Understanding domestic water use in rural & peri-urban region of Valle del Cauca, Colombia: an application of the VBN framework

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Preface

This research project marks the final step to obtaining my Master's in Civil Engineering at the Delft University of Technology, in the field of Water Management Engineering. It was an exciting and challenging experience to find new insights and approaches to the use of domestic water in rural areas.

I am particularly grateful to Saket Pande for his valuable guidance. The knowledge of hydro-sociology and modelling of water systems shared during our meetings helped me a lot in developing my research.

I express my deep gratitude to Diana Callejas, my daily supervisor at TU Delft. Her support since the moment I was looking for my thesis project is highly appreciated. I greatly value her continued assistance and guidance throughout my project.

I am deeply grateful for the support of Erick Mostert. His critical thinking and knowledge of social research and research design have been essential to the development of my thesis and are much appreciated.

Finally, my deep and sincere gratitude to my family, my husband and my dear friends for their continued and unparalleled love, companionship, help and support. Their encouragement and teachings have made this Master's degree an enriching life experience.

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Summary

This study explores domestic water use in the rural areas of Santiago de Cali and Restrepo, Colombia, focusing on the application of the Values, Beliefs, and Norms (VBN) theory to understand individual water use behaviours. Recognizing the critical importance of water as a fundamental resource, the research addresses the complexities of water management, particularly in the context of increasing demand and inconsistent availability. The study seeks to fill gaps in traditional water use research by incorporating psychological factors and decision-making frameworks, aiming to contribute to the broader field of water management.

Utilizing data from 926 households, the study employs a multi-linear regression analysis to examine the relationships between socio-economic factors (SEC) and VBN psychological factors with three dependent variables: perceived total water use, shower time, and the use of water-saving devices. The analysis identified significant predictors of water use behaviour, with VBN factors providing additional explanatory power beyond that of socioeconomic variables. Specifically, VBN factors accounted for an additional 2% of the variance in total water use, 3.3% in shower time, and 4% in the use of water-saving devices. Values, particularly biospheric and altruistic, were the most consistent contributors to water-saving behaviours, while beliefs had minimal impact.

The findings highlight the importance of promoting biospheric and altruistic values, as well as reinforcing personal norms related to water conservation, in encouraging sustainable water use behaviours. Educational campaigns that emphasize the moral responsibility to conserve water and the community benefits of sustainable water use are likely to be effective, particularly in rural areas. The study also notes that individuals with strong egoistic values, such as a desire for unlimited water supply, are less inclined to adopt water-saving behaviours, suggesting the need for targeted interventions that connect personal benefits with conservation efforts.

In conclusion, while the VBN framework provides valuable insights into specific water use behaviours, its overall impact on total domestic water use is moderated by contextual and socioeconomic factors. Future research should continue to explore these dynamics, with an emphasis on developing tailored interventions that address both the psychological and contextual determinants of water use behaviour. This approach can help policymakers and environmental educators foster more sustainable domestic water use, particularly in rural areas where such factors play a significant role.

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Chapter 1

Introduction

Water is a basic and fundamental resource for the development of any society. Water is a naturally occurring resource that is renewable, but its temporal availability in terms of both quantity and quality is not always guaranteed, which can cause communities to struggle. Furthermore, as the demand for water continues to grow, it has become increasingly vital to understand the complex dynamics of water management (USGS, 2019). To mitigate the problems with sustainable management, a comprehensive understanding of how this resource is managed and used may be helpful (Bouman et al., 2018).

This comprehensive understanding not only entails the technical aspects but also the contextual and psychological factors that influence its utilisation and conservation. The knowledge would not be complete without understanding the decision-making frameworks related to water use on an individual scale (Russell and Knoeri, 2020). This research explores domestic water use from the perspective of individual behaviour and the relationship people have with this resource.

The objective of this exploratory study is to identify to what extent the Values, Beliefs and Norms (VBN) theory is applicable to understanding domestic water use in the rural areas of Santiago de Cali and Restrepo, in Colombia. This study enhances the traditional methods of researching domestic water use, which mostly concentrate on social and technical factors (Corbella and i Pujol, 2009). However, there were gaps remaining in understanding individual behaviour and psychological factors have started to be considered in different research on water behaviour studies to address this. However, this is not a deeply explored area, and there is an ongoing need to explore these factors more deeply in water management engineering (McCarroll and Hamann, 2020, Russell and Knoeri, 2020).

This study uses Stern's VBN theoretical framework as a tool to study domestic water use. In summary, the VBN theory is a behavioural framework that attempts to explain how pro-environmental behaviour results from a causal chain that includes values, general environmental beliefs, awareness of consequences, attribution of responsibility, norms and, finally, consequent actions. (Bouman et al., 2018; Lind et al., 2015; Stern et al., 1999). The focus on studying pro-environmental behaviour that this framework represents, is the reason why this behavioural theory was chosen to study how people use water indoors, as water is a natural resource. Additionally, the VBN has not been widely implemented to comprehend domestic water use behaviour despite its potential applicability in the water management field (Van der Linden, 2015). Therefore, the focus of this research is to contribute to expanding the field knowledge on domestic water use by applying this framework.

The database was provided by PhD candidate Ir. Diana Callejas, and consists of 31 questions asked to 926 residents of eight rural areas with different water supply systems in Colombia, with each respondent representing their household. The database consisted of self-reported information, which relies on the perceptions of the respondents. It is important to note that this exploratory research is part of a broader study conducted by PhD candidate Ir. Diana Callejas (Callejas Moncaleano et al., 2023).

In order to provide insight and have a better understanding of the VBN theory, an extensive literature review was conducted. In addition, a multi-linear regression method was implemented to find relationships between the VBN theory and domestic water use.

1.1 Research question

To what extent is the theoretical framework of VBN applicable to the understanding of water use in the rural areas of Restrepo and Cali in Colombia?

1.2 Objectives

- Obtain current information about the VBN theory.
- Apply the VBN theoretical framework to domestic water use.
- Describe if the VBN theory could influence/explain the domestic water use in rural areas of Valle del Cauca.

This report is structured as follows. In chapter 2, the literature review about domestic water use and the VBN theory are presented, accompanied by case studies where the theory was applied to study people's environmental behaviour. Next, chapter 3 outlines the methods and materials used for this research and information about the study area. In chapter 4, the report delves into the research results. Chapter 5 discusses the contribution of the VBN theory and the limitations of this study and provides suggestions for future research. Finally, in chapter 6 the conclusions are presented.

Chapter 2

Literature Review

Domestic water use plays a critical role in societies, requiring an understanding of the factors that drive consumption and usage. To enable societies to address sustainability challenges and develop appropriate solutions, reliable knowledge about changes to freshwater resources and their usage is required (Fan et al., 2013).

We cannot understand or make future predictions about the dynamics of the water resource system without understanding how economic gain, environmental degradation, and social situations play out in society, and how individual and social perceptions of these issues impact management decisions related to water consumption and use (Srinivasan et al., 2017). This understanding will remain incomplete until we fully address and understand the issues that arise from human culture, including how components of culture, i.e. values, beliefs, and norms, relate to water use (Sivapalan and Blöschl, 2015).

The literature review will evaluate existing literature and research concerning domestic water use and its relationship with human behaviour. In particular, the review will dive into VBN theory as a framework for understanding these dynamics. Additionally, it presents cases where the VBN theory has been implemented.

Literature selection

A systematic literature review was conducted across multiple academic databases. The primary databases utilized were ScienceDirect, Scopus, JSTOR, Web of Science, PubMed and Google Scholar. These platforms were chosen for their comprehensive collections of scholarly articles and publications, allowing for a thorough investigation into the relevant topics.

The initial step in the literature review involved identifying and selecting material literature that applied the VBN theory to environmental behaviour, with a particular emphasis on domestic water use. This was achieved by employing a strategic combination of keywords in search engines, including terms such as 'Values Beliefs and Norms theory', 'pro-environmental behaviour', 'domestic water use', 'psychological factors' and 'water conservation'. The results from the searches were filtered based on relevance, with a focus on studies that provided significant insights into how the VBN theory explains water use behaviour at the household level.

In the initial search strategy, terms specific to the Valle del Cauca region, such as 'Valle del Cauca,' 'Restrepo,' and 'Rural Cali,' were included. However, due to the lack of relevant studies in these areas, the terms were removed to broaden the search to more general contexts of domestic water use. Also to reduce the amount of articles retrieved, the search was filtered limiting the area of interest to engineering, environmental science, decision sciences and social sciences. In Table 2.1 below, the main search queries employed across different platforms and the number of results retrieved are presented.

Table 2.1: Initial search strategy

Topic	Values beliefs & norm theory and domestic water use			
Concept groups	VBN theory	water use	Factors in domestic water use	Study zone
Develop terms; define search terms / Keywords	VBN theory/ pro-environmental behaviour/ Values beliefs & norm theory	Domestic water use/ domestic water usage/ water conservation	Contextual factors/ psychological factors/ environmental values	Valle del Cauca/ Restrepo/ Rural Cali
Truncation/relation	(Concept 1 OR concept 2) AND (Concept 3 OR Concept 4)			
Search strategy	(Values beliefs & norm theory) AND (domestic water use or psychological factors or water use)			

Note: 1,426 results search results found in Scopus, 2,704 in ScienceDirect and 80 in JSTOR, 235 in Web of Science

The search queries were carefully designed to capture a wide range of studies relevant to the research objectives. The articles retrieved were screened according to their titles, abstracts, and keywords to ensure thematic relevance to the research question. Preference was given to studies that examined the relationship between psychological factors and water use within domestic settings, especially those applying VBN theory. Following the initial filtering, the selected articles underwent a thorough review to extract key insights and data that would inform the development of the research framework. The main themes emerging from the literature were categorised into three broad areas: VBN theory, psychological factors influencing water use, and contextual factors. Keywords associated with each theme were noted to guide further analysis and categorization of the literature. Where necessary, terms with similar meanings were grouped to refine the analysis further, ensuring a comprehensive review of the literature.

The literature was synthesized to highlight gaps and opportunities for further research. This synthesis formed the foundation for the subsequent phases of the research, including the development of research questions and hypotheses.

The literature review process was integral to identifying the core theoretical frameworks and empirical findings that would guide this study. By systematically selecting and analysing a diverse array of scholarly sources, the review provided a solid basis for exploring the complex interplay between environmental values, psychological factors, and domestic water use.

2.1 Previous studies about domestic water usage

This section explores the literature and evolution of research on domestic water use, from investigations focused on socioeconomic and contextual factors to the incorporation of psychological factors. In the next section, the VBN theory is introduced to analyse domestic water use in rural areas.

