Study

A single qualitative case study has been the choice of design for this research. Since the research intended to explore, investigate, and understand the drivers, trends, and phenomenon of future residential water use, a single case study proved effective for this purpose (Yin, 2009). Additionally, it also proved advantageous in a setting where several actors are sources of information with multiple perspectives (Blomkvist & Hallin, 2015). The arguments for choosing a single case study are also motivated by the sole fact that there has not been a project, research or work done entirely similar to what is to be completed. Meaning that the methods are chosen, and the results may be challenging to verify thoroughly (Gustafsson, 2017). However, one similar comparative study was conducted in Finland (Rohrdrommel, 2017), to the authors' knowledge, discussing drivers for residential consumption trends. This research and project are expected to travel a different path. Acquiring influences from the direction of the publication by De Bruin *et al.* (2009) to translate qualitative data to quantitative. With the endeavour to discover and to map intact grounds, shed light on hidden facts and new territory. Meaning that comparable initiatives are close to none and further motivated the choice of a single case study investigation (Yin, 2009). However, it does not mean that published literature and findings are irrelevant to the study but somewhat scattered, and the ambition of this thesis is to compile it.

Naturally, as the research continued, new perspectives, impressions, and facts are acquired and collected, which meant that the authors must sustain flexibility and the chosen methodology itself. Stake (1995) and Merriam (2009) argue for case studies methodologies to be flexible and suitable for qualitative research design since it aids the authors to clearly formulate, firstly the research design but also the epitome, tools, and methods applied. Solberg Søilen and Huber (2006) elaborate on this argument and argue for case studies being open-ended where one precise solution is challenging to find. On the other hand, the purpose of a case study research design is more about producing background material to elevate the discussion of the posed problem. The arguments raised by Stake (1995), Solberg Søilen and Huber (2006), Merriam (2009), Yin (2009) could be seen as advantageous. However, an open-ended and flexible approach can dispute the scientific credibility of the results according to Encyclopedia Britannica II (1979) and open to criticism (Gustafsson, 2017). While also confusing the design of the case study since the conclusion can neither be illustrative or confirmable. Thus, the concerns raised by Wells (2004) is highly accurate and justifiable that the study should partly address and disclose the raised concerns above. But the study should

also have a chronological and narrative composition when presenting findings and facts and minimize the risk of random interpretation. “Science is a story. Tell it.” (Wells 2004, p. 758).

The advantages of single case studies outweighed the negative aspects in this matter. The sparse bank of resources, in terms of time and workforce, confined what was possible. While the authors intended to create high-quality research, the single case study was the definite option. It aided the authors to acquire a deeper understanding of exploring the subject, the research field and industry. It also showed benefits when describing the phenomenon's existence and helped the authors question old theoretical relationships and explore new ones (Gustafsson, 2017).

The authors seek to answer the RQ and ultimately modelled the work by accomplishing the steps presented in the chapter Methods. The MRQ was answered partly by conducting the research, as the nature of the question is exploratory. MRQ was also confirmed by answering RQ1-2. The creation of the theoretical framework to understand the concepts of LTS, MLP and Scenario building was aligned with the purpose of the study. RQ1-2 are specific in the context of SOI. However, answering the RQ’s has been done by the compiled and acquired knowledge from the theoretical framework. RQ1-2 has been predominantly answered by applying the analytical tools of PESTLE and MCA, which have permeated the whole report. Answering the RQ has been accomplished through the literature review results and the data collected from the empirical study. The MCA conducted and presented in the chapter Results and Analysis has been based on different criteria with associated analysis. Table 3 has quantified each criterion's implication of the identified drivers and helped the level of discussion, which enabled the authors to answer all of the research questions. Conclusively, all of the research questions have been addressed in the chapter Discussion, and an in-depth review and scrutiny of the results have been disclosed and discussed.

4.2 The Research Process

In this section of the report there is a transparent presentation of the necessary steps taken to complete the study. The study has been divided into two sections: pre- and main study. The literature review was conducted throughout the pre-study to get a comprehensive picture of the research area, and theoretical framework applied. The literature review would also contribute to the results of the main study. Once the objective of the main study was declared through the Pre-study, interviews were conducted. They would complement the results gathered by the literature review to answer the research questions formulated. For a chronological development of the research process, see Figure 5.

4.2.1 Pre-Study

The thesis sponsor posed an area of relevancy identified as essential for the future of their business and society. Therefore, a significant amount of time had to be allocated to understand the water industry and the posed problem formulation identified by the thesis sponsor. Once the industry was fairly scoured through reading literature and meetings with project stakeholders, narrowing down the area of study and formulating a more direct problem formulation was initiated and completed. Thus, creating a research area accepted by all stakeholders that include gaps to fill in previously published literature and research.

The first posed area of interest was related to the field of forecasting water consumption for households. However, to the knowledge of the authors, thesis sponsor and supervisor, much of previous literature and industry organisations interest have been directed in publishing such information and data. Hence, it became apparent for the mentioned stakeholders that other areas had not been thoroughly explored, and additional gaps were obvious and some unknown. What became apparent was the lack of compiled knowledge and information connected to the exploration of the measures Peak daily consumption (PDC) and MDWC within the household. What drivers drive the increase or decrease of the two measures is covered in a modest amount of international and in some Nordic literature but not in the context of Sweden specifically. As this is an unfamiliar area of exploration, it became apparent that studying the LTS in the context of the water sector and evaluating the dimensions of PESTLE will be a unique way to explore what drives and partly determines residential water consumption. The authors concluded that PESTLE was a valuable tool through the suggestion and guidance of the supervisor. Although the suggestion was valid, it had to be evaluated by the authors to fit the SOI. The authors had also been developing their own framework similar to PESTLE, subconsciously creating an easy transition.

4.2.2 Main Study

As a result of the challenging times caused by the COVID-19 pandemic, the study was done completely remote using digital communication software. This has not been deemed an issue for the study since it mainly consisted of data gathering through reviewing literature or conducting interviews. In hindsight, it may have resulted in better and more effective time allocation. Additionally, interview respondents have enthusiastically accepted the author's digital invites. In summary, the digital layout and work processes have been deemed beneficial for the entirety of the study. The possibilities to standardize work and interviews are perceived to be an essential part of the study.

After the processes of the pre-study, the main study could begin. Firstly, a number of areas through the PESTLE framework were discovered to understand the research area further and more in-depth. The discovery was enabled by scanning and reading available literature while constantly referring to the theoretical framework constructed by the thoughts and suggestions of LTS and MLP. The application and choice of building the theoretical framework based on LTS and MLP originated from the supervisor's recommendation. However, the authors did not blindly trust the recommendation without understanding the theories and their fit for the SOI. Based on the gaps identified, the modified model of PESTLE to P(L)ESTE was constructed through gaining inspiration from meetings between the authors and individuals with both extensive and novel backgrounds within the industry of water and sewage management. Once the more defined and delimited research area was established, building the theoretical framework in combination with conducting the empirical interview study was initiated. To utilize time and labour efficiently, interview respondents were identified through the themes of P(L)ESTE and contacted in the early phases of the project. The authors were enthusiastically greeted within the industry sector, however finding a time and date was problematic. While interviews were booked and scheduled, the authors continued to write and structure the theoretical framework and chosen methods. The P(L)ESTE framework also gave the authors inspiration on structuring the study and carefully allocating time and focus into correct areas. The study relied on the incorporation of a multitude of literary and empirical sources, methods

and tools. The authors worked in accordance with the principles of theory triangulation from the early works of Patton (1999) and later works of Gibbert, Ruigrok and Wicki (2008); Turner and Turner (2009). By continuously searching and scouring for literature with the ultimate endeavour to achieve a degree of saturation or what Patton (1999) refers to as convergence will be of importance for the authors.

Assuring *construct validity* is the consideration of how well relevant concepts, methods and theories are applied and practised in the study. To ensure this, the authors have thoroughly studied the methods applied in the study by reading published literature about the methods. As well, literature that practically utilizes the methods while also constructing a written theoretical section on how to apply and what to consider when utilizing the chosen methods. In addition, concepts and theories have also been a subject of theoretical and practical evaluation, where concepts are both practically tested and theoretically reviewed and presented in the theoretical framework.

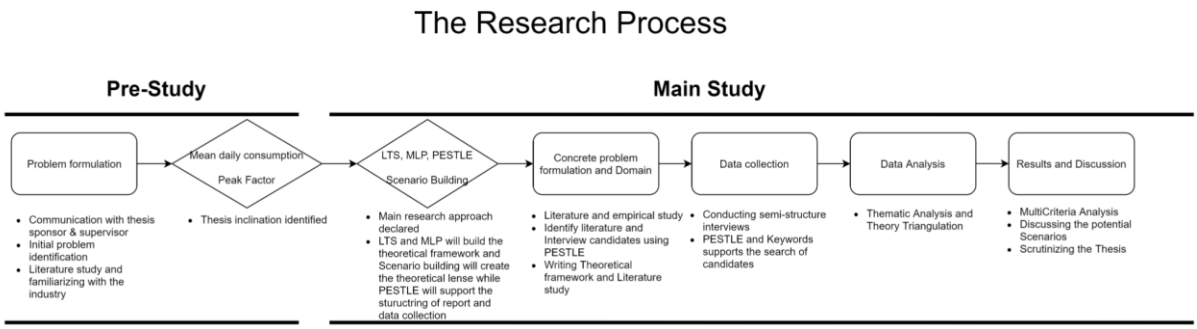

Figure 5: A complete illustration of The Research Process.

4.2.3 Literature Review Approach

The process of constructing the literature review is a two-step process. The first step is getting acquainted with the problem and research domain. It was accomplished by reading literature posed by the thesis sponsor and searching the internet for introductory literature on the industry. Resulting in multiple keywords identified related to the inclination of the thesis and thus aided the proceeding of the thesis in searching relevant literature. This process included multiple dead-ends in reading and scouring much literature, which ultimately did not get included in the literature review. Once a more comprehensive knowledge and grasp over the inclination of thesis and understanding of the industry was established, the search of literature became much more effective, and keywords could be identified using the mode of PESTLE. Henceforth, the literature review continued into the second step. The reviewing of literature is built upon the PESTLE process of identifying and reviewing areas of criticality. The authors attempted to only focus on one of the areas at a time in order to reduce conflicts in the search and when narrowing down literature and minimize unnecessary work, such as both authors doing double work by writing about the same subject. However, as anticipated, much of the literature and conclusions are interrelated and cross-boundary. Resulting in overlaps of both literature and naturally in the literature study. However, this was not deemed as problematic since this partly verifies the concerns and conclusions raised in the theoretical framework of LTS and MLP, which states that LTS are complex and cross-boundary systems. It also

supported the purpose of the research project and indicated that the authors are heading one of many correct paths.