Socioeconomic factors are integral components of the contextual factors that influence domestic water use. These factors refer to the social and economic conditions, such as income level, education, employment status, occupation, social status, access to resources, cultural background, and living conditions, that shape individuals' behaviours, attitudes, and opportunities. Contextual factors encompass the external elements that impact a given situation, including the physical environment, social context, and demographic situation (Constantino et al., 2021). They are defined as environmental influences that affect an individual's behaviour, emotions, and cognition, distinct from internal dispositional or psychological factors, which are internal or individual influences. Consequently, contextual factors, including socioeconomic conditions, play a significant role in shaping behaviour, with widespread acknowledgement of their importance in the analysis of environmentally significant behaviours (Steg and Vlek, 2009). Understanding the role of these contextual factors is crucial for comprehending how context shapes behaviour and decision-making processes, particularly in situations involving water use, which entail complex decision-making dynamics.

Previous studies on domestic water use have emphasized a broad array of contextual factors, including socioeconomic status, demographic characteristics, and climatic variables. For example, Corbella and i Pujol (2009), underscores the importance of socioeconomic factors in understanding the driving factors behind water consumption. Their work analysed existing research on domestic water demand factors and the relation between domestic water usage and contextual factors such as price, income, household size, age and climate in urban environments. Although the scope of this thesis is domestic water use in a rural area of Colombia, this study reviews different literature and most of the concepts are applicable to domestic water use.

Water price is the first factor considered in influencing domestic water usage, as price represents one of the most relevant strategies to reduce water demand (Arbúes et al., 2004). The reason is that higher water prices lead to lower consumption, which is true to a certain degree, however, water is not a pure economic good and many water uses are essential and irreplaceable (Shaw, 2021).

Households are crucial for analyzing changing sociodemographic structures and are an important scale for environmental and resource analyses (Esteve et al., 2024). In principle, the higher the number of people living in a household, the larger the expected aggregated water demand. The age structure of a given population is another relevant driver of domestic water consumption (Fan et al., 2013). Basically, older people tend to spend less water per capita and families with children can be expected to use more water. Education appears to be related to environmental consciousness and awareness. Related to water use, this could be translated into the purchase of water-conserving appliances or the planting of drought-tolerant garden species (Bich-Ngoc and

Teller, 2018).

Climate is one of the most explicate drivers of domestic water use and consumption. In other words, domestic water consumption is supposed to vary depending on climate variables, especially temperature and rainfall. As mentioned, early research focused on socioeconomic factors to explain domestic water use. Demographic factors were added to the analysis such as household size, age, gender and education. When complementing this with climate factors, domestic water use is analysed from a complete view of contextual factors (Corbella and i Pujol, 2009).

The analysis of the contextual factors is very important in explaining domestic water use. However, the psychological factors related to domestic water usage have not been fully explored in the literature, it is only in the last years that these factors have started to be considered in many studies (Corbella and i Pujol, 2009; Daniel et al., 2019; Guo et al., 2022; Sanchez et al., 2023; Whitley et al., 2018), and therefore it is necessary to contribute to this gap in the existing literature.

Psychological factors such as attitudes, values, beliefs, motivations, norms and perceptions, play a crucial role in shaping individuals' behaviours, including those related to water use (Stern et al., 1999; Stern, 2000). With the maturation of environmental psychology, researchers go deeper into the psychological determinants of pro-environmental behaviours, including those related to water conservation (Allen, 2016).

Russell and Knoeri (2020) explored the complex interaction between psycho-social factors and household water conservation intentions. Their findings provided insight into the complex web of motivations, attitudes, and beliefs that support individuals' water-saving behaviours. Their study highlights the importance of understanding the socio-psychological dynamics shaping water use patterns. Similarly, Addo et al. (2018b) found that psychological factors such as values, beliefs, norms, trust, and emotional reactions significantly influence water conservation actions. This study emphasizes that effective water conservation interventions must consider these psycho-social factors alongside socioeconomic and environmental variables to be successful. These studies increased the understanding of how psychological factors influence people's decisions about water use, setting the framework for broader approaches to water conservation programs (Sanchez et al., 2023).

This growing trend of incorporating psychological factors alongside traditional contextual and socioeconomic analyses paves the way for a more comprehensive approach, which led to the focus on the VBN theory as a framework to better understand water use behaviours. In the next section, the VBN theory will be explored and discussed, as a method to explain the interaction between psycho-social and water use behaviour and gain understanding how environmental behaviour is shaped by values, beliefs and norms.

2.2 The Values Beliefs and Norm theory

The VBN theory emerged as a comprehensive framework for understanding pro-environmental human behaviour (Stern, 2000). While earlier studies focused on contextual factors, the VBN theory offers a psycho-social approach, considering the interplay between individual values, beliefs, norms and behaviour. By integrating the VBN theory into research on domestic water use on top of the contextual factors, this research searches for a possible relationship between underlying motivations and individual influences in driving water use related behaviours.

Various psychology concepts and frameworks have been employed to study human behaviour and decision-making. For example, the Risks, Attitudes, Norms, Abilities, and Self-regulation (RANAS), the health belief model (HBM), the integrated behavioural model for water, sanitation and hygiene (WASH), the theory of reasoned action, the structure of underlying personal values, the health action process approach (HAPA), and the VBN theory (Akintunde, 2017;Daniel et al., 2019;Bruch and Feinberg, 2017;Ives and Kendal, 2013;Mosler, 2012;Salazar, 1991;Steg and Vlek, 2009; Stern et al., 1999). These theories, which originated in social science and behaviour, have been applied to the health and business sectors (Davis et al., 2015; Dreibelbis et al., 2013;Salazar, 1991).

In this research, the theoretical framework of VBN is explored to understand if it contributes to the understanding of domestic water use in rural areas. The VBN theory was chosen as it provides a comprehensive framework that integrates values, beliefs, and norms, offering an understanding of how these factors interact to influence behaviour. VBN captures a broad spectrum of human motivations, including moral and ethical considerations (Stern et al., 1999). This holistic approach is particularly useful when studying behaviours that are driven by values and norms, such as environmental conservation, like in this case the use of a natural resource like water for domestic purposes (Dietz, Fitzgerald, & Shwom, 2005).

The VBN theory is a theory of environmentalism known for explaining how values impact pro-environmental behaviour and offers a framework for examining normative elements that support consumption and sustainable actions (Stern, 2000). In the literature, this theory can also be referred to as a behavioural model. The VBN theory puts together the value theory (Schwartz, 1992), the new environmental paradigm perspective (Dunlap et al., 2000), and the norm-activation theory (Schwartz, 1977).

The theory implies a chain of variables or events, as seen in figure 2.1. The process starts with values and a broad concern for the environment and moving on to beliefs about the unfavourable effects of specific actions and the personal responsibility and ability of the individual to prevent these unfavourable effects. This activates sustainable personal norms for behaviour (Stern, 2000). This means that individual values and general environmental beliefs will influence the degree to which a person recognises an environmentally related problem and acknowledges its consequences, as well as the degree to which they are willing to recognise their role in contributing to solve the problem.

In the VBN theory, three generally accepted types of values are believed to be particularly important precursors of environmental beliefs and behaviours (Schwartz, 1992). These are biospheric, altruistic and egoistic values. *Biospheric values* give weight to environmental protection in making decisions for non-human species. *Altruistic values* emphasize human welfare beyond the individual. *Egoistic values* primarily focus on self-interest in terms of the cost and benefits of the course of action (De Groot and Steg, 2007; Stern et al., 1999). Biospheric and altruistic values are considered positive pro-environmental, while egoistic is a negative environmental value (Stern, 2000). Previous studies have also found that hedonist values influence actions related to pro-environment behaviour. Hedonistic values prioritize the achievement of immediate gratification and enjoyment. Individuals who adhere to hedonistic values prioritize experiences that bring them pleasure and satisfaction, often seeking out activities or possessions that enhance their well-being in the short term (Bouman et al., 2018; Steg et al., 2014).

Another element of the VBN theory are 'beliefs'. 'General environmental beliefs' reflect individuals' beliefs about humans' appropriate relationship with the environment. Examples are:

- Appropriateness of human dominance over nature.
- Perceived fragility of the earth's ecosystems.
- Faith in humans' ability to solve environmental problems.

These beliefs are influenced by the knowledge about the new environmental paradigm (NEP), the adverse consequences of a given situation (AC), the perceived ability to reduce threat (AR) and a person's social norm reference group (Steg and Vlek, 2009; Stern, 2000; Yakut, 2021).

The NEP places a strong emphasis on ideas about the boundaries of human growth, the need to maintain the natural order, and the necessity of striking a balance between economic development and environmental protection. It includes environmental beliefs, awareness of environmental issues, and recognition of the necessity of sustainable development (Nordfjærn et al., 2014).

The NEP states that people's perceptions of their surroundings have an impact on their awareness of the consequences of particular behaviours as well as their perceptions of their capacity to prevent the negative effects of those behaviours. The hypothesis that norm activation may play a role in a range of sustainable behaviours has been supported by various studies (De Groot and Steg, 2010; Stern et al., 1999).

It is necessary to distinguish between beliefs that centre on particular sustainable behaviours (AC) and those that centre on general environmental conditions (NEP) because they play different roles in influencing behaviour. Personal norms are activated by these particular beliefs, and personal norms can impact a variety of sustainable behaviours, as can be seen in figure 2.1. It also establishes whether the person believes that acting in an environmentally friendly manner is morally required (Steg et al., 2005).

The personal norm of the VBN theory is based on a psychological framework called the norm-activation theory. This seeks to explain the variables that influence people's intentions and behaviour towards environmental actions. The theory describes how people form their own set of personal norms. Personal norms are people's beliefs about their moral duty to act in a pro-social manner, or their expectations. These standards are developed using situational elements and individual characteristics (Schwartz, 1977). To understand more about the VBN theory, it is necessary to expand on the concepts and theories that conform to this theory.

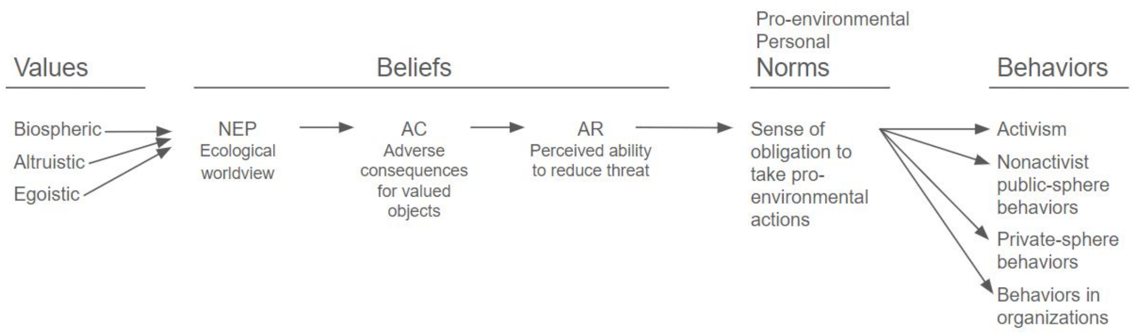


Figure 2.1: VBN Theory: chain of variables

(Stern, 2000)

2.2.1 Theories that compound VBN framework

Theory of values

Schwartz's Theory of Values offers a comprehensive framework for examining the influence of individual and cultural values on human behaviour and societal dynamics. Schwartz identifies a core set of universal values that transcend cultural boundaries and shape human behaviour. These values, conceptualized as abstract ideals representing desirable goals and principles, play a fundamental role in guiding individuals' actions and social interactions. Widely employed in psychology and sociology, this theory serves as a valuable tool for understanding human motivation, decision-making processes, and cultural phenomena (Schwartz, 1992).