Table 1: List of keywords used to identify literature in “The Research Process”.

Section of the Report	Keyword used	
Pre-Study	[Forecasting Water use/consumption] [Creating reliable forecasts] [Urban Water System] [Swedish Water Sector] [Dimensioning Water Systems] [Water metrics/measurements for Households]	
Main Study		
Theoretical Framework	[Large technical System] [Large Infrastructural Systems] [Multi Level-perspective] [Building/Creating Forecasts/Predictions] [Building/Creating Scenarios/Plans] [PESTLE Analysis/Methods] [Identifying Trends/Drivers] [Research Validity/Verification/Reliability]	
Methods	[Multi-criteria Analysis] [Research Design] [Case Study Design]	
Literature Review & Interview Candidates	Area	
	Political and Legislative	[Water Consumption Communication] [Informative and Communication Water Use] [Certification Water House] [Regulatory Framework for Water Consumption/Usage] [Water Pricing Policies]
	Economical	[Economic Growth and Water Usage] [Water Pricing] [GDP and Water Usage]
	Social	[Human Water] [Human Water Usage] [Housing Development Water Consumption] [Housing Construction Water Consumption]
	Technological	[Technology and Water Consumption/use] [Innovation and Water Consumption/Use] [Innovative Technology for Water Consumption]
	Environmental	[Water Consumption/Usage Ecology] [Water Consumption Environment]

Keywords were used to search for publications and literature in the search portal WebOfKnowledge™, regarding each individual dimension of P(L)ESTE using the keywords presented. See Table 1. Publications and literature were first sorted based on title and topic. If the number of searched publications exceeded 50, publication year, the number of times cited and relevancy was also used when sorting for publications. Once several articles were

identified based on the parameters mentioned above, they were downloaded. It was possible to download through the author's student ID from KTH, giving access to many databases. The next step was to filter the literature and deem it appropriate and suitable for the study based on reading the abstract and conclusions. Read and categorized literature were tracked using excel. Once all the articles were read, they were sorted and selected. Occasionally, articles identified could be better suited for discussing another dimension of P(L)ESTE and sorted accordingly. The final selection of literature would build the literary reviewing foundation of the area of focus based on P(L)ESTE. Additional articles on specific topics mentioned or referenced in one of the publications could be added along the literature review process. KTH Primo or Google scholar™ were then used to search for literature regarding that specific topic. It was also common to use the references in literature to get additional information on a specific topic or model used. Once again, KTH Primo or Google scholar™ was used for the search of the particular published literature.

To assure validity in the used literature for this study, the authors have used reputable search engines for literary sources and journals. The number of times the literature has been cited has also been of consideration. In addition, to not exclude any potential literature which could interfere with the results. The authors have kept track of keywords used and saved searched literature in cloud storage. Hence, the ability to rediscover excluded literature is possible. The authors stayed true to the P(L)ESTE model to ensure the inclination of the thesis.

4.2.4 Interviews

One of the central parts of the research study is the empirical study and information gathering from industry professionals and scholars to produce data for the specific context of Sweden to give a balanced result with the acquired information from the literature review. Secondly, it has also added additional perspectives for the study and been a central part of the report's evolution as it has laid the foundation for it and created its uniqueness. Through the five dimensions of P(L)ESTE, potential interview candidates were identified by searching the internet for publications or projects. Publications and projects related to understanding water demand, water production, water technology, water policy and economy or previously published literature and publications closely related to understanding water consumption trends. The keywords used in the search for literature were also applied when searching for candidates to interview. However, the search was mainly targeted in the context of Sweden. See table 1 for keywords used.

A few of the interview candidates were contacted based on the proposition of already interviewed candidates. The interview candidates were contacted via standardized email explaining the author's intentions of the interview and the purpose of the project. Additional explanation of the report and project could appear if requested by the potential interview candidate. Once the interview candidate accepted the interview invitation, the meeting was booked and scheduled using Microsoft Outlook™. This principle was consistent throughout the process of identifying interview candidates. Candidates who responded were interviewed, which means that the original list of potential interview candidates is far more extensive than the final list of interviewees shown in table 2. The interview respondents got the questions beforehand to understand better and grasp the inclination of the project and the interview itself. It also gave the interviewees time to reflect upon the questions and formulate answers in

advance to be effective when conducting the interview and provide well-thought answers. The interviewee was repeatedly informed that the option of declining to answer a question or to erase an answer of the audio recording was permitted. Furthermore, the interviewees were informed that the answers would be made anonymous and untraceable in the report, to the best ability of the authors. The questions asked during the interview were of semi-structured character and were altered based on the dimensional belonging to the P(L)ESTE model. A selection of the questions was fundamental, but to ensure that specific information was collected from the extensive knowledge of the industry professionals and scholars, it was deemed most effective to alter the questions based on the interviewee background and specific area of interest. Given this, the authors decided to exclude any documents related to the interview process, i.e., the multiple questionnaires used, since it can be a way to identify the interviewees. It should be noted that the steps mentioned were all done in Swedish, from first contacting the interviewee to finally interviewing them. Except for interviewee 15, where all steps were done entirely in English due to a language barrier. See table 2.

To assure internal validity, the interviewees were selected due to their role and competence in the areas of importance and interest identified in the literature review. Industry experience is considered when identifying and choosing interview candidates as important. However, candidates with novice experience are not excluded from the thesis since they will bring new perspective and knowledge from the industry. Identified, contacted and completed interviews were tracked using Excel™. The meetings were conducted via the communication software Zoom™ which enables voice recording for the authors to re-listen to the audio recording. See table 2.

Table 2: Listed are the chronological order of every interview completed with additional information.

Interview	Date	Sector	Area of Interest	Length (minutes approx.)	Recorded
1	2/19/2021	Water and Sewage	Technology and Political	35	Yes
2	2/22/2021	Water and Sewage	Social and Political	30	Yes
3	2/23/2021	Water Technology	Technology	60	Yes
4	3/1/2021	Community Developer	Social and Political	30	Yes
5	3/3/2021	Industry Organisation	System perspective	55	Yes
6	3/5/2021	Innovation Matchmaking	Technology and Political	45	Yes
7	3/5/2021	Agency	Environment and Political	70	Yes
8	3/8/2021	Agency	Environment	25	Yes
9	3/8/2021	Water Technology	Technology	30	Yes
10	3/8/2021	Community Developer	Political and Economy	55	Yes
11	3/10/2021	Community Developer	Economy and Environmental	55	Yes
12	3/10/2021	Water and Sewage	Political and Economy	60	Yes
13	3/11/2021	Agency	Environment	40	Yes
14	3/11/2021	Water and Sewage	Systems perspective	55	Yes
15	3/15/2021	Industry Organisation	Political and Economy	50	Yes
16	3/16/2021	Researcher	Technology and Economy	45	Yes
17	3/17/2021	Community Developer	Social	40	Yes
18	3/17/2021	Researcher	Technology and Social	45	Yes

4.2.5 Data Analysis

Noticeable for the project and report is the application of the P(L)ESTE model. It has succeeded in creating a fundamental and observable perspective for the comprehensive research area and aided the authors to explore and identify areas of interest. The data analysis and compilation of results will stay true to the structure and continue to follow these dimensions when identifying and discussing potential drivers for future residential consumption. As suggested by Blomkvist and Hallin (2015) in social science, a deemed suitable analytical approach is thematic analysis. It is an analytical approach offering accessible and theoretical flexibility to analyse qualitative data (Braun and Clarke, 2006). The model of P(L)ESTE has partly shaped the data collection method. However, to not ignore or disregard valuable data, conducting a thematic analysis has helped the authors to search and identify themes and patterns within the already stated themes of P(L)ESTE. In one aspect, the thematic review acted as a confirmative measure to strengthen the approach of P(L)ESTE and the identified areas within each dimension. It has also helped authors objectively identify similarities or differences and find additional patterned responses or meaning for the research question (Braun and Clarke, 2006; SBU, 2016). Although the flexible offerings of the thematic review, it also includes and poses disadvantages. For example, lack of analytical narrative when analysing the data, overlaps between themes or the inconsistency of them are common and influential (Braun and Clarke, 2006).

Practically, the transformational process from raw data to data in a more comprehensible and observable format followed the six-step process presented by Braun and Clarke (2006).

1. Familiarising oneself with the data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report

Due to the large amount of collected raw data, the authors decided not to transcribe the entire length of the interviews. Instead, they deemed it more time-efficient to firstly re-listen to all of the interviews. Secondly, listen once more and only transcribe parts and sections of the interviews where valuable knowledge and data could be extracted based on the dimensions of P(L)ESTE and for the purpose of the study. The transcribed Swedish parts would be translated to English and implemented in the analysis. Each paragraph has a translated part, i.e. quote, from the interviews. To minimize the risk of extracting data out of context, transcribed data were structured in relation to both the question asked and previous discussion. Once data was transformed from audio recordings to written text, the data analysis process continued by structuring the actual results of the research study.

4.2.6 Multi-Criteria Analysis Applicability

A MCA was conducted and applied in order to present identified drivers based on the findings and discussions of the reviewed literature and the empirical interview study. It has also laid the foundation of the analysis and the discussion that follows. The MCA is a method that appraises or evaluates a given plan by investigating a wide variety of dimensions and criteria of interest predetermined or chosen by the utilizers (Dean, 2020). MCA assists investigators with a structured flow of work and proves its advantages for multivariate cases and problems. It is also a method that has been utilized and applicable within a long history of different research fields and in casual decision situation, ranking, sifting and deciding the best or most relevant or plausible option at hand (Dean, 2020). However, there are commonly discussed pitfalls and issues with the method. One is the multiple issues regarding choosing correct criteria and hierarchically structure them and applying appropriate weights. Then there is the issue of making a decision based on one single score, which partly shall reflect a complex situation. Finding one superior, conclusive, or unique solution is often difficult due to the nature and setting of the decision making. In general, it is rare that a single alternative is as good or better than all other alternatives for all criteria (Kujawski, 2003). Hence, the highly complex multidimensional decision problem translated from qualitative data to quantitative data and reduced to a single number will impose difficulties (Kujawski, 2002).

The suitability of applying MCA on qualitative research from an empirical standpoint is the model's ability to illuminate the complexities of the factors in the problem (Munda, Nijkamp and Rietveld, 1995). It is suitable for research that dives deep into sustainability problems as it incorporates a level of accuracy and precision for the measured variables. To apply MCA in this research or similar, there has to be an effective way to standardize the evaluation of the different criteria of the different objectives and options. When the numbers are a blurry representation of perceived reality, the context in which the numbers represent must be well-defined (Munda, Nijkamp and Rietveld, 1995). Commonly there are two ways to approach qualitative research. The first approach is a “direct approach”, meaning that the acquired qualitative information is used in the evaluation method without being transformed into quantitative units. The “indirect approach” is the opposite in the sense that it takes the acquired qualitative information and transforms it to cardinal information, for it to be used later on one of the quantitative Multi-Criteria methods to be applied (Munda, Nijkamp and Rietveld, 1995). The indirect approach has been applied for this study due to the advantages when sorting, dissecting and managing a multitude of sources in different formats. Hence, the qualitative information is first transformed into cardinal information, which will then be cardinalized and evaluated using MCA. Optimally, “the data should be precise, certain, exhaustive and unequivocal” (Munda, Nijkamp and Rietveld 1995, p. 81). However, reality is not perfect, and it is often necessary to use information that does not possess any of those characteristics. Thus, authors need to be aware and act accordingly to face the inbound uncertainties of qualitative data being stochastic and or fuzzy at times (Munda, Nijkamp and Rietveld, 1995).

4.2.7 Multi-Criteria Analysis: Formulation of criteria and approach

Much of the inspiration in applying and utilizing MCA in the context of studying drivers and sociotechnical studies are gathered from the works of Munda, Nijkamp and Rietveld (1995) and De Bruin *et al.* (2009). Dean (2020) and Kujawski (2003) are the primary first-hand sources of how to use MCA practically. By providing a structured way of working and applying the fundamentals of MCA. Below is the chronological order of applying MCA in this particular setting, and the eight steps are directly replicated from the work of Kujawski (2003).

1. Define the objective(s)
2. Determine the criteria that relate to each objective 3. Structure the criterion into a hierarchy
4. Develop candidate alternatives or options
5. Determine the importance of the criteria and assign corresponding weights to them
6. Evaluate the alternatives with respect to the criteria
7. Combine or synthesize the multiple single-criteria values into a single aggregate multi-criteria score
8. Step back and evaluate the results.

The first step of the MCA methodology is to define the objective or objectives. The objective of this MCA is to determine how each identified option (driver) will affect future residential water consumption. The second step is to determine the criteria. In this case, four criteria have been chosen and formulated as the following.

1. Driving effect. How much would it affect residential water consumption? Data is scrutinized and evaluated based on the perceived impact the driver will have within the SOI. Giving a high grade (5) becomes a recognition of the high “driving effect” the driver has on the SOI, while a low grade (1) shows a lack of driving effect.

2. Urgency. How urgent is the implementation of the driver for effect to act sustainably? Data is scrutinized and evaluated based on the urgency of the driver to be considered and further investigated to act sustainably. Consideration of negative consequences for the future wellbeing of the SOI and ecosystem is included. A high grade (5) indicates a high urgency of action. A low grade (1) indicates a lesser to none urgency of action.

3. Plausibility. Is it a plausible driver to be implemented in the system? Data is scrutinized and evaluated based on the adaptability and the possibility to implement the evaluated driver within the SOI. For example, by studying the redundancy and barriers of success. A high grade (5) indicates that the driver is a plausible option of implementation on the SOI, while a low grade (1) suggests that the driver has a low plausibility of implementation.

4. Evolution. How evolved is the driver to date? Data is scrutinized and evaluated based on the advancement of the criteria, i.e., where the particular driver is located on the evolutionary scale. Has much progress been accomplished within the particular driver, and is there room for improvement and exploration. The grade for this criteria is inverted, where a high grade contra low grade has an opposite meaning to the other

three criteria. A high grade (5) indicates that the driver is a non-evolved driver for the SOI, while a low grade (1) indicates it is a developed driver.

Summary is the summarized score of the four previous criteria connected to the driver. It is meant to provide an overview of how these criteria together culminate in importance to the SOI. Depending on the driver and the score, there can be an evaluation and discussion of the driver. The summary of each driver's score will be in the span of 4 to 40, where 4 indicates a low score and 40 a high score. What the total score indicates will be analysed and discussed in the latter part of the report.

Thirdly is to structure the criteria into a hierarchy. This study has only one objective, to understand if the drivers will determine future residential water consumption. Therefore, as a result of one objective, the criteria are already structured in a hierarchy. Fourthly, it is to identify and select options, which are the drivers of residential water consumption for this research. The drivers have been selected and identified based on the categories of P(L)ESTLE. As well, the frequency and discussed relevancy in both literature and interviews with industry professionals and scholars have been an essential factor in the selection of drivers. See Figure 4 for a clear representation of the inspired P(L)ESTE model. The fifth step is to determine and assign corresponding weight for each criterion. The authors have decided not to assign weights to each criterion. This decision is based on the intention and inclination of the report since its purpose is to elevate the research area of better understanding water consumption. Also, to build and explore a foundation that will hopefully inspire further research. The sixth step is to evaluate each option individually and assign grades for the four criteria. The authors decided that the data from literature and empirical study on the drivers will be separated and individually graded from 1 to 5. However, results will be compiled into one table.

The grading process will require a standardized evaluation process of the different performances for each objective and option. The grading will represent the perceived reality of the authors, based on the discussion and understanding of each driver from the literature or the empirical data set. Through discussions, common ground could be found in grading the different criteria for the different drivers. Thus, each criterion within each driver has been questioned and evaluated. For the literature, this has meant investigating several relevant literatures associated with a specific driver. Thus, giving the authors an understanding of what the grade should be. The grading process entails a judgement based on the 18 interviewees opinion of different drivers. For example, if all of the 18 interviewees have the same opinion on a specific driver concerning water consumption, then a grade would reflect that. A high grade (five points) implies that the criteria is recognised and discussed on a high level, and it is a common area of topic within the literature or sector. Conversely, a low (one or two points) grade does not explicitly indicate that the discussion is irrelevant but is not deemed crucial for the investigated criteria. However, in general, a low grade will indicate that the viewpoint within literature or the sector perceives the criteria as unimportant, or a low degree of impact and focus should be directed to other areas. A medium grade (i.e., three points) is usually applied when facts and arguments are polarised in the debate. Distinct agenda or arguments regarding the specific driver and option evaluated are not clear. It will imply that the future will be determined based on either cross-boundary decision or the development of other drivers in this study.

The authors graded each driver and criteria individually by discussing and arguing for their perception of how the literature or the collected data perceived the significance of the driver. If unanimous, both authors assigned the same grade, and it was accepted as a satisfactory result. However, if the decision was split, the rule of common ground was applied, which means that each author was arguing for their individual grading. The authors had to state their case and reasoning in the discussion. Split decisions regarding the grading happened rarely. This could indicate that the compilation of results has reached the authors unanimously and is mutually perceived based on the literature reviewed and data collected.

The seventh step is to combine the scores and initially observe the adequacy of the results. The final and eighth step is to step back and analyse the results. However, after the final step, the analysed results will be discussed further. For example, discussing how is the reasoning behind grading each option. What this implies for the future will also be discussed and related to the research problem and research questions.

4.3 Research Ethics & Sustainable Contribution

Research ethics considers questions about how to formulate and determine the research topic, the design of the research and how to access, collect, process, and store the data. Thereafter, analyse the collected data and finally compile, select and express the findings of the thesis in a moral and responsible way (Saunders, Lewis and Thornhill, 2016). The authors of this thesis have always intended to be as transparent and documentative as possible in the research process by presenting extensive descriptions and fully disclosing each step of the research process. An additional section added to the thesis where the authors are commenting on what the implication of subjectivity could imply for the results and the research process itself. This thesis is potentially the last academic publication of both authors. It would be wasteful and destructive to not take the opportunity to act and contribute to academia and society. Since the project spans across multiple boundaries, it is important to be transparent and to preserve both the author's integrity and integrity of the research. Furthermore, the nature of the problem and the chosen research approach will invite multiple stakeholders and sources of information. The validity of both the thesis and results is determined by conducting an honest, transparent, and respectful data collection, specifically through the interviews. Nevertheless, it is important to refer to sources without interfering and altering information in a deceptive manner.

In this thesis, regarding ethical research study will be concluded and stipulated according to the Swedish Research Council and Swedish Engineers Code of Honor (Vetenskapsrådet, 2018), where certain criteria must be ensured when conducting research (Sveriges ingenjörer, 2019). As engineers, the authors have certain additional responsibilities regarding the utilisation and exploitation of the results. The intention of the thesis is to enhance the prosperity and welfare of society in the future, rather than proposing and presenting areas of vulnerability for exploitation with negative consequences.

In terms of the contribution to a more sustainable future, the evidence is clear. The study has heavily incorporated the three dimensions of sustainability as a fundamental perspective to

partly observe the problem and research area and how to solve and propose solutions. (1) Environmental – ecological aspects. (2) Social – human health, democracy, education, societal belonging. (3) Economical – economic growth and welfare (Baumgartner and Rauter, 2017).

Firstly, environmental, the specific research context of water has invited great discussion on extracting, supplying, and consuming water in the future more sustainably. As raw watermarks are getting depleted while simultaneously observing and experiencing climate change more frequently. Secondly, the social dimension is also a central part of the discussion as society is dependent on the urban water system. If the urban water utility system abruptly stopped the supply of fresh drink water, society would stop in tandem. People and their health are heavily relying upon the perpetual system of water supply. Thirdly, the economic aspect will help water suppliers, society, and governments better understand what the future beholds and act accordingly. This short list of sustainable contributions is mainly a result of acquiring a systemic perspective, but there are many additional contributions listed and discussed throughout the thesis.