According to Schwartz (1992), a value is defined as: "a desirable trans-situational goal varying in importance, which serves as a guiding principle in the life of a person or other social entity". Values utilise their influence by directing attention toward information consistent with one's values and shaping the perception of this information.

Values are characterized by several key attributes. The first attribute is that values are cognitive constructs interlaced with emotions, beliefs, and motivations. Secondly, values act as motivational guidelines, representing desired goals that people work to achieve. Values become evident in specific actions and situations, guiding individuals' behaviour in contextually specific ways. Furthermore, they function as evaluative criteria, guiding the selection and assessment of actions, policies, and individuals. Ultimately, values create a structured hierarchy in which people rank certain values higher than others based on their importance and relevance (Schwartz, 1992).

The abstract nature of values distinguishes them from concepts such as norms and attitudes, which belong to specific actions or situations. Schwartz's Theory of Values has identified 57 values that are prevalent across more than 60 cultures. Individuals select and prioritize these values based on their personal beliefs and aspirations. From these 57 values, Schwartz has delineated 10 broad values that drive human behaviour and are considered significant, see figure 2.2. These 10 values are categorized into four typologies: openness to change, self-transcendence, self-realization, and conservation.

- Openness to change: this encompasses values related to embracing novelty and new experiences

- Self-transcendence: reflecting an orientation towards altruism and concern for others
- Self-realization: focusing on the fulfilment of one's personal potential and aspirations
- Conservation: centered around values associated with tradition, security, and family

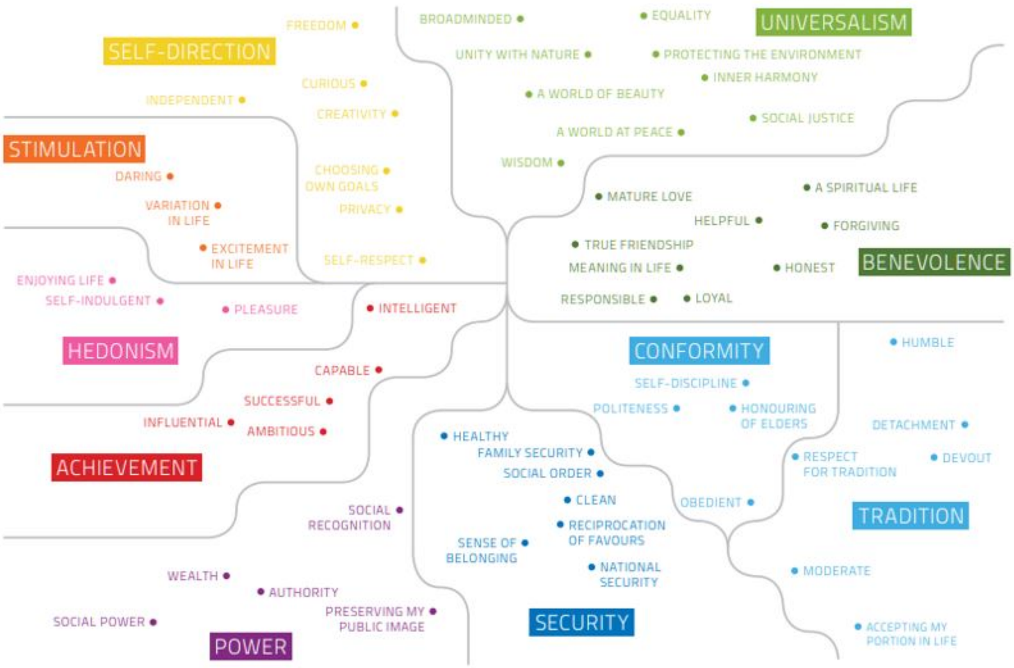


Figure 2.2: Schwartz values Infographic

(Cause, 2011)

These four categories and the corresponding 10 broad values constitute the foundation of Schwartz's theoretical model of human values. Illustrated in figure 2.2, this model provides a visual representation of the complex interplay between values and human behaviour across diverse cultural contexts.

Schwartz's Value Theory provides a foundational framework for understanding the motivations behind human behaviour. The concepts of biospheric, altruistic, and egoistic values can be seen as specific applications within Schwartz's broader value categories. Biospheric values, which prioritize the well-being of the environment and the preservation of nature, align closely with Schwartz's universalism value, where concern for the welfare of all people and nature is the primary concern. Altruistic values, which focus on the welfare of others and social justice, correspond with Schwartz's benevolence and universalism values, emphasizing the importance of community and concern for others. Egoistic values, which focus on self-interest, personal achievement, and resource control, are related to Schwartz's values of power and achievement, where personal success and control over resources are important motivators. Together, these provide an understanding of how individuals prioritize environmental and social concerns, balancing self-interest with broader ethical considerations, as conceptualized in Schwartz's Value Theory (Stern et al., 1999).

New Environmental Paradigm

The New Environmental Paradigm (NEP) represents a fundamental shift in societal attitudes towards the environment, emphasizing an integral approach to environmental management and sustainability. Developed in response to growing concerns over environmental degradation and resource depletion, the NEP includes a set of principles aimed at promoting respect for the limits of nature to growth, maintaining ecological equilibrium, and establishing the coexistence of a thriving economy with a healthy environment (Dunlap et al., 2000).

Fundamental to NEP is the recognition that environmental, social, and economic systems are interconnected and the recognition that human well-being is intrinsically linked to the health of the natural world. This principle emphasizes the importance of adopting a long-term perspective on environmental issues and prioritizing strategies that promote sustainability and resilience in the face of global challenges such as climate change, biodiversity loss, and resource depletion.

Research has shown that individuals who endorse the principles of the NEP tend to hold more positive attitudes towards environmental conservation and are expected to engage more in pro-environmental behaviours (Derdowski et al., 2020; Guagnano et al., 1995; Stern et al., 1999). The NEP is developed to measure individuals' alignment with the principles of the paradigm, has been widely used in environmental psychology research and has demonstrated its applicability across diverse cultural and geographical contexts (Dunlap et al., 2000).

Overall, the NEP represents a paradigm shift towards a more holistic and sustainable approach to environmental management. This highlights the importance of promoting a deeper understanding of environmental issues and collective action towards achieving a harmonious balance between human needs and ecological integrity.

Norm Activation Theory

To comprehend the Norm Activation Theory (NAT), it is essential to understand the concept of norms and their role in shaping human behaviour. Norms are societal rules dictating acceptable and expected behaviours. Despite norms representing expected behaviours, they often diverge from actual behaviours as they not only influence our beliefs but also guide our actions, defining what is thought suitable in a given context (Schwartz, 1977).

Various norm theories or type of norms offer insight into the complex nature of norms and their influence on human behaviour. For example:

- Social norm: reflects societal norms and behaviours (Fanton et al., 2023).
- Subjective norm: centres on the perceptions of significant others and their behaviours (Ajzen, 1991).
- Personal norm: focuses on individual beliefs and actions (Schwartz, 1977).

Norms enter every aspect of human behaviour and belief systems, influencing individuals' decisions and actions. However, the influence of different type of norms varies depending on the individuals' self-esteem level. People with high self-esteem prioritize personal norms, while low self-esteem individuals are more influenced by subjective and social norms (Schwartz, 1977).

The NAT describes the circumstances under which personal norms are likely to be activated, particularly concerning pro-social behaviours. However, the mere existence of personal norms does not guarantee their consideration in decision-making processes. According to NAT, personal norms are activated when individuals (Han, 2014):

- Are aware of consequences (AC): Individuals must recognize both the problem and potential solutions and feeling capable of implementing these solutions.
- Accept personal responsibility (AR): Individuals must acknowledge their role in the outcome and accept personal responsibility for the consequences.

The activation of personal norms subsequently influences behavioural intentions and actions, leading individuals to act in accordance with their internal moral guide. Hence, a person must be aware of the consequences of a potential action or even inaction, upon something they care about, and they have to accept personal responsibility for those consequences. In these cases, a personal norm becomes a moral obligation that encourages action (Han, 2014).

Notably, individuals are more inclined to act when they feel responsible or when it is hard to deny responsibility, for example when explicitly asked for help or when social pressure is present. Collective efforts and social reinforcement can enhance motivation and responsibility acceptance. By fostering a sense of collective responsibility and engagement, individuals are more likely to act in pro-social ways, transcending individual interests for the collective good (Schwartz, 1977).

In summary, the NAT provides valuable insights into the psychological mechanisms underlying pro-social behaviour, highlighting the interplay between awareness, responsibility, and collective action in shaping human responses to environmental challenges.

2.3 Study cases where VBN theory was implemented

The VBN theory's use case to understand different types of particular sustainable behaviours has been supported by several studies (Steg and Vlek, 2009). According to a study performed in the Dutch city of Groningen, the model explained why energy policies aimed at lowering household CO_2 emissions were considered acceptable (Steg et al., 2005).

Moreover, the VBN theory has been utilized to forecast attitudes and actions associated with selecting a mode of transportation. Ünal et al. (2018) discovered that a sense of moral obligation to reduce car use was linked to acceptance of transportation policies that increased the cost of driving. These findings also suggested that awareness of the environmental consequences of driving and feelings of responsibility for these consequences were related to reduced car use (De Groot and Steg, 2008). Results based on data from five European countries showed that the VBN theory forecasts a reasonable percentage of the acceptability of road-charging, as well as the intention to decrease the use of their car when such a policy is implemented (De Groot and Steg, 2008). The same conclusion was found in the research from Nordfjærn et al. (2014), which investigated whether the value-belief-norm theory can explain reported travel mode change in the

Norwegian urban population. The values and beliefs explained 58% of the variance in personal norms.

Abrahamse et al. (2009) showed that car choice for commuting was chiefly explained by perceived behavioural control and attitudes, while the intention to reduce car use was explained by personal norms. The VBN theory was also proven to be applicable for explaining policy acceptance and the willingness to reduce car use in Argentina, thus indicating that the theory is not culture-specific (Jakovcevic and Steg, 2013).