5. Results & Analysis

This section firstly presents the table which summarizes the MCA conducted. It further and individually analyses and motivates the choice of each score for the respective criteria. Quotes from the interviews completed are also presented with the purpose to strengthen the motivation of the score. The chapter is finished with a summarization of the distribution of points and additional comments.

5.1 The Results of the Multi-Criteria Analysis

Table 3 presents the results of the conducted MCA. See table 3. It shows each area that was investigated and the drivers within those areas with their corresponding grading. The upper left box under each criterion represents the grading from the interviews (I), while the upper right represents the grading from literature (L). Below these boxes is the sum for each criterion based on the grading from interviews and literature. Finally, under the "summary section" of the table is a summarized score of all of the criteria, for interviews and literature, and the total score of I and L together.

Table 3: Presents the compiled results from MCA conducted based on literature and the Interviews.

Area	Driver	Driving Effect		Urgency		Plausibility		Evolution		Summary	
		I	L	I	L	I	L	I	L	I	L
Political and Legislative	Pricing	3	2	4	4	5	4	5	3	17	13
		5		8		9		8		**30**	
	Laws and Regulations	5	4	3	3	4	5	3	4	15	16
		9		6		9		7		**31**	
	Informative Measures	5	4	4	5	5	5	4	2	18	16
		9		9		10		6		**34**	
Economical	Socio-economic	3	3	2	2	1	2	1	2	7	9
		6		4		3		3		**16**	
Sociological	Behavioural Changes	5	5	5	5	5	4	4	2	19	16
		10		10		9		6		**35**	
	Demographic Development	2	2	1	1	1	2	1	4	5	9
		4		2		3		5		**14**	
	Housing Development	5	5	3	3	3	3	4	3	15	14
		10		6		6		7		**29**	
Technological	Household Innovation	5	5	3	4	4	4	1	3	13	16
		10		7		8		4		**29**	
	System Changes	3	2	5	5	4	2	5	3	17	12
		5		10		6		8		**29**	
Environmental	Climate Change	5	4	5	4	4	4	2	2	16	14
		9		9		8		4		**30**	
	Environmental Awareness	5	5	5	4	4	4	3	3	17	16
		10		9		8		6		**33**	
Total Summary		46	41	40	40	40	39	33	29		
		87		80		79		62			

5.1 Future Political and Legislative Drivers for Residential Water

5.1.1 Analysis of Driver: Pricing

According to the studied data, the driver Pricing indicates that it has a great significance to the residential water system, which can be showcased with its total summarized score of 30. It indicates how important correct water pricing structure is for the system in order to enhance the aspects of sustainability. Driving Effect (5) for the driver Pricing shows a relatively low number, both from the literature and interviews. It is mainly motivated by arguments that despite the price of water, humans need a sufficient volume of water for basic and essential needs. The Urgency (8) and Plausibility (9) criteria score respectively shows a need to incorporate a more efficient solution of pricing water, and there is room for it to be done. The Evolution (8) criteria score represents that there is a need to develop it further. Mainly the need for development is motivated through a better disposition of responsibility. Individuals consuming water recklessly should be punished accordingly. Some form of environmental taxation or cost recovery of water extraction could also be a plausible option for internalising external costs. I. e. the cost consumers pay for water should cover more areas than just production costs, and water providers should recognise this and have a supportive regulatory framework.

"They do not care if we do right by protecting the environment, distributing water is more important than the price of water." - Interviewee 15

"The luxury commodity that is water should be paid for. However, it is a given right to have drinkable water." - Interviewee 18

5.1.2 Analysis of Driver: Laws and Regulations

The driver Laws and Regulations have the highest total score in the criteria Driving Effect (9) and Plausibility (9). There is reason to believe from international literature and the interviewees that there is room for improvement of existing laws and regulations. There is always an incentive to implement and improve laws. It is a way to keep balance in society and from falling into chaos because it is one way to regulate individual behaviour. This is also believed to be the case for residential water consumption as there is room for improvement in current water consumption laws. Fundamentally, there is no justified reason why water should not be better regulated with laws, according to literature and interviewees. The same is for behaviour towards water, and with more viable laws and regulations there can be consequences for reckless water consumption. Thus, making the driver a driving force to achieve a high degree of sustainability within residential water consumption. However, the score of Urgency (6) and Evolution (7) is because there is more than enough water in Sweden, making it a commodity highly accessible. This is reflected by the giving score lower for Urgency as there is no need to act rash, but a need to act more reasonably with water management. The primary law towards water consumption, "Allmänna vattentjänstlagen", is perceived as outdated by many scholars as it does not specify consumption sufficiently nor carefully enough. The law is open for much interpretation and has contributed to negative consequences and may induce more in the future. It is discussed that it should be updated in accordance with the current Swedish water situation since the situation is constantly changing. Thus, the law which regulates it

should change accordingly. These reasons are why the summary score for the driver Laws and Regulations is 31, indicating that it has a significant impact on water usage.

"An important aspect is that water access varies based on the climate and season, which means that it is hard to give permits for a constant withdrawal of water if the source of water is not constant." - Interviewee 8

"Water and Sewage organisations can do more toward water conservation, but they need the backing of politicians to get the right support of financing and decision. Where politicians and officials have a tremendous responsibility to reduce water consumption." - Interviewee 18

5.1.3 Analysis of driver: Informative Measure

Informative Measure has the second-highest score of all of the drivers scoring 34 points, as it is one of the most important courses of actions to affect water consumption, according to the study. Informative measures are a reasonable proposition to impact individuals by making individuals aware of their impact. Driving Effect (9) is given the score because it impacts individuals to be aware of the environment they live in. Raising awareness can be done through advertisement, governmental initiatives, education and a multitude of other informative and knowledge building acts. The Urgency (9) and Plausibility (10) of the driver is high, mainly because it is important to create awareness for the current, the newer and older generations. This is perceived and believed to be an act of progression. Thus, a long-term perspective in actions considered and initiatives implemented must adopt a holistic and lasting approach. It is urgent and highly plausible to implement as information is available for anyone to find. However, those who are not aware and do not acknowledge the situation are believed to be reached through a multitude of information channels for effective results. The Evolution (6) criteria score reflects that there is information available for anyone who wants to seek it. However, it can be developed even further by incorporating it into mainstream information channels and education. The central point of action is getting the message out to society for everyone to be aware of their actions' outcome, and the information is unitary. Information cannot and shall not confine nor contradict its purpose.

"We thought we would get a common communication concept and include the industry organization, but they were not mature nor had the human resources to take on the issue, or that it was not in the business plan." - Interviewee 12

"An interesting way is to convey the message to people how to change their behaviour. Technological development can be crucial. It is not a specific method but a combination of several." - Interviewee 10

5.2 Future Economical Drivers for Residential Water

5.2.1 Analysis of driver: Socio-economic

The driver Socio-economic was quite divisive in the international literature with conflicting results. This is reflected in the total summary of 16 points, the second-lowest score of the study. The socio-economic status of individuals in relation to water consumption was not unanimous in the literature as it was argued for being dependent on the geographical location, and no common conclusion could be withdrawn. Meaning that individuals with higher socio-economic status tended to consume more water in certain parts of the world, while in other parts, the opposite was noted. The interviewees were not also confident that this was the case in Sweden or, generally speaking. As the access to water is high for everyone and there is no disparity, clean water in Sweden is seen as a non-privilege. It is dependent on circumstances and environmental factors rather than socio-economic in most situations. Hence, Driving effect (6) is motivated by the polarised discussion of whether or not it affects water consumption. For instance, some consume more water as they have the water payment incorporated in their rent, leading to consumers not being aware of their actual consumption since the water billing is not disclosed. This payment structure is argued for making individuals not concerned with their water consumption. The relatively low score of Plausibility (3) represents that it is believed to be a low potential of actions and initiatives being implemented. Arguing that it is challenging to shift economies in a short time period. This was strengthened by most interviewees, which claimed water being cheap enough that it could be afforded by individuals regardless of wealth. The criteria Urgency (6) is treated equally in literature and interviews. There is no general perception that actions are required instantly. It was concluded that individuals with higher incomes usually have larger properties with more bathrooms than the average home and swimming pools. The urge of having swimming pools and maintaining green laws is in many aspects to uphold oneself socio-economic status in society, which is not frictionless to regulate through governmental initiatives. However, other initiatives can be done through informative measures and better regulating the price of water according to consumption patterns. The perception of the criteria Evolution (3) is also similar to the discussion before. The data set could not find any significant difference other than individuals with more buying power could be a market of introduction to water-efficient technology and water-saving technologies (e.g., rainwater collection systems). Because of the divisiveness of the literature and the agreement of the majority of interviewees regarding socio-economic status in relation to water consumption, this driver does not have a high score in any of the criteria.

"It could also be the other way around, that the status of having a pool in a residential area without water cannot look good. At the same time as in Australia, one can see that having a clean car indicates that the individual is an environmental culprit." - Interviewee 6

"It is not an unreasonable assumption that water consumption is greater in apartment buildings than in detached houses (villas). It is believed that this is the case as the fee is included in the rent for apartments." - Interviewee 10

5.3 Future Sociological Drivers for Residential Water

5.3.1 Analysis of driver: Behavioural Changes

The driver Behavioural Changes has the highest overall summarized score, 35, and is deemed to have the most impact on residential water consumption. Individuals actions and behaviour when consuming water will correlate highly with the volumes of water consumed. The overall results from the interviewees indicate that to change behaviour, a new relationship with water needs to be established. The criteria Driving Effect (10) scored the maximum of available points. Since both interviewees and literature unanimously concluded that effective change could only happen if individuals actively take action in society regarding their own and their peers' water consumption. Urgency (10) also scored maximal points since international literature and interviewees shared similar views regarding the urgent need to adopt new behaviour towards water and water consumption. Plausibility (9) of implementing the driver almost scored maximum because of the varying operationalability and the multitude of strategies that can be implemented. For instance, a strategy could be during showers to close the water flow when applying soap or shampoo, an easy way of effectively saving water. These types of changes must be adopted by society in a joint effort to minimize water consumption. The criteria Evolution (6) medium score is because literature claims the driver is evolved. However, the interviewees disagree with this and think there is a lot of room for improvement regarding adopting a more sustainable lifestyle and consumption patterns for residential water consumption.