In Whitley et al. (2018) research, the VBN theory was extended to analyze which psychological factors influence five sustainable behaviours: support for political candidates who say they support environmental policies, recycling, electricity use, food selection and transportation choices among 2828 students at Michigan State University students. They found that people with pro-environmental values are more likely to adopt sustainable behaviours in comparison to people with egoistic values. Hiratsuka et al. (2018) tested the VBN theory in Japan. The research shows that people who believe that driving has a negative impact on the environment (biospheric value), feel more responsible for the problems caused by driving, and feel personally obligated to reduce their car use.

There have also been studies where the VBN theory was used and related to water use. For example, the paper by Çakır Yıldırım and Karaarslan Semiz (2019) titled *'Future Teachers Sustainable Water Consumption Behavior: A Test of the Value-Belief-Norm'* explores the sustainable water consumption of teachers using the VBN theory. The study concludes that the VBN theory can explain teachers' sustainable water use behaviour and that personal norms are a powerful indicator. The teachers were aware of the consequences of their actions on water resources, accepted responsibility towards water consumption, and felt a moral obligation to save water. As the VBN theory has mostly been used to predict general pro-environmental behaviours, this study revealed that the VBN theory was successful in explaining the water consumption of the teachers.

The study *'Bringing the social into socio hydrology: Conservation policy support in the Central Great Plains of Kansas, USA'* by Sanderson et al. (2017) states that socio-hydrology, the science of people and water, is an emerging area of interdisciplinary engagement on issues of critical importance. Continued advances in socio-hydrology will require incorporating social science. The VBN framework is used to hypothesize that support for conservation policies is an outcome of linking environmental values to ecological worldview beliefs and perceptions of ecosystem vulnerability. People with strong environmental values should hold strong ecological worldviews, making them more likely to perceive ecosystem vulnerabilities and thus more likely to support water conservation policies.

The factors affecting the water savings behaviour of farmers in China were investigated in the research from (Su et al., 2021). The VBN theory and the structural equation model were used to analyse the factors influencing water-saving behaviour. The conclusion is that water saving behaviour of farmers is significantly impacted by their willingness, knowledge and age. Gender and annual household income have a significant impact on water use. Furthermore, personal habits, policy incentives, and egocentric and biospheric values have a significant impact on the personal water-saving behaviour of farmers.

Synthesis

Due to climate change and rapidly expanding societies, the need to understand the factors that drive domestic water usage may have never been greater. Therefore, it is important to focus on gaining knowledge about water use behaviour to be able to manage sustainable challenges related to water resources and implement effective measures.

Early studies focused mainly on contextual factors, including socioeconomic status, demographic characteristics, and climatic variables. There is conformity in previous research on the relevance of contextual factors such as water price, household size, age, education, economic status and climate.

For a holistic view, psychological and behavioural factors, such as attitudes, values, beliefs, motivations, norms, and perceptions, related to domestic water usage should also be considered, to complement the understanding of factors that drive domestic water use.

The VBN theory uses a psycho-social approach, considering the dynamics between individual values, beliefs, norms, and behaviour. Various studies support the ability of this behavioural theory to provide a robust understanding of pro-environmental behaviours and their driving factors. For instance, Stern et al. (1999) demonstrated how the VBN theory could predict a range of environmental behaviours, from energy conservation to activism, and linked personal values and beliefs with environmental concerns and actions. Similarly, a study by Steg et al. (2005) reinforced the VBN theory's effectiveness in explaining car use reduction intentions, highlighting its applicability in different domains of pro-environmental behaviour. Therefore, the VBN theory is used in this research. By integrating the VBN theory into research on domestic rural and peri-urban water use alongside contextual factors, this study aims to contribute to the existing literature by investigating the relationship between underlying motivations and individual influences in driving water use behaviour. Additionally, the implementation of the VBN framework in rural domestic water use research, as opposed to the more commonly studied urban contexts, is necessary to assess whether the theory's predictive power holds true in rural settings.

Chapter 3

Methods and materials

In this chapter, the methods and materials adopted to execute this exploratory research will be presented. The first section defines the methodology approach. In section 3.2, the ethics statement is presented. Section 3.3 dives into the data management of the research, explaining how data was used and processed for statistical analysis. Then in section 3.4, the conceptual model is defined. Finally, the last section provides insight into the statistical methods chosen to use for the analysis of the conceptual model analysis.

3.1 Methodology approach

This study adopts a quantitative research methodology, primarily relying on secondary data sources (Bhattacherjee, 2012). This approach allows for the utilization of diverse statistical techniques to achieve the research objectives (Bhandari, 2023). The choice of this methodology was based on the need to comprehensively explore the contextual and VBN factors using quantitative statistical inference methods.

3.2 Ethics statement

The Human Research Ethics Committee of Delft University of Technology approved the study design and questionnaire. All respondents provided written informed consent, and participation was entirely voluntary. Additionally, before starting the fieldwork, consent was obtained from the leader of each communities water association.

3.3 Data Management

The method used to structure and represent the data significantly influences the quality and reliability of the analysis conducted (Tan et al., 2016). Excel (Microsoft Excel for MS 365 MSO Version 2112 Build 16.0.14729.20254 64-bit) and Python (version 3.10.12) were employed to perform the necessary data management. Subsequently, the structured dataset was exported to Excel and utilised in Python for statistical analysis using the 'statsmodel' package. Visualization of the statistical data was accomplished by using the 'Seaborn' package (Seabold and Perktold, 2010; Waskom, 2021).

3.3.1 Study area

Colombia is located just above the equator in the northwest of South America bordered by Panama and the Caribean Sea in the northwest, Venezuela and Brazil on the east, Peru and Ecuador on the south and the Pacific Ocean on the west. The country is divided into 32 departments. The Valle del Cauca Department, in the southwest, features diverse landscapes, from the Pacific coastline to the Andean mountain range as it is presented in figure 3.1.

Figure 3.1: Location map. Rural area of Restrepo and Cali below right; with a key map of the Valle del Cauca region above right; and left, showing its location within the larger region of Colombia.

Approximately 23% of the Colombian population lives in rural areas with limited access to piped water, with only about 40% of the population having access in 2017 (Pointet, 2022). The peri-urban zones of Cali have seen significant population growth due to migration from urban areas, partly driven by displacement from violence in other regions. Therefore, these areas have expanded infrastructure to accommodate the increasing water demand (Callejas Moncaleano et al., 2023).

This study focuses on the rural municipality of Restrepo and the peri-urban areas of Cali, the capital city of Valle del Cauca. The towns in the study zone are located in the geographical valley of the Cauca River, at altitudes ranging from 980 to 1620 metres above sea level. The main economic activities in these areas include agriculture, livestock, and tourism, with many residents commuting to Cali for work. In general, women are the main caregivers in households (Agencia de Desarrollo Rural, 2021).

Specifically, the study examines domestic water use in eight aqueducts in Valle del Cauca: four in peri-urban zones near Cali (Las Palmas, La Buitrera, El Hormiguero, and Los Mangos) and four in rural Restrepo (Acuapaltres, Alto Cielo La Tesalia, Calimita, and Diamante). These areas primarily source water from springs and small rivers, except for El Hormiguero, which relies on a well (Callejas Moncaleano et al., 2023).

Valle del Cauca experiences a warm climate with average temperatures ranging from 18°C to 24°C, depending on altitude. The region has a bimodal rainfall pattern with wet seasons from April to May and October to November, and dry seasons in June to September and December to March. Annual precipitation varies significantly, thereby affecting water availability for domestic uses (Marin and Ramírez, 2006).

The water supply infrastructure in the study areas is managed by the community and the systems are operated by Water User Associations (WUAs), which are regulated institutions. These associations are responsible for maintaining the water supply systems, which often lack regular maintenance due to limited financial resources and the voluntary nature of management (Machado et al., 2023). The systems are characterised by intermittent water distribution and variable levels of treatment depending on the water source. National organisations include Fecoser (Federación de Acueductos Comunitarios del Valle del Cauca) and Aquacol (Asociación de Organizaciones Comunitarias Prestadoras de Servicios Públicos de Agua y Saneamiento). These institutions oversee compliance with national regulations such as Law 142 of 1994 and Decree 1076 of 2015, which mandate safe water provision and efficient water use programmes (Callejas Moncaleano et al., 2023).

3.3.2 Data Sample

This study uses a cross-sectional study that contains data obtained from a survey conducted between November 2020 and December 2021 across eight rural towns in the department 'Valle del Cauca'. The data sample consisted initially of responses from 926 households, each completing a survey of 37 questions. The survey has 11 questions aiming to understand the socio-economic context; and 26 questions related to values, beliefs, and norms. Three variables were used to study how water is used at a domestic scale: the total perceived water used denominated 'wu', spending time taking a shower 'ST' and an index that indicates the number of saving devices installed per household 'SD' (Callejas Moncaleano et al., 2023). Households were randomly selected for interviews and this study assumes that the self-reported water behaviours of the respondents are representative of those of the entire household.

For the evaluation of values, beliefs and norms, the 26 questions aiming to understand the people's perceptions are displayed in table 3.1 and also shows the keywords used for question identification. Even though the original survey data contained 11 SEC and 29 VBN factors, the tables only include the remaining factors studied in this research, because some information was removed due to data incompleteness since it can lead to misleading statistical analysis.

Table 3.1: VBN questions

Factors	Questions
Values	
Biospheric: Limit_my_use	Do you try to limit the use of water when performing household tasks?
Biospheric: Adequate_use	How necessary is it for you to use water adequately or rationally?
Biospheric: limit_use_conservation	Whenever you rationally use water, do you do it to conserve your water resources?
Altruistic: limit-use_for-others_present &future	How important is it to you to reduce water consumption, keeping in mind that this will contribute to the short and long-term well-being of the rural community?
Altruistic: limit-use_Everyone_right_Water	Is the rational use of water important to ensure access to water for the whole community?
Altruistic: limit-use_Water_conservation	How important is the following statement to you: using water rationally to help conserve save water
Altruistic: aware_water_conflicts	Do you think in your region there are conflicts related to water use?
Egoistic: unlimitated_water_supply	Indicate to what extent you agree with the following statement: Humans have the right to use water according to their needs (That is why water consumption should be unlimited)
Egoistic: interest_Own_supply	Indicate to what extent you agree with the following statement: my only concern regarding water is that my home is supplied for my basic needs
Beliefs	
waterproblems_responsability _everyone	Indicate to what extent you agree with the following statement: each person is responsible for the problems related to water consumption
waterproblems_responsability _Aqueduct	Indicate to what extent you agree with the following statement: The water company is responsible for the problems related to water consumption
waterproblems_responsability _Government	Indicate to what extent you agree with the following statement: The local, regional and national government are responsible for the problems related to water consumption
waterproblems_responsability _environmental-authority	Indicate to what extent you agree with the following statement: the regional environmental authority is responsible for the problems related to water consumption
waterproblems_responsability _economic sector	Indicate to what extent you agree with the following statement: the economic sector in the region are responsible for the problems related to water consumption
Droughts_Village	Please indicate your perception about the following statements: In the village/town water scarcity is a problem

Factors	Questions
Droughts_Only_Property	Please indicate your perception about the following statements: water scarcity is a problem only affecting my property
Excesive_w.intake_region	Please indicate your perception about the following statements: In this region, water is used more than required
Norms	
saving-water_regarless-others	Indicate to what extent you agree with the following statement: you feel morally obliged to save water, regardless of what others do
everyone_can-save-water	Indicate to what extent you agree with the following statement: Anyone could do any action in order to use water rationally
guilty_waste-water	Please express the degree to which you agree with the following statement: "You experience a sense of guilt when you do not use water in a rational manner"
if_$_buy-Saving-Device	Indicate to what extent you agree with the following statement: If you had the economic means to buy a new water-efficient appliance (e.g. d dishwasher or other appliance/shower), you would feel morally obliged to do so
Obligation_save-water _d.activities	Indicate to what extent you agree with the following statement: you feel obligated to save water in your daily activities
if_saves-water_better-person	Please indicate the extent to which you agree with the following statement: "You would feel like a better person if you saved water"

According to Callejas Moncaleano et al. (2023) and Callejas Moncaleano et al. (2024), the questions assessing the psychological factors were based on the VBN theoretical framework. The questions were derived from previous research that aimed to study environmental behaviour and water use in rural areas.