"I think it is a whole re-revision of how we value water and how we use this linear thinking. We cannot just turn on the tap and expect to get water. We also need smaller systems that are flexible and circular where water production is decentralised." - Interviewee 18

5.3.2 Analysis of driver: Demographic Development

The driver Demographic Development has the lowest summary score, 14. The main reason for this is the common perception that demographic development is easy to study using statistics when studying age and life expectancy. However, factors of cultural or general lifestyle preferences are difficult to study since results with high accuracy are uncommon. Furthermore, the evolutionary development of individuals' choice and preferences changes constantly and evaluating these in statistical models can be challenging. In addition, it is also acknowledged in both literature and among the interviewees that demographic development has partly its own agenda, which is difficult to interfere with. Demographic development is also perceived to be a driver which spans over a multitude of other drivers. Meaning that there is a greater driving effect and potential in focusing on the other drivers. In addition, results are often shown latently. Thus, a low and unified score can be seen for the criterion Driving effect (4), Urgency (2) and Plausibility (3) except for Evolution (5). There was a split result on the criteria Evolution as the literature suggested that the driver is evolved, and there is not much change that can be done. While interviewees suggest that it is not as evolved and there can

be ways to create the right circumstances in society to make sure the demographic evolution evolves naturally.

"Young people are ambassadors for families. They are a medium for communicating how useful, cheap and smart water is." - Interviewee 12

5.3.3 Analysis of driver: Housing Development

Housing Development has a summary score of 29. The Driving factor (10) suggests that both studies had similar results. It is suggested that new housing will enable a new set of parameters for individuals to consume within. Meaning that if the right technology and systems are in place, it will ensure sustainable consumption. Then the user will be confined within those parameters, and in doing so, it will affect the individual's water consumption. This is the case with newer built houses and apartments with new and modern technology rather than older buildings that usually have outdated technology in terms of water efficiency and water use. Urgency (6) and Plausibility (6) criteria have equal score and distribution, indicating conflicting thoughts and arguments within the interviews and literature. The conflict resides in whether it is possible to implement the driver and if it is the most urgent to focus on in relation to water consumption. The basis of this conflict is whether there can be a sufficient amount of development on pre-existing houses. The Evolution (7) criteria scored a, 4, from the interviewees, and 3 from the literature. Suggesting that the driver must be more developed for a meaningful impact.

"Had the dialogue of interest meant a greater focus on water demand, we would have developed with sustainable water consumption in mind." - Interviewee 4

"Municipalities and housing developers have to work together, they have not been successful on a large scale." - Interviewee 5

"There are also interesting ideas, you can make demands on how to use the land, on the buildings that are erected." - Interviewee 18

5.4 Future Technological Drivers for Residential Water

5.4.1 Analysis of driver: Household Innovation

The summary score for the driver Household Innovation is 29, indicating that it will have a moderate effect on water consumption. The criteria Driving effect (10) getting the highest score possible. Motivated by the reason to believe that innovative technology and innovation, in general, will affect water consumption positively, i.e., decrease residential water consumption. With new technology, there is a possibility to have a similar or improved lifestyle while contributing to natural resource conservation. Urgency (7) and Plausibility (8) have similar scores, as there is a great need to constantly improve through new technology, which is most plausible for implementation. It is discussed that the implementation of technology will be dependent on the type of technology and how great the investment is in terms of finance and time. Evolution (4) has the lowest score for the particular driver. The low combined score

suggests that the driver is already developed and existing technology can enable a sustainable lifestyle. The literature had contradicting arguments and remarks regarding whether or not available technology is sufficient enough for reducing water consumption. For example, there is technology that can transform sewage water into drinkable water. However, it is not a standard technology and method to use since it is a common belief that technical water is as pure as water produced from conventional methods. Water-efficient faucets are shown to reduce water considerably and are available in most stores for a reasonable price compared to "non-water efficient" faucets. Water monitoring instruments are also available, showing decreased consumption for people to recognise their consumption patterns easily. To summarize, the technology is available to be adopted, but it is a question if it will be and when, if decided to.

"People need to be aware that water-efficient products will not mean a change in lifestyle." - Interviewee 3

"Water measurement is a positively contributing technology. It opens up opportunities to study behavioural patterns and develop systems according to them." - Interviewee 10

5.4.2 Analysis of driver: System Change

The driver System Change has an equal summarised to the driver Household Innovation of 29. Making the two drivers of Household Innovation and System change equal in terms of impact on water consumption. However, the distribution of criteria points differ. The score for the criteria of driving effect (5) suggests that it will not have a considerable effect on the residential water system. Most technologies regarding system changes are circulating or recirculating systems, which primarily will affect the withdrawal of water rather than residential water consumption. However, the criteria of Urgency (10) demonstrates that there is a need to continuously change and increase the sustainability performance of the system. Decentralised and circulating system as anticipated to be a contributing part in this development. Plausibility (6) of applying system changes has a score indicating that although there is possibility for change to be implemented, there are many ways to do it and finance it. This is also reflected in the criteria Evolution (8), meaning that the system requires development. The water sector in Sweden is generally perceived as conservative, which means that the same foundation and infrastructure built and established many years ago, withholds to this day. There has to be an update on the current system, but this requires a lot of investment and driving force, making it not plausible for some regions. System change does not exclusively mean changes to current infrastructure, but it also includes changes to better decision-making processes and work procedures. For example, fixing leaking pipes and how to act when natural disaster and drought inflict.

"The VA systems are very technical as it is the majority of engineers who solve problems. Societal problems that are technically solved." - Interviewee 14

"We see a need in developing a decentralized system since it will be less vulnerable because a smaller number of individuals will depend on it. It will also increase the

involvement of consumers in the issue of sustainable consumption and what is happening in the local area." - Interviewee 6

5.5 Future Environmental Drivers for Residential Water

5.5.1 Analysis of driver: Climate Change

Climate change may be one of the common topics of discussion in the scientific community, and there is a strong consensus that the climate is changing and contributing to the worse. This is also the case for residential water consumption. The summary score is 30. Driving effect (9), Urgency (9) and Plausibility (8) has a score that indicates the drivers' importance to the residential water consumption. It was clear from the literature and the interviewees that there were similar arguments and ideas of the driver. Concerning residential water consumption, the driver has and will have a significant impact to a point where there has to be consideration of how to deal with the driver. More importantly, have an appropriate response to it. Climate change and environmental discussion are as important as ever and should be a high priority of organizations and individuals regardless of societal status or impact. It is not revolutionizing the number of various options to combat the effect of climate change. However, the low score of the criteria Evolution (4) suggests that the driver is already developed. To be noted is that this driver should be continuously studied as the climate constantly changes. Although there are always new areas of research relevant for further exploration of climate change, there is enough evidence currently to act upon, especially in connection to residential water consumption and water extraction in general.

"*The problem with Climate change is very apparent. There are changes in precipitation and temperature that will affect the access to water."* - Interviewee 8

"Individuals are reactive with water. When individuals feel dirty they shower, as plants become dry individuals water them. Temperature will be a highly important factor to consider." - Interviewee 7

5.5.2 Analysis of driver: Environmental Awareness

The driver Environmental Awareness is the driver with the third-highest score of 33 points. Similarly, to drivers Informative measures and Behavioural change, it is about making individuals act upon existing information. For individuals to act according to existing information, it must be available and digested for a sustainable outcome. Driving Effect (10) scores the maximum available points, indicating that the driver will have a considerable impact on the outcome of residential water consumption. Urgency (9) and Plausibility (8) criteria highlight that it has the potential not only to be considered and implemented in existing systems, but must be done urgently and continuously in society. The Evolution (6) criteria have a score that suggests that the driver has been evolved to a certain extent, but more work is to be done. This driver is similar to many other drivers, where there have to be appropriate ways of communicating and making individuals realize the severity of different actions that directly or indirectly affect the environment. Creating awareness in its turn is to have a societal dialogue and create different types of reforms in legislation to make people realize the consequences of their actions. Like many of the other drivers, the driver Environmental

Awareness overlaps with other mentioned drivers. For it to have a positive impact, it has to be solved in accordance to other drivers.

"Climate change and water scarcity can be the two big trends in the future that can introduce new behaviour and consciousness." - Interviewee 5

5.6 Future Drivers and Trends of the Residential Water System

The performed MCA highlights the various degrees of significance the drivers have on the residential water system and its consumption, specifically the MDWC. Behavioural Changes scored a total of 35 points, the highest total score of the conducted study. Informative Measures scored a total of 34 points. Third place is occupied by Environmental Awareness with a total score of 33 points. Fourth place with 31 points is Laws and Regulations. A shared fifth place is between Climate Change and Pricing at 30 points. A common observation of the top-ranked drivers is the grading of the criterion Driving Effect and Urgency. All of the drivers acquired max available points or close to max. However, in general, the top three had an equal distribution of high grades regardless of criteria. Indicating that discussions regarding the drivers are of importance and topical.

The results of the study are primarily connected to the drivers' effect on MDWC rather than PDF. The interviewees had difficulties understanding the relevance of PDF for the study and the water system as a whole. Hence, the score of the conducted MCA is mostly a reflection of how each driver will affect the metric MDWC. However, what can be observed is, according to figure 2, the relation among the metrics Peak day consumption (PDC) through MDWC, which is equal to PDF. PDC is the day of the year with the highest consumption of water per capita. The literature primarily suggests these days appear during the warmer seasons of the year, late spring and summer. This is observed by the driver Climate change. The study has not concluded any specific analysis regarding the metric PDC. The authors have brought forward the topic of PDF in the interviews. However, the interviewees suggested that it was not of greater relevance compared to MDWC. This perception can be discussed, and it will be later in the thesis. If one can better understand trends and what drives consumption, i.e., MDWC, some synthesis of arguments could be used to understand the development of PDF better.

5.6.1 Analysing: The Distribution of Points

Besides scrutinizing each score individually, there is an opportunity to take a holistic perspective on the disposition of scores in the table of results. The max score of 40 for a driver was not reached for any of the drivers identified. The highest total score was 35 for the driver Behavioural Changes, and the lowest score was achieved by Demographic Development, 14. The mean score of the study is 30, and six of the 11 drivers were in this span of mean +-1. The total for each criterion was Driving Effect: 87, Urgency: 80, Plausibility: 79, Evolution 62. Since there were 11 drivers total and the max score for each criterion was 10 per driver, the total score summarized score for each criterion is 110. Suppose the score would be 66 or in the range +-4. It could indicate that the criteria are non-conclusive in a polarized debate where one unanimous decision or discussion regarding the criteria cannot be withdrawn. Hence, it can be observed and analysed that the criteria besides evolution were deemed to have some driving effect for the future, indicating that the choice of drivers are sufficient and adequate for the purpose. Hopefully, the driving effect will be enough for the driver to be considered. If not, the plausibility of implementing the driver and the urgency to act sustainably could tip the scale

for change. Evolution, as mentioned, scored the summarized score of 64, meaning that in general, the drivers are discussed as non-conclusive, and there are no conclusive arguments. The total number of points that could be assigned was 440, and 299 of them were assigned in this particular MCA. See bottom of table 3 for a visual representation of the distributions of points.

6. Discussion

In this section of the report, there will be a discussion upon the section "Results & Analysis". Discussing the drivers' significance on the system with a more in-depth focus on drivers with the highest and lowest scores. Furthermore, a discussion of the implications a sociotechnical analysis has on a LTS and the specific implications regarding the context of the sector residential water and its future. The section will also discuss general ideas about the future of residential water consumption and present potential scenarios. This section will also present how different stakeholders should use this study. Finally, this section closes with scrutinizing the methods used to give complete transparency of the research and the results of the thesis.

6.1 Significance of Drivers

6.1.1 Drivers of Greater Significance on the SOI

Three out of five of the highest-ranked scores are somewhat related to behaviour and awareness, targeting mostly the consumer of the system. According to the results, behavioural changes are the most important driver to pursue, but also the most important to scrutinize if Sweden shall reach a national average per capita of 100 litres per day in water usage. Vice versa, new behavioural changes could also increase consumption. Thus, it is important to consider both outcomes, but trends and evidence impose a decrease in water consumption as a natural and more likely outcome. However, for behavioural changes to happen, the right set of parameters must be set accordingly and effectively. Based on the results, it can be observed that Informative measures, the second highest-ranked driver, as key. It is also confirming the conclusions of Hughes (1986) and Joerges (1988). For change to happen and achieve its full potential, understanding the changes implemented are a prerequisite. The authors of this thesis have not conducted and completed a quantitative study examining the common perception of water in Sweden and cannot fully announce the following. That most of the Swedish people are not aware of the actual water situation in Sweden or how their own decision and behaviour will affect the present and future water system and ecosystem. However, it is suggested that informative measures will be an enabling factor in the quest for educational communication in the future. This statement is not to target nor discourage the informative efforts and attempts of all of the water utilities in Sweden. They have to their best ability and resource availability undertaken this immense task to complete. Nevertheless, it is concluded that new strategies must be identified and formulated. It may also be a question of source of origin. Information may need to reach customers through new platforms and originate from other sources to better acknowledge the present unsustainable consumption patterns of Swedish inhabitants. Change and information should also originate from regulatory frameworks. Redefining prior regulations and sometimes discussing outdated legislation is perceived to be an important action for the future.

The literature and interviews, in general, discussed that people have an ulterior awareness of environmental consciousness. However, it must be better triggered and targeted for people to act more sustainable regarding their water consumption. Many poses in both literature and the interviews that little sacrifices must be made to act and consume water more sustainably and sparsely. There is a lot of new water-efficient technology available which drastically reduces water consumption when used. Individuals need to opt for these solutions when

investing in new water appliances and faucets. Economic measures are discussed to be key. Individuals may also need to be charged more according to their consumption. Water in Sweden is discussed to be too cheap, and this conversation will be continued in the future. The price of water results in difficulties for individuals to see the actual value of water. There is also the aspect when comparing the expenses related to water consumption, energy and electricity, as a large portion of utility expenses are heating and electricity costs. Thus, making it financially reluctant to reduce consumption or to invest in water-efficient technology since the savings are marginal. This concerns both consumers and producers of water.

The problem becomes more complex since the cost of the system is based on the capacity of the system rather than the actual cost of water. Hence, in some sense, the cost of the system is fixed. Here the metrics of MDWC and PDF become factual since they determine the dimensions of the production system and the distribution network. Observing the equations in Figure 2 indicates this, specifically in the equation of PDF, which is the quota of PDC through MDWC. Furthermore, a significant difference between MDWC and PDC will result in a system with large capacity and unutilized capacity. Thus, contributing to a higher increase in the fixed costs of the system. Thus, if the PDF is equal to MDWC or relatively close, it would mean theoretically that the capacity of the system and consumption is as optimized as possible.

Observing international water pricing structures, lessons can be learned and investigated to identify the most suitable and optimal option for the situation of Sweden. It is not a question of restricting Swedish residents to consume something as valuable and critical as water for good and aspiring health. It is instead a question of how to inform and make people responsible for their actions. Spot market introduction may not be an applicable solution for Nordic countries with a good supply of water. However, Sweden in the future could face similar climate change problems to those of certain parts and areas of the US and Australia. Thus, the question of implementing such or similar systems is adequate and justified by its reason. It is acknowledged in the Swedish water industry that individuals consume more water than necessary. The fluctuating demand for water is deemed problematic for the future both in terms of production and distribution capacity, which is partly the reason for this thesis. However, there is also the aspect of climate change due to increased mean global temperatures. Inhabitants of the earth will experience new environmental challenges, and the water cycle from raw water to sewage water will be affected in all of the steps. Water may not always be available for production to meet demand due to increased temperatures, a shift in precipitation patterns and catchment areas. This is also reflected in the results since the driver Climate change got one of the highest scores in the study. Climate change is discussed to most likely affect PDF and contribute to the system dimensioning for increased residential water consumption.

By proactively preparing and reducing MDWC, the system and consumers become more sustainable towards water consumption. The harsh reality in the future of lesser water available per person and increased water scarcity globally could be a catalyst for initiatives of water conservation since the effects are more tangible. Thus also increasing general awareness and common perception of water. However, if the initiatives are delayed and not proactively considered, it could prove to be too late, similarly to the progression and status of Denmark. A country that at times had a MDWC compared to Sweden, but during the last 30 years have substantially reduced its consumption to around 100 litres (Danva, 2019). This has been done by proactively restructuring the water pricing structure and policies, making water

pricier but not financially disruptive. There are also the actions and incentives formulated towards reducing leakage, spillage, and better monetary allocation within the industry to increase effectiveness. In addition, informing the general public of water scarcity has been established early and has been continued, making 100 litres per person per day a natural state of mind for Danish residents. Based on the concerns, discussions, and conclusions of Gleick (2003); Markard, Raven and Truffer (2012); Kiparsky *et al.* (2013); Spiller *et al.* (2015), multiple factors must be considered when opting for the best technological solution. Despite the minor differences in how to handle and cope with innovation, the authors agreed that change is necessary and required. The literature proposes that much resistance is embedded in the infrastructure and stipulates hurdles for change. Hence, change will require new standards of thinking and technological implementation. Secondly, most interviewees and some literature agree that the linear flow of water and the existing centralized system will and have to change. However, there is also the perspective of which the water utility system is a part of the ecosystem since it extracts and returns water to collection areas. The water only takes the detour into the city. Similar to the natural cycle of water, water originates from one place and falls down in another place.

6.1.2 Drivers of Lesser Significance on the SOI

The authors have understood MLPs influence and implication on the niche and regime actors, which primarily focus on technological and regulatory aspects (Geels and Kemp, 2007). Extending MLP through P(L)ESTE has aided the authors in not actively or unconsciously disregarding any potential driver from the exogenous environment (Carruthers, 2009). In the case of the driver Demographic development, which is ranked the lowest of all drivers, it does not mean that it is not important to discuss nor consider. The aspect of affecting water consumption directly is relatively low, according to this performed study. Firstly, people are inevitably getting older and living longer due to the progression of health care possibilities and better quality of life. Secondly, older aged individuals can often be set in their ideas towards different topics, such as water consumption. Thus, minimising the chance of influencing their behaviour. Thirdly, cultural preferences are difficult to influence and change. However, the authors believe that a younger generation will be more susceptible to new ideas of changes in water consumption. Hoping that the younger and newer generation will continue to develop a better consciousness of sustainability and attitude towards sustainable consumption. However, to enable change in water consumption, individuals' attitudes and behaviours must be adopted by individuals regardless of age.

The same principle of arguments is also applied to driver Socio-economic., which has the second-lowest score. The basis of the score is that water is affordable in Sweden, and the access to water is argued to be constant, regardless of Socio-economic status. However, individuals with higher Socio-economic status usually are in other circumstances with greater options of activities, including water consumption. For example, larger houses and properties with pools could be a factor to consider. There is also the argument that these individuals often have higher education. Thus, implying they are more aware of the consequences of their action if they act accordingly is still debatable. There are also findings indicating that individuals with higher education work more and spend less time at home. Therefore, decreasing the possibilities of consuming water. Whether this is the case in Sweden is also highly debatable. Regarding individuals in Sweden with lower Socio-economic status, it is

found they have fewer possibilities of activities consuming water in their household but have a greater incentive. Incentives such as the fee for water is included in the rent.

In general, the drivers which could be labelled as originating and belonging to the Sociotechnical Landscape have ranked low in this study. Meaning that this evolutionary development may be difficult to affect and influence as change will happen regardless of a particular action. Certain outcomes could be predetermined. However, they can be critically understood to a degree where they do not induce a “short-term shock” of the system (Geels and Kemp, 2007). However, the sector was facing a “short-term shock” of environmental and climate change if acquiring a holistic view of the problem or occurrence. Globally and nationally (Sweden), for the last five years, the frequency of natural disasters has increased and may have contributed to a greater awareness of human impact. The actualisation of environmental impact and change will hopefully contribute to positive effects. For example, reminding individuals of their impact on the environment in general and in the question of water. However, the naively sparse and feeble actions to combat climate change have resulted in a snowballing effect, where the “short-term shock” has prolonged, and water becomes scarcer by day. Thus, creating a new era of dealing with future problems related to water, where practical actions will have to overcome theoretical possibilities.