The surveyed questions were designed to gather information about SEC and VBN factors prevalent in each household. Among the SEC factors included in the dataset provided were age, education level, residential zone (rural/peri-urban), gender, and occupation 3.2.

As previously mentioned *'wu'*, *'ST'* and *'SD'* variables represent specific aspects of water use in order to explain the domestic water use in the study zone. The total daily self-reported water use per inhabitant *'wu'* was derived from Callejas Moncaleano et al. (2023), wherein self-reported data on the time spent on various water use activities from each household was utilized for estimation. The total volume was estimated due to the absence of water metres in the households within the study area. The *'ST'* was gathered during the survey and the last variable *'SD'* was obtained from Callejas Moncaleano et al. (2024). These variables are presented and defined in Table 3.3. The variable *'ST'* was an indication of water use in terms of personal conservation or curtailment behaviour, while *'SD'* was examined to understand household water use efficiency behaviour facilitated by technological interventions such as the saving devices.

Table 3.2: SEC Questions

Factors	**Questions**	**Factor name**
Inhabitants	Number of inhabitants in the house?	inhab_house
Age	How old are you?	Age
Education level	What is the highest education level you have attained?	Education_level
Gender	Gender?	gender
Altitude	Height at which the dwelling is located?	altitude
Zone	In which zone is located your home/land?	zone
Occupation	What is your occupation?	Occupation

Table 3.3: Specific domestic uses studied

Variable	**Statement**	**Units**
wu	Self perceived amount of water usage	$[L * hab/day]$
ST	Duration in the shower?	$[minutes]$
SD	Maximum water saving potential	[%]

3.3.3 Renaming variables

The original names of the variables in the different datasets provided were renamed. These names were based on the type of questions the respondents answered during the questionnaire, as it was shown in tables 3.1 and 3.2. This is important because when merging all the datasets, the data belonging to a certain question should be in the same place for every respondent. Translation of some of the questions to English was necessary as the survey was originally executed in Spanish.

3.3.4 Merging data frames

The socio-economic factors and the VBN questionnaire were provided in five Excel documents. It was therefore necessary to merge them into one single document to manage only one dataset. Also, *'wu'*, *'ST'* and *'SD'* were added to the final data framework since they came from two different Excel files. After merging the data in Python, every response corresponds to a row in the dataset and was assigned an identifying number.

As mentioned, the merged dataset contains 37 questions. Every row in the dataset represents the answers of one respondent i.e., household. Every column in the dataset represents a certain question that the respondents were asked to answer.

3.3.5 Removing incomplete information

Only relevant data is used to guarantee the analysis's quality. Specifically, questions with more than 50% missing responses were excluded from the final dataset. The following questions were removed as a result:

- How concerned are you about water conflicts due to water use? (VBN: Altruistic value).
- In the last year (2019/2020) what was your monthly household income before taxes? (SEC / Income).
- How necessary is it for you to use water in an adequate or rational way? (VBN: Biospheric value)
- Is the rational use of water being important to guarantee water access for the whole community? (VBN: Altruistic value).
- Indicate to what extent you agree with the following statement: my only concern regarding water is that my home is supplied for my basic needs (VBN: Egoistic value)
- Please indicate your perception about the following statements: water scarcity is a problem only affecting my property (VBN: Beliefs)
- How long have you lived at your current address? (SEC).

3.3.6 Recoding the data

Since it is not possible to perform a statistical and descriptive analysis of qualitative data, the textual answers were encoded into numbers. However, not all the answers were properly encoded. Therefore, it was necessary to re-scale them to have the same order of magnitude. The type of encoding scale is shown in Table 3.4.

Table 3.4: Final scaled coding for VBN and SEC factors

1: never 2: rarely 3: sometimes 4: often 5: always	1: it is not very much necessary 2: it is not es necessary 3: Neutral 4: It is necessary 5: It is very much necessary	1: not at all important 2: low importance 3: Neutral 4: Important 5: very important	1: strongly disagree 2: disagree 3: neutral 4: agree 5: strongly agree	1: not at all concern 2: a little concern 3: neutral 4: very concern 5: extremely concern	1: none 2: incomplete/completed primary School 3: incomplete/completed secondary School 4: incomplete/completed technician 5: completed professional/Master

Another type of encoded variables were binary variables and other scaled values that are shown in Table 3.5. In the appendix A a table with all variables and their respective coding is presented.

Table 3.5: Other variables scale

Scales				
Zone	Gender	Altitude(h)	Occupation	Age
0: Rural 1: Peri_urban	0: Male 1: Female	1: h <= 989 2: 989 > h <= 1173 3: 1173 > h <= 1381 4: 1381 > h <= 1612 5: h > 1612	1: full time/ part time employed/Independent / self-employed 2: Full time student / study only & work 3: household labours / engagement in home duties 4: unemployed 5: volunteer work and other e.g., social leader / retired / pensioner / option 7 and other between 1 & 9	1: age < 24 2: 24 > age < 35 3: 35 > age < 45 4: 45 > age < 55 5: age > 55

3.4 Conceptual model for domestic water use

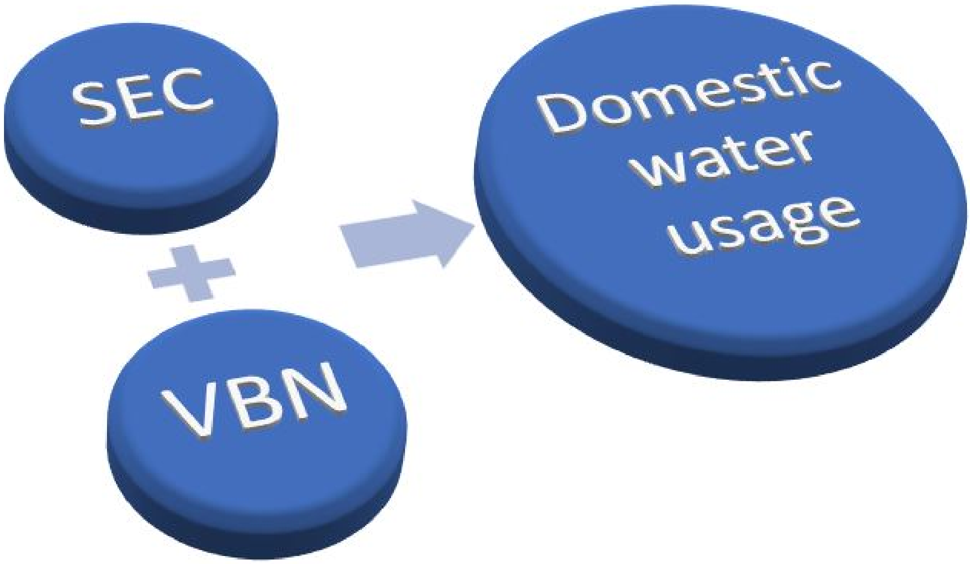
Following an extensive literature review, a conceptual model aiming to understand domestic water use in the study area was developed using the VBN theory and socioeconomic factors (Bruch and Feinberg, 2017;Cleff, 2019; Saunders et al., 2009). The model considers three aspects of water use and water use behaviour: perceived total water use *'wu'*, shower time *'ST'* and saving devices *'SD'*.

The contextual factors, such as socioeconomic factors, were used since literature refers to their relevance for studying water use behaviour (Bandhu et al., 2024;Daniel et al., 2019;Seimetz et al., 2016;Willis et al., 2013). For example, Callejas Moncaleano et al. (2023) found that household size, education, age and occupation are critical factors that influence the perceived water use in rural areas of Valle del Cauca, Colombia. Additionally, several studies recognise that situational and contextual factors may influence sustainable behaviours, and have considered these factors when implementing the VBN theory (Brouns, 2019;Callejas Moncaleano et al., 2021;De Groot and Steg, 2007;Lind et al., 2015;Nordfjærn et al., 2014;Steg et al., 2005).

To adapt the VBN theory to domestic water use we could state that domestic water use can be based on a moral obligation (norm) to behave in a sustainable way (pro-environment behaviour) according to Stern and Dietz (1994), Stern et al. (1999) and Stern (2000). Therefore, it is possible to implement the VBN theoretical framework, which is used to understand the drivers of pro-environmental behaviour (De Groot and Steg, 2010;Roobavannan et al., 2018;Stern and Dietz, 1994;Stern et al., 1999;Stern, 2000;Steg et al., 2005;Ünal et al., 2018).

To find a possible relationship between VBN and domestic water use, three variables to measure water use were taken into account. The first variable is the perceived total amount of water use denoted as *'wu'* per capita per day $[L * hab/day]$. Secondly, we analyze the duration of time individuals spend showering. Shower time is denoted as *'ST'* and measured in $[minutes]$. Lastly, we introduce an index termed 'saving devices' *'SD'* [%], representing a percentage of water points within households equipped with water-saving devices to measure water use behaviour.

The total perceived water use allows us to assess the overall impact of the VBN framework on total water use, though its based on estimates. Additionally, by analysing specific aspects of water uses that are observed rather than estimated such as shower time, which can involve behavioural curtailment, and the presence of saving devices, which represents an indirect method of reducing water usage through technology adoption, deeper insights can be gained on how the VBN theory interprets these various aspects of water use behaviour. See figure 3.2 which represents the conceptual model for domestic water usage, measured in terms of *'wu', 'ST'* and *'SD'*.