6.2 Understanding the Future of a LTS through Sociotechnical Analysis

Through the developed framework (see Figure 4), the authors have accomplished the task of identifying drivers and trends of the observed system of interest with their significance according to the studied data set. Therefore, the MRQ can be deemed possible for the given and formulated purpose of this study. The conducted analysis gave answers to what drivers and trends will determine the future of water consumption based on the domain knowledge of the authors. However, this identified significance cannot fully declare future strategic decisions. The reason is that the authors do not have the specifics of what decision will be taken given the conducted analysis. Hence, if the conducted study would be duplicated by other individuals with another set of domain knowledge and experiences, the drivers and trends, including their significance, may differ. Likewise, would the scenarios which are to be discussed later in this section be different. Given the brief experience and insights of the industry of water professionals and the extensive knowledge among the interviewees. To their best ability, the authors can attempt to build scenarios, given the acquired knowledge and data from this particular study.

The study has continuously reminded the authors of the unsustainable attitude of conservatism towards system change. The difficulty of all stakeholders is to identify the circumstances and criticalities in a large system and specifically the system of water supply and consumption. The fundamental thought that the system cannot be observed as a “non-evolutionary black box” (Joerges, 1988) has shown significance when analysing the dimension of P(L)ESTE. Change can happen indisputably and independently to other dimensions, i.e., system artefacts can be substituted, disposed of, or redesigned. The study has encountered a lot of potential technology and innovation that could substitute prior technology and partly redefine the business model and service offering of water utilities for consumers. There are a handful of practically implemented new water pricing structures internationally, some proven

beneficial, others not so much. It was identified through the interviews that simple certification on water-efficient technology or water-efficient houses, similar to what is indicated if a house is energy efficient or a fridge, could be effective. However, if not the system perspective is acquired, the potential risk of reaching the “irreducible potential for controversy” (Joerges, 1988) would increase. Individuals tend to be reluctant to change in a system where concurrent systems are acceptable in the common eye. This leads to a disparity in perception of a dysfunctional and functional system, particularly for this study of urban water supply. It has been highlighted by this study showing a broad distribution of points when observing the compiled and objective results. Individuals have fostered a mentality that water is an unlimited product. Once supply seizes, the consequences are accelerated, and reactions increased. Shown in later years where the topic and discussion of water have increased in Sweden due to change of climate, increased periods of heat and drought, lesser and skewed precipitation patterns making problems related to water more tangible. It may be that pre-emptive action is the best course of action rather than acting reactively to current and future water situations. Preemptive action could act as a deterrent to any type of water constraints, such as risks of increased levels of water production and consumption during certain times of the year.

It can be observed and concluded that the system requires niches to happen across a multitude of dimensions in the system (Geels and Kemp, 2007). Behavioural patterns and practices must be in place. For it to happen, new technology and regulative structures must set new parameters for individuals to act within and become a new setting of default. The system cannot solely trust the change on an individual level to happen. It must also conceive a change in the sociotechnical system to enable regimes to happen (Geels and Kemp, 2007). Redefining and changing the perception of the value of water across all institutions could be beneficial. The collective understanding of routines and social norms may also induce a more sustainable and collective perception of the value of water. The study shows traces of both understanding the requirements and urgency for this to happen, and that it does happen across the industry. However, the initiatives are sparse and have not reached their full potential. Reducing and potentially reconstructing the path dependency of the development of water infrastructure and practices will be an important action. Lock-in effects (Geels and Kemp, 2007) are evident in the industry, and the water industry has been criticized for being conservative and reluctant to change for many years. Whether this is factual is difficult to conclude. From an external perspective, this may be the perceived sight of reality. Internally, the industry has been a victim of lock-in development, large, unmodern, and costly infrastructural networks and big production sites, resulting in an abundance of sunk costs. Water infrastructure is mostly dug and submerged below surface ground. Some of the raw water is also extracted from ground water marks, meaning that water is visible primarily for the average consumer when turning on the water faucets or taking a shower. Contributing to a relatively high level of presumption and mentality of water being available around the clock all year. The product water is relatively simple and may have contributed to the presumption that water shall be available around the clock. Water shortages due to drought and production faults are occasions where water supply is seized, and the value of water to consumers is tangible. It is presumed that the climate will affect the precipitation patterns and watermarks, thus contributing to an increased risk of water shortages.

6.3 Future Scenarios of Residential Water Consumption

All of the research questions have both been answered and discussed in previous sections of this chapter. However, the opportunity would be wasted not to use the data collected and analysed through the methods posed by this study. To not discuss what possible scenarios will inflict in the future for the water sector. Furthermore, what this will mean for the MDWC and PDF. Below will four different scenarios be posed and discussed with some additional prospecting of the future. It should be noted that formulated scenarios are a few of many possibilities. The scenarios presented are the most possible based on the results of this study.

There is a common perception and ideal reality among the water industry professionals, in this study, that MDWC equal to 100 litres is not an unrealistic future. There is close to no evidence that MDWC will increase from 140 litres per day. Regarding PDF, it is suggested that this measure will not increase but could most certainly variate over the years to come due to climate change and higher temperatures which usually drives peak consumption. However, an important aspect of PDF is the frequency of which days the consumption is close to PDC. The PDF quota may not be drastically impacted, but the understanding of PDF frequency could enable a better grasp of how to deal with consumption patterns. The study also suggests that apartments will be the major contributing factor to the MDWC, while detached houses will primarily contribute to the PDF. Studies suggest that apartments do usually have a higher MDWC compared to detached houses. The number of apartments is also growing rapidly, increasing the need for sustainable and water-efficient housing. During warmer seasons, detached houses and individuals who occupy these have a greater reason to consume water, i.e. watering lawns and filling up pools. The difference is that although these factors should decrease over a year, they will increase if the circumstance provokes it. Circumstances such as climate change contribute to higher mean temperatures and lesser precipitation, increasing the risk of droughts. It will also create reasons for individuals to consume more water.

A predetermined conclusion (Schwartz, 1997) of this study is that warmer weather increases individuals' consumption. Individuals may consider the effect of their actions during periods of drought and low water levels, but they may not act accordingly. The reason being individuals' perception of the value of water and their right to consume water since they pay for it. Systemic changes like desalination or recirculating systems will decrease the volumes of raw water extraction. Thus the possibilities of water depletion will significantly reduce. However, it may result in consumers thinking that consuming water will be a way to cope with their consciousness of sustainability, resulting in negative rebound effects. It could potentially lead to increased consumption of water among individuals since it is sustainably produced. Increased efficiency of the grid network could also act similarly since water is treated more efficiently. Similar to what is happening in the car industry, where cars are getting more fuel-efficient. However, it has in some instances, resulted in individuals driving longer distances. Efficiency increases but so does consumption. This could be detrimental to the development of reducing water consumption and will be an important factor to consider when innovation and new technology is implemented. A more efficient and functioning system can also show water consumers that water is more valuable than letting it leak out through broken pipelines. Thus, it is vital to continue the proactive work of informing consumers that reducing water consumption should be of priority to reduce the implications and the risk of water scarcity. The scenario where water consumption increases is deemed highly unlikely. However, maybe the

market is not mature enough for it to happen, and behavioural changes must happen before systemic changes are in place and water deficiency is history.

However, it may be discussed previously that a potential scenario (a) could be labelled as "business as usual" with a slight gradual decrease of MDWC yearly. However, the inherent and unsustainable perception of water restraints the plausible rate of decrease. How this will affect PDC is harder to predict, but there could be a lower average of PDC, which means that the PDC would be significantly lower during some seasons of the year while higher during other seasons. Imaginably it will be higher during dry summers as individuals would use water for more activities than regularly, such as gardening, cleaning outside, washing vehicles and using swimming pools. Regardless of whether individuals are aware of their consumption, they would identify a need and justification for the water to be consumed. However, this scenario could also be overacted since much more proactive initiatives, and tangible effects of climate change are a fact. However, this reality of depleting water marks and warmer climate have not reached the population since this is mainly issues in the southern parts of Sweden and specifically the east coast. This scenario where individuals are not willing to change their behaviours will significantly impact the development of water consumption and the decrease of water consumption. Water consumption is indeed highly associated with individuals' behaviour as it is something humans consume and use for most everyday activities. The authors pose that no immediate changes in water behaviour will happen unless action is taken. Informative measures will be an important part of this action.

This second scenario (b) is an extension of business as usual with the gradual rate of decreasing MDWC yearly. However, the rate could be perceived as a more stair-like progression. During periods of 10 years, the decrease of MDWC is noticeable. The PDF is also expected to be constant, but the frequency of days where consumption is close to PDF is decreasing. This is expected to result from a better water pricing structure where individuals are responsible for their consumption and pay accordingly. Laws and Regulations are supportive in the battle against unnecessary consumption where little to no content is a victim of misinterpretation. Water-efficient technology for households is continuously being adopted. The consumer can now better identify these technologies where a standardized and visible system of certification is in place, showcasing water savings for the product similar to what can be found on household appliances or TVs regarding energy consumption. Individuals will continue to develop their perception of water consumption and environmental awareness. It is a slow progress, but the development is moving forward. The water utilities are also continuing their work as usual, and change is happening in small portions. No radical innovation is adopted to disrupt the business model and induce system changes. Work within the water sector consists of being proactive rather than reactive. There are better strategies for coping with the increased possibility of scenarios and seasons where water levels are low. However, housing contractors notice the slow progression of people getting more involved in water questions like the politicians and similar to what happened with the industry regarding electricity and heating in 2005 and forward. A direct focus on water-saving technologies is being adopted in bigger housing development complexes. Slowly, but surely aiming for the target of MDWC at 100 litres.

A third scenario (c) would also be an extension of scenario one and two. Besides these initiatives realized there is also the adoption of smaller and decentralized re-circulating systems in apartment complexes. The system is treating water more efficiently and using small

volumes of water to achieve individuals' everyday needs, where the right water of quality is available depending on the activity. However, this is difficult to adopt in already established residential areas and estates. Change is happening in newly built residential areas where economies of scale exist. Rain-water collection or smaller silo of water storage underground are adopted in a modest amount among already established estates. However, there is still a redundancy against the saving in adopting such systems.

The fourth scenario (d) poses a future where the water sector is solely re-circulating a given amount of water, and water extraction is a net positive. Smaller decentralized production facilities are a reality and means that communities rely on them to deliver. However, it will require an extensive overarching organization that proactively ensures uptime of facilities and people must understand and acknowledge that water quality is not compromised. It will also mean that societies are more self-sustained and a lesser threat if disaster strikes.

6.4 Scrutiny of Methods

The authors did not initially identify nor fully understand the importance of LTS. Thus, it became clear why the application and foundation of such a theoretical framework would prove to be scientifically beneficial. Giving the authors the possibility to acquire a holistic perspective in understanding the problem. The authors were also not interested in one individual's reaction and behaviour in the system, but rather how the collective of individuals would react to changes in the system. The interest lies in how would the behaviour of individuals change in the system and affect the system itself. These dualities of influence and impact of the three perspectives (industrial, functional and individual) will be crucial for achieving the objective of the report. As the water system changes and affects other systems, the ecosystems or the sociosystem will affect the water system. Likewise, will technology and legislation be part of the dynamic change.

There is always a need to reflect on how the study could be performed better and where things could have been done differently as well more efficiently. This study's complexity meant that the research design, methods and theoretical framework were chosen based on authors' knowledge collected from their academic background. Prior studies have not been done in this exact setting or a similar context. Thus it has required the authors to be creative within the frame of science to construct a methodological approach on the area of interest. The pre-study required much time for the authors, as there was a clear objective but no clear approach. The authors had to identify different relevant and achievable objectives that met the necessary criterion set by the stakeholders. Although the pre-study was a difficult hurdle to overcome, it gave the authors a clear structure to work by. However, this put the authors in a constrained time frame. Through an established and formulated plan, the authors could work and keep up with the time frame. Henceforth, it also allowed the authors to narrow down the scope more effectively. This ensured the authors an effective way of allocating time for the different components of the work, such as identifying scientific tools and methods, finding literature and conducting interviews.

The authors also have a critical view of the results, as it may not be representable in some aspects. For instance, the literature studied and examined for the different drivers is highly likely, not the only available literature. Then it becomes a matter of whether the chosen literature to study can represent a particular driver connected to residential water consumption.

Also, if additional excluded literature should have been incorporated to increase the accuracy of results. Furthermore, it means that the authors must question if the chosen literature based on the search criteria is effective for sorting literature. For example, if literature chosen on the factor as most cited is diverse enough to bring forth and score. By choosing the most cited literature, the authors can look at the most popular research among scholars. However, literature was also chosen based on search criteria such as relevancy and date of publication to increase the spectrum of knowledge. The authors also perceived that literature conducting similar studies was sparse and difficult to find, which could be indicated by the multiple keywords used in the study. Meaning that the authors had to acquire a broad perspective when searching for literature available. The majority of the literature chosen has an international origin that could question the aspect of understanding the context of Swedish residential water consumption. However, the majority of interviewees were experts on the Swedish water utility sector, and their answers reflected international literature, according to the results. See table 3. Thus, it confirmed that it was valid to use the chosen literature in the Swedish context.

This research scours uncharted territory in Sweden. It can be further explored since the results cannot be fully confirmed. As this study is of qualitative nature, it requires objective judgement on the decisions regarding the scoring of the criterion for each driver. The difficulty lies in casting judgement when deciding, as there is always a factor of subjectivity in each decision. To reduce the subjectivity, the authors can conduct a quantitative study identifying the correlation between the factors and the development of MDWC and PDF, confirming or disconfirming the results of this study.

Criticality must be inflicted on the interview processes in relation to the results. The authors have to contemplate if the correct questions have been asked to fulfil the purpose. Furthermore, if the semistructured interview process has provided enough structure for the interviewees to answer. Meaning if the interview process affects the relevancy of their answer. The authors also must reflect upon if the chosen interviewees represent the sector adequately. Therefore, a wide range of field experts was interviewed to get educated answers on each driver. The individuals interviewed in this study, within the water utility sector, could be deemed members of eco-chambers of ideas, as many experts are familiar with each other’s work. This creates the problem of not getting a wide range of nuance in their answers. Then it becomes important to bring in professionals from other industries with another perspective on existing problems, which the authors did for this study. As well there can be questions, whether the authors gave an appropriate score regarding the empirical study. To ensure objective scoring, the authors need to base their opinion on the facts from sources for each driver, which was the case. However, scoring might have been more valid and representative if each driver was scored individually by the interviewed individuals. This could be a way to give an accurate description of the collective opinion within each criterion.

6.5 Practical & Theoretical Contribution

The result of this thesis could be used by different stakeholders depending on their different purpose and aspiration. If the stakeholder is Norrvatten, then this report should be used as a summary of relevant drivers that affect their production demand. The drivers should be continuously researched, observed and adjusted given their development over time. For example, as society evolves, Norrvatten must keep up with the development to understand

how to make strategic decisions most efficiently. Norrvatten can also further extend upon this thesis to identify other drivers. This will ensure that they get an even more accurate description of the current water sector. However, it is essential to highlight that any similar water utility provider can use this study to its advantage or for inspiration. As this study was made based on Sweden, additional parameters can be considered when delimiting to a particular region of Sweden.

This study should be perceived as a different perspective to understand the development of large infrastructural systems through LTS, MLP, Scenario Building, PESTLE and MCA. Through this study, it should help researchers for exploration of LTS that include water or other natural resources. It can also be used as an inspiration on how to understand trends and factors of a system. The uniqueness of this thesis is that the setting is different, and methodology is unique to the extent that it has not been previously performed in Sweden. Therefore, it may open up doors for extending this research in Sweden, as well as looking at other non-explored settings.

7. Conclusions

This thesis originates from the desires of understanding how residential water consumption will develop in the future. However, this poses additional concerns to address, such as how a LTS should be studied and understood. Furthermore, how to utilise and evaluate this knowledge of the system domain and dynamics to build potential scenarios of the SOI. This thesis poses one structured way to understand and build potential scenarios for a specific SOI, given that it qualifies as a LTS. See Figure 4.

To uncover how the SOI functions, it is crucial to understand the dynamics of the system. This is posed to be accomplished through scouring literary sources, research coverage and an empirical interview study. Combining this with the fundamental knowledge of how a LTS functions, and what dynamics interplay in such systems through the levels of MLP. The authors pose that sufficient knowledge of the system domain is acquired. LTS dimensions originate from the analytical model of PESTLE, which are posed to uncover NRV. NRV data are to be analysed and translated into a quantitative model by the analytical ranking model of MCA. These drivers could not only be identified but also graded through four criteria with the purpose to quantify driving effect, urgency, plausibility, and evolution. The aspiration is to compare how the literature perceives the driver contrary to how interviewees perceive it. From there on, the authors have to a certain degree, attempted to formulate future scenarios for the SOI.

In table 3, relevant drivers are presented with a summary score determining their significance to residential water consumption and its future. If the LTS changes, the results will most certainly differ, and the exclusion or inclusion of drivers could change, respectively. Likewise, if the scope of the project changes, the results would most likely change. The distribution of grades and ranking of significance for the future does not mean that other analysed drivers will not affect the SOI. Instead, depending on how they are managed, their significance may differ. Furthermore, it should be noted that the drivers should not be managed independently but rather as a collective of drivers. Some of the drivers relate to each other as they overlap and are interconnected. This research has studied the drivers' effect on the SOI independently at first but is discussed in “Discussion” codependently.

According to the study, the most impactful drivers are connected to behaviour and awareness of the drivers identified and analysed, i.e., the drivers' Informative Measures, Behavioural Changes and Environmental Awareness. The attitude towards water consumption is interlinked with awareness towards the value of water. For there to be a positive outcome of a driver, the consumer must be aware of the significance and decide in accordance with the driver’s effect and importance. Meaning that it all depends on how educated the consumer is and act accordingly. Accountability could summarise initiatives required for societies to act more sustainably in the future regarding water consumption. The study concludes and suggests that individuals must understand and take responsibility for their actions. There is no dispute in this study that the price of water is low in Sweden. Fundamentally, the price of water does not reflect or even remark the actual value of water, compared to far more expensive natural resources with lesser importance to life and health, such as gold or diamonds. Thus, accountability and responsibility will have to increase along the value chain. This can be achieved as discussed in multiple ways. For example, restructuring the pricing structure,

regulatory framework, and legislation supports the purpose of better and more effectively value water. This will hopefully result in educating individuals in what their action implies for the welfare of water. Positive change in consumers consumption can also be achieved more efficiently if producers lead by example, which means that consumer accountability could potentially increase due to identifying how the system owners take responsibility and accountability. Technological advancements and innovation will be an important part. Most sources deem that technology is available both for consumers and system owners. However, both actors have difficulties in deciding what technology should be adopted and implemented. There is uncertainty and unawareness of what the future holds, and costs are substantial. Thus, creating a reluctance for change.

Ultimately, awareness among individuals can be achieved by a multitude of initiatives, which is showcased in this thesis. However, by staying true to the method proposed by this thesis, one can better understand what areas of focus could be important for consideration and steer the future along a more sustainable path of natural resource consumption.

7.1. Future Research

Future research on the same SOI can be approached by conducting a deeper and more detailed analysis of each driver. Details such as understanding the link between each driver and how the different drivers affect each other. Giving more clarity and nuance in the analysis. Studying countries comparable to Sweden, comparable in natural resources and economic status, can confirm if the drivers for this study are the most significant for residential water consumption. Furthermore, there could be further research to understand and identify drivers that affect other countries' residential water consumption. Studying a country in another setting may result in additional drivers and new perspectives to increase nuance and understanding of the future. Another intention of this research is to pave the way for different or similar approaches on LTS to identify drivers for the future, which means that the approach suggested by this study is not static nor perfect. Hence, new characteristics and factors will require a flexible approach within the frame of science.

As this study is qualitative, it has some limitations. Specifically, the identified and extracted data has been subjected to a degree of subjectivity, which puts limits on the research. In addition, the data collected was not in the format of numbers, where the authors could construct statistical significance and conclusions. Instead, the data collection required the authors to compile sentences, context and reasoning to construct valid conclusions. Adopting a quantitative approach can be another confirmation if the drivers chosen are the most significant. Utilising other analysis tools than MCA could also be a way to minimize the subjectivity of the result.

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