Note: SEC = Contextual factors, VBN = values, beliefs & norms

Figure 3.2: Conceptual model for domestic water usage analyses

3.5 Statistic method to implement the conceptual model

Based on the research question, the data type of this study and the conceptual model implemented to analyze the domestic water use in the study area, a multi-linear regression statistical inferential method was implemented (Saunders et al., 2009). The multi-linear regression statistical inferential method was implemented based on recommendations from existing literature, suggesting this method contributes to the understanding of data and its suitability for exploratory studies (Cleff, 2019). This choice is also encouraged by its capability to accommodate multiple predictor variables simultaneously, allowing for a comprehensive examination of the complex interplay between various studied factors and water use behaviour. Additionally, multi-linear regression offers the advantage of providing interpretable coefficients, facilitating the identification of significant predictors and their respective effects on domestic water use (Cleff, 2019; (Hair et al., 2013;Granados, 2016;Uyanık and Güler, 2013). By employing this method, we aim to explain the possible relationships between socio-economic variables and psychological factors contributing to the understanding of household water use.

Before implementing the multi-linear regression (MLR) method, several tests were conducted. First was determined whether inferential parametric or non-parametric statistics could be applied by establishing the possibility of using parametric methods by assessing the normal distribution of dependent variables, which were observed to be numeric and fulfil the criteria of independent observations. Consequently, it was concluded that implementing inferential parametric statistics was feasible.

After evaluating options for data analysis, linear regression was chosen over logistic regression. Logistic regression was deemed unsuitable as the research does not expect to have binary or dichotomous outcomes limited to two possibilities but rather from a scale of values with a focus on observing the direct association of all factors with domestic water use. Additionally, other methods considered were principal component analysis (PCA) and machine learning. PCA was disregarded due to its inability to provide insight into the influence of each significant variable within each component. Similarly, machine learning, while capable of providing an algorithm to estimate domestic water use based on studied variables, does not clearly define or visualize the association, description, or influence of each factor on domestic water use, and is therefore not suitable for an exploratory study.

The multi-linear regression can be performed with three different methods, forced entry, step-wise entry and hierarchical entry. For this research two methods were selected: the forced entry and hierarchical method, while the step-wise entry method was not implemented. The reason to not use step-wise entry is to avoid bias in the regression coefficients (Tibshirani, 1996). The forced entry method was chosen due to its recommendation for implementation in exploratory studies (Cleff, 2019; Keith, 2019). This method is employed because it reduces the bias that may arise from the order in which the independent variables are introduced in the regression. By including all independent variables simultaneously, the forced entry method ensures that each variable's unique contribution to the model is assessed without any predetermined order (Keith, 2019).

Furthermore, the hierarchical method was selected to investigate the sequential order of the chain of variables as proposed by the VBN theory. This method allows for testing different combinations of independent variables in a hierarchical manner, enabling the evaluation of how much variance in the dependent variable is explained by the VBN theory. By systematically adding variables based on their theoretical relevance, the hierarchical method provides insights into the hierarchical structure of the VBN theory and the relative importance of each significant variable for water use. The next subsections explain the methodology followed for these two methods (Fein et al., 2022).

3.5.1 Forced entry method

The forced entry method is a method that explores potential relationships between two or more independent variables and a dependent variable. This method allows for all independent variables to be entered into the regression equation simultaneously, without considering their hierarchical order or statistical significance, as well as to determine the significant parameters. Usually, this method is used in social science research to investigate the influence of demographic, socio-economic factors, and cultural variables on certain outcomes (Fein et al., 2022).

The general mathematical expression for MLR is:

$$y = \beta_0 + \beta_1 X_1 + ... + \beta_n X_n + \epsilon \tag{3.1}$$

Where:
y = dependent variable or variable of interest (wu)

β_0 = the y-intercept (value of y when all other parameters are set to 0)
$\beta_1 X_1$ = the regression coefficient (β_1) of the first independent variable X_1
$\beta_n X_n$ = the regression coefficient (β_n) of the last independent variable X_n
ϵ = model error (a.k.a. how much variation there is in our estimate of 'y')

By using this approach, we aim to get insight and assess the combined influence of 7 SEC and 24 VBN factors on domestic water use, as earlier mentioned in section 3.3.2. In this context, the factors from SEC and VBN are the independent variables and 'domestic water use' the dependent variable.

To analyse domestic water use, three variables were selected. The first is the total water used volume, denoted as *'wu'* and measured in litres per person per day $[L * hab/day]$. Secondly, we analyze the duration of time individuals spend showering, shower time is denoted as *'ST'* and measured in $[minutes]$. Lastly, we introduce an index termed saving devices *'SD'* [%], representing a percentage of water points within households equipped with water-saving devices.

Then, these three types of variables *'wu', 'ST', 'SD'* were used as shown in the regression equations below.

$$wu \approx \beta_{wu} + (\beta_{SEC} * SEC) + (\beta_{VBN} * VBN) + \epsilon_{wu} \tag{3.2}$$

$$ST \approx \beta_{ST} + (\beta_{SEC} * SEC) + (\beta_{VBN} * VBN) + \epsilon_{ST} \tag{3.3}$$

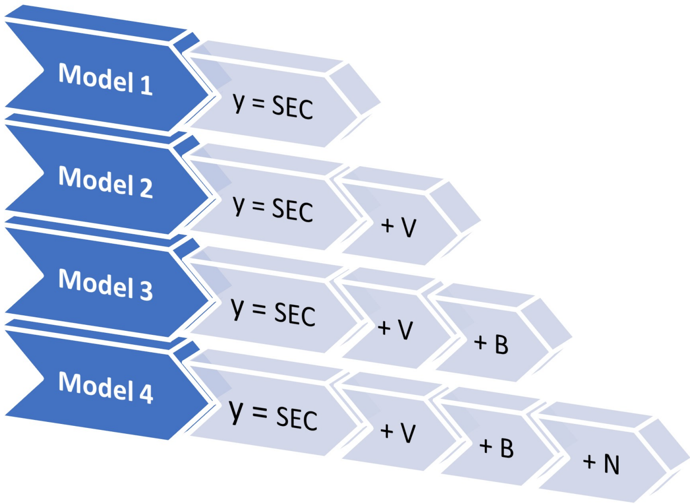
$$SD \approx \beta_{SD} + \beta_{SEC} * SEC + \beta_{VBN} * VBN + \epsilon_{SD} \tag{3.4}$$

3.5.2 Hierarchical method

A statistical technique to determine how much each independent variable or a set of independent variables contributes to the variance in the dependent variable is the hierarchical multiple regression method. Based on theoretical considerations, it requires introducing sets of independent variables to the regression model in a hierarchical order. The primary goal is to determine the distinct variation that each set of independent variables explains after adjusting for the impact of other factors that are already part of the analysis, also known as control variables (Fein et al., 2022; Keith, 2019). This allows assessing the incremental contribution of new variables to the dependent variable's variance, revealing the relative significance of various elements in the explanation. (de Jong, 1999).

The hierarchical regression analysis was conducted to investigate the contribution of the psychological factors to the variance explained by using the contextual factors as control factors (de Jong, 1999). Specifically, with the aim to determine the extent to which psychological factors interact with contextual variables in explaining the variance in the three types of domestic water use studied and previously specified (*'wu', 'ST', 'SD'*).

In the analyses, the socioeconomic factors, including the number of inhabitants per household, age, gender, altitude, zone, occupation, and education level were included as control variables in the initial step of the model. Subsequently, psychological factors categorized under 'values' were introduced, followed by those related to 'beliefs'. The final step involved incorporating psychological factors associated with 'norms'. Figure 3.5.2 illustrates the progressive entry of variables in the hierarchical regression analysis. The hierarchy followed was set in the same order as the VBN theory suggests.



Note: y, represents the three specific domestic water uses studied

Figure 3.3: Hierarchical regression

Chapter 4

Results

This chapter presents the results of the implementation of the VBN theoretical framework for domestic rural water use in the rural area of Valle del Cauca, Colombia. First, the framework and database is provided in section 4.1. Second, the results from the multi-linear regression models are shown in section 4.2.

4.1 Final data framework

After performing the data management restructuring mentioned in the methodology section, a final dataset and framework was created containing all questions answered in the survey. This data framework is suitable for running multi-linear regression models on the stats models package in Python.

The original data retrieved from the surveys consisted of 923 surveyed households. After restructuring the data, the final data set had 793 data points and 24 questions targeting VBN, and 7 SEC factors. Additionally, the three variables representing the specific water use explored in this research (*'wu'*, *'ST'*, *'SD'*) were added to the final data framework.

4.2 Regression analysis

In order to test if the VBN theory contributes to the understanding of water use in the study area, a multi-linear regression model was executed for three variables representing water uses: perceived total water use *'wu'*, shower time *'ST'*, and saving devices *'SD'*. The multi-linear regression model was performed with the Ordinary Least Squares method 'OLS' and the statistical Python package called 'Statsmodels' (Seabold and Perktold, 2010).

The coefficient of determination R^2 measures the proportion of the total variability in the dependent variable that is explained by the regression model and the $p-value$ (threshold is max 0.05) determines which variables are significant (Sarstedt et al., 2019).

In subsection 4.2.1, the results of the descriptive statistical analysis of the data and the significant parameters for *'wu'*, *'ST'*, and *'SD'* using the forced entry method will be presented.

Additionally, in subsection 4.2.2, the significant parameters using the hierarchical method for the three variables and the explained variance for these variables related to the VBN framework will be presented.

4.2.1 Significant parameters forced entry method

Descriptive Statistic

The survey results show that out of the 793 respondents, 269 (33.9%) are male and 524 (66.1%) are female. The average number of inhabitants per household is close to 4 people (3.7) with a standard deviation (Std) of 1.38. The average age of the respondents is in the range of 36 to 45 years old. Regarding the level of education, most of the people surveyed have attended primary or secondary school (77.9%), with a small minority having completed a master's degree (7.94%), followed by technical education (11.6%), and 2.5% reported having no education. The living areas of the respondents are situated at elevations between 989 and 1,173 meters above sea level. As for the occupation of the surveyed community, 48.8% reported having employment and 30.4% being involved in household chores; volunteer work represents 10.4%, students 7.3%, and unemployed nearly (3%). See figure 4.1 for the concentration distribution.

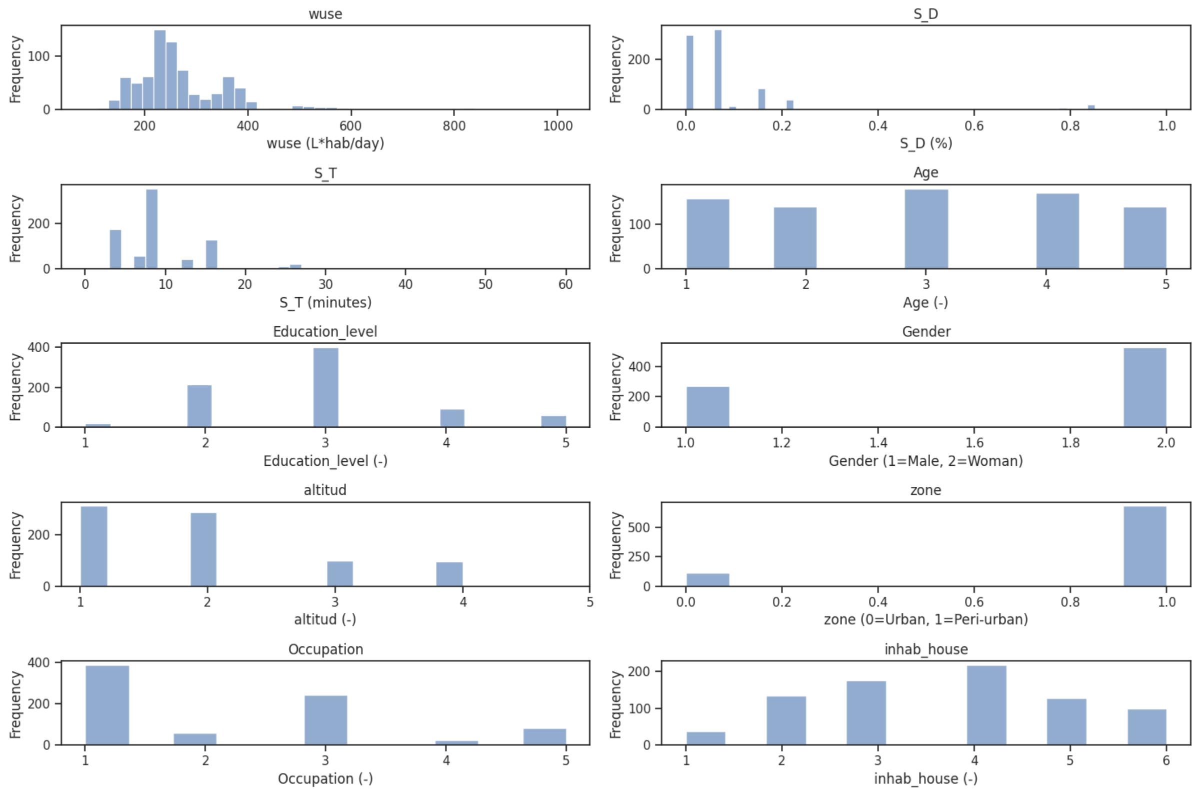


Figure 4.1: Histogram for the dependent variables and SEC factors

The average water use among the respondents *('wu')* is approximately 273.47 ($l * hab/day$), with a Std of 99.57, ranging from a minimum of 84.7 to a maximum outlier of 1016.6. The *'SD'* index has a mean of 0.10 and a Std of 0.18, with values ranging from 0.00 to 1.00 (%). The *'ST'* has a mean of 9.30 minutes with a Std of 6.25, ranging from 0 to an extreme of 60 minutes.

Regarding the VBN factors, the average for 'Limit_my_use' is 3.97 ($Std = 0.83$), and for 'Adequate_use' it is 4.08 (Std = 1.03), both ranging from 1.00 to 5.00. The mean for 'Limit_use_conservation' is also 3.97 (Std = 0.92), while 'Limit_use_for_others_present_future' averages 4.26 (Std = 0.63). 'Limit_use_Everyone_right_Water' has a mean of 4.29 (Std = 0.62), and 'Limit_use_Water_conservation' is at 4.27 (Std = 0.61).

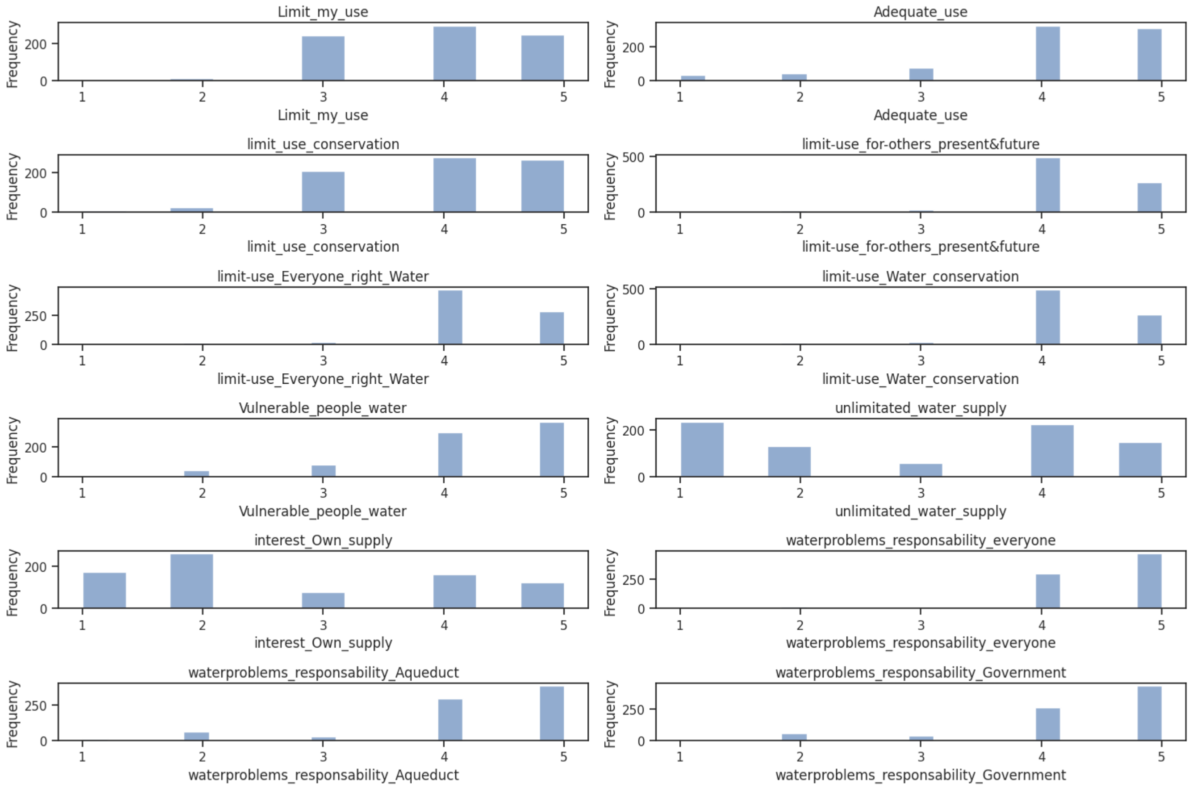


Figure 4.2: Histogram for 12 VBN Factors

For the 'Vulnerable_people_water' factor, the mean is 4.24 (Std = 0.88). 'Aware_water_conflicts_1' and '_water_supply' have means of 3.97 (Std = 0.83) and 4.08 (Std = 1.03), respectively. The mean score for 'Interest_Own_supply' is 3.97 (Std = 0.92), while 'Waterproblems_responsibility_everyone' averages 4.26 (Std = 0.63).

Other VBN factors include 'Waterproblems_responsibility_Aqueduct' with a mean of 4.29 (Std = 0.62), 'Waterproblems_responsibility_Government' at 4.27 (Std = 0.61), and 'Waterproblems_responsibility_environmental-authority' with a mean of 4.24 (Std = 0.88). The average score for 'Waterproblems_responsibility_economic_sector' is 4.08 (Std = 1.03). Figure 4.2 shows a histogram with the 12 VBN factors mentioned.

Furthermore, the 'Droughts_Village' and 'Droughts_Only_Property' factors have means of 3.97 (Std = 0.83) and 4.08 (Std = 1.03), respectively. The 'Excessive_w.intake_region' factor has a mean of 3.97 with a Std of 0.92, while 'Saving-water_regardless-others' averages 4.26 (Std = 0.63). Finally, 'Everyone_can-save-water' and 'Guilty_waste-water' have a mean of 4.29 (Std = 0.62) and 3.84 (Std = 0.96), respectively. The histograms from the other missing VBN factors are presented in figure 4.3.

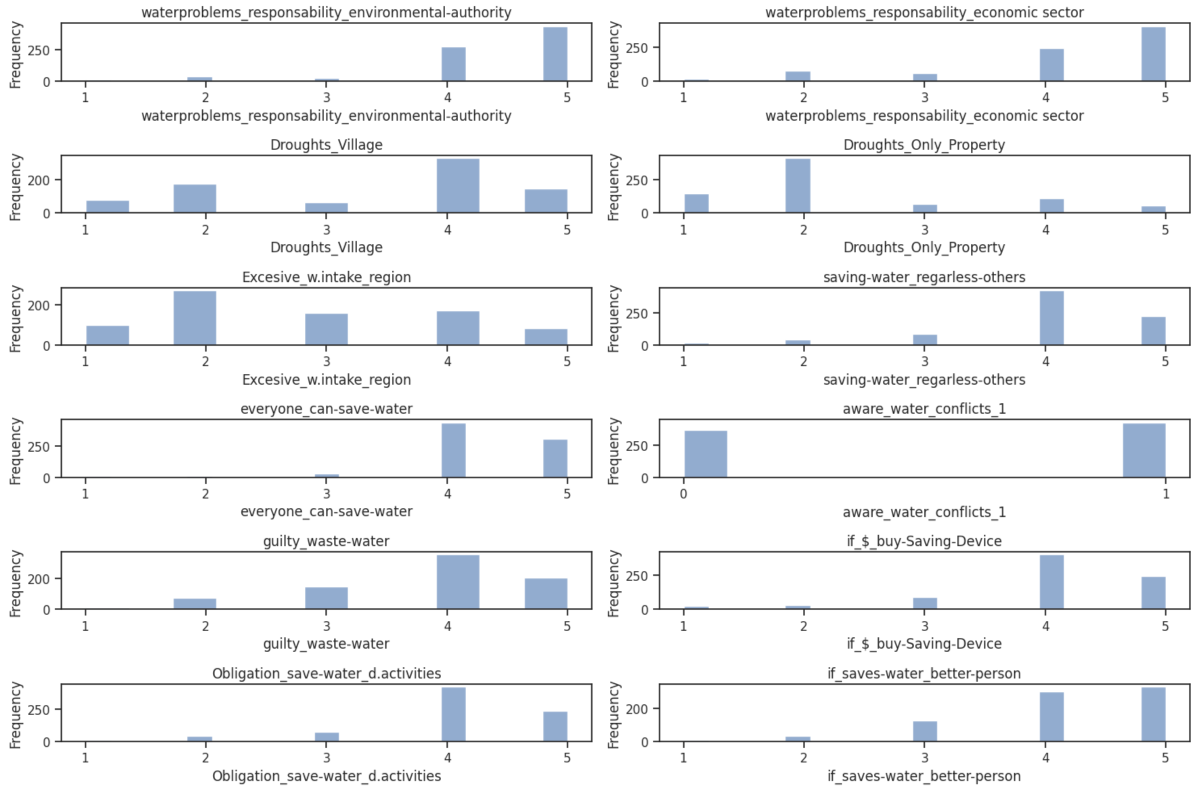


Figure 4.3: Histogram for the other 12 VBN Factors

In figure 4.4, the correlation matrix for all factors evaluated in this study is presented. Typically, a correlation value greater than 0.8 is considered to indicate a high correlation, while values below this threshold correspond to a low correlation (Schober et al., 2018). Therefore, since no factor reached a correlation value greater than 0.8, we can conclude that the factors in this study are not strongly correlated. In Appendix B the phyton code and the results for each of the regressions analysed in this chapter are presented.

Forced entry for total perceived water used 'wu'

The regression results showed that 6 of the 31 variables are significant ($p\_value < .05$). The 6 variables are: trying to limit water use performing household tasks (Limit_my_use), feeling morally obliged to save water regardless of others (savingwater_regardlessothers), in which zone the house is located (zone_1.0), number of household inhabitants (inhab_house), the gender of the respondent (Gender_2) and the level of education received (Education_level). These significant variables with corresponding statistical values are shown in table 4.1. The regression accounted for approximately 19% of the variance in '*wu*'. When all 6 variables are equal to zero, β_0 is expected to be approximately 267.28 litres per inhabitant per day $[L * hab/day]$.

The coefficient of determination R^2 measures the proportion of the total variability in the dependent variable that is explained by the regression model. In this case, R^2 has a value of 0.22 and Adj. R^2 of 0.19. This means approximately 19% of the variability in '*wu*' can be explained by the independent variables included in the model.

Figure 4.4: Correlation values between all the factors studied

The significance of the regression is measured through the F test. The F test is performed to determine whether the observed relationships inside the regression are statistically significant. A small p-value indicates that the observed results are unlikely to be due to chance, suggesting a significant association between the independent and the significant dependent variables. The values of the F test of this regression are $F(31, 793) = 6.31, p < .001(4.33E - 24)$.

The β coefficient is a parameter that represents the relationship between an independent variable (predictor/factors) and the dependent variable. Each beta coefficient β measures the expected change in the dependent variable for each unit change in the associated independent variable, while keeping all other independent variables in the model constant. In this inferential analysis, the value 'Limit_my_use' ($\beta = -12.66, t(793) = -2.56, p = .011$) is an ordinal categorical variable measuring the awareness of utilising individual water use when performing household tasks. The interpretation of the categorical variables depends on the positive or negative sign next to β. In this case, the variable exhibits a negative regression coefficient, indicating that a higher

Table 4.1: Significant variables for *wu* using forced entry method.

Variable type	Significant Variables	β	p-value
SEC	$zone\_1.0$	48.52	0.004
SEC	$inhab\_house$	-16.94	0.000
SEC	$Gender\_2$	15.29	0.052
SEC	$Education\_level$	24.45	0.000
Bio	$Limit\_my\_use$	-12.66	0.011
N	$saving - water\_regardless - others$	-10.35	0.043

Note: $F(31, 793) = 6.31, p < .001. R^2 = 0.22$ and $R^2_{adj} = 0.19$.

Bio=Biospheric, N=Norm.

awareness of the personal environmental impact, and therefore limiting the use of water during household tasks, decreases the perceived water use.

Similarly, for the personal norm 'saving-water_regardless-others' ($\beta = -10.35, t(793) = -2.03, p = .04$). The negative coefficient indicates that the stronger a person feels morally obliged to save water, independently of the opinion of others, the lower the reported perceived water use is.

The regression coefficient of SEC variable 'Education_level' ($\beta = 24.45, t(793) = 5.93, p < .001$) is positive, which indicates that the higher the level of education a respondent attained, the higher the reported water use.

Furthermore, for SEC factors 'Gender_2' ($\beta = 15.3, t(793) = 1.95, p = .05$) and 'Zone_1.0' ($\beta = 48.5, t(793) = 2.87, p = .004$) results show that women and the 'peri-urban' population are more likely to report to have a higher perceived water use than men and of people living in the rural area.

Regarding the SEC variable 'inhab_house' ($\beta = -16.9, t(793) = -6.98, p < .001$) result reveals that as the number of inhabitants per house increases, there is a corresponding decrease in the perceived water use per capita.

Three main observations can be made based on the results. Firstly, individuals who are conscious of their water use and feel a personal moral obligation to conserve water tend to reside in households with multiple inhabitants, resulting in lower perceived water use per capita. Secondly, individuals with higher levels of education typically exhibit higher perceived water use per capita compared to those with lower educational attainment. Lastly, women as well as individuals residing in peri-urban areas, have on balance reported higher perceived water usage per capita.

Forced entry for Shower Time 'ST'

The regression shows that 4 of the 31 variables were significant, with a p_value<.05, namely: 'zone_1.0', 'Education_level', 'Limit_my_use', 'saving-water_regardless-others'. Table 4.2 shows the significant variables and their respective statistics values. The regression accounted for approximately 16% of the variance in '*ST*'. When all four predictors are equal to zero, β_0 '*ST*' is expected to be around 7.15 minutes.

Table 4.2: significant variables for ST forced entry method

Variable type	Significant Variables	β	p-value
SEC	$zone\_1.0$	3.53	0.001
SEC	$Education\_level$	1.57	0.000
Bio	$Limit\_my\_use$	-1.09	0.001
N	$saving - water\_regardless - others$	-0.76	0.020

Note: F(31, 793)=5.4, p<.001. $R^2 = 0.2$ and $R^2_{adj} = 0.16$. Bio=Biospheric, N=Norm

In this inferential analysis, the value 'Limit_my_use' ($\beta = -1.1, t(793) = -3.5, p = .001$) is an ordinal categorical variable measuring awareness of individual water use. The variable shows a negative regression coefficient, indicating that higher awareness lowers the time people spend taking a shower.

The same is the case for the personal norm 'saving-water_regardless-others' ($\beta = -0.76, t(793) = -2.32, p = .02$). The coefficient indicates that the more morally obliged a person feels to save water, independently of the opinion of others, the lower is the perceived shower time reported.

The SEC binary variable 'zone_1.0', ($\beta = 3.53, t(793) = 3.27, p = .001$) results indicate that the 'peri-urban' population is more likely to report spending more time in the shower than people living in rural areas.

The 'education_level', ordinal categorical, ($\beta = 1.57, t(793) = 5.95, p < .001$) has a positive coefficient, suggesting that the higher the level of education of a person is the longer their perceived shower time.

This indicates that the respondents who are aware of water use and feel a personal moral obligation to save water, typically live in a rural area and don't have higher education. They report less time spent showering than those with higher education, living in peri-urban areas, who are less aware of saving water and are not as concerned about what others might think of their water use behaviour.

Forced entry for Saving Devices 'SD'

From the regression 6 of the 31 predictors were significant, with a p_value<.05, namely: 'zone_1.0', 'education_level', 'limit-use_for-others_present&future', 'unlimited_water_supply', 'guilty_waste-water' and 'if_saves-water_better-person'. Table 4.3 below shows the significant variables and their respective statistics values. The regression accounted for approximately 31% of the variance in '*SD*'. When all six predictors are equal to zero, the variance of '*SD*' is expected to be around 15%.

In this inferential analysis, the altruistic value 'limit-use_for-other_present&future' ($\beta = 0.06, t(793) = 3.79, p < .001$) and the norm 'if_saves-water_better-person' ($\beta = 0.021, t(793) = 2.33, p = .020$) are ordinal categorical variables that assess the concern and agreement for short and long-term well-being of others and the community. The positive regression coefficient indicates that a higher

Table 4.3: significant variables for SD forced entry method

Variable type	Significant Variables	β	p-value
SEC	$zone\_1.0$	-0.25	0.000
SEC	$Education\_level$	0.028	0.000
Alt	$limit - use\_for - others\_present\&future$	0.062	0.000
Ego	$unlimited\_water\_supply$	-0.014	0.001
N	$guilty\_waste - water$	-0.021	0.022
N	$if\_saves - water\_better - person$	0.021	0.020

Note: F(31, 793)=11.45, p<.001. $R^2 = 0.34$ and $R^2_{adj} = 0.31$. Alt=Altruistic, Ego=Egoistic, N=Norm

level of concern is associated with a higher percentage of installed saving devices per household. Comparable to the previous variables, SEC 'education_level' ($\beta = 0.028, t(793) = 4.0, p < .001$) follows a similar trend, where the positive coefficient suggests that the higher the level of education a person attained, the higher the percentage of saving devices.

Contrarily, the following are also ordinal categorical variables but with a negative coefficient. The egoistic value 'unlimited_water_supply' ($\beta = -0.014, t(793) = -3.28, p = .001$), measures the level of agreement with the right to use water based on individual needs and that water use and supply should be unlimited. The variable 'guilty_waste-water' ($\beta = -0.021, t(793) = -2.3, p = .022$), is measuring a personal norm regarding guilt when not using water rationally. The negative coefficients point out that a higher agreement with the respective statements is associated with a smaller percentage of installed saving devices.

Finally, concerning to SEC factor 'zone_1.0' ($\beta = -0.25, t(793) = -8.83, p < .001$), the negative coefficient is indicative of its association with the rural population. This shows that individuals in rural areas are more likely to have a higher percentage of saving devices installed than those in peri-urban areas. In other words, the peri-urban population is associated with a lower percentage of saving devices compared to the rural population.

The findings indicate that individuals residing in rural areas, who demonstrate significant concern for both the short and long-term well-being of others, tend to have a higher percentage of installed water-saving devices. In contrast, those living in peri-urban areas prioritize unlimited water supply, experience guilt regarding wasting water, and perceive themselves as better individuals when they save water.

When summarizing the results from the previous regressions for the three dependable variables (*'wu', 'ST', 'SD'*), we can observe that 'zone' and 'education_level' are the contextual factors which were most significant. The biospheric value 'limit_my_use' was a significant parameter common in *'wu'* and *'ST'* regressions next with the personal norm 'saving water regardless others'. The *'SD'* regression did not share significant VBN factors with the regressions of *'wu'* and *'ST'*.

It was expected that 'zone' and 'education level' are significant parameters in domestic water use in the study area, since several other studies have found these factors as relevant contextual

Table 4.4: Common factors across the regressions

Significant Variables					
wu		**ST**		**SD**	
SEC	zone_1.0	SEC	zone_1.0	SEC	zone_1.0
SEC	inhab_house	SEC	Education_level	SEC	Education_level
SEC	Gender_2	Bio	Limit_my_use	Alt	limit-use_for-others_present&future
SEC	Education level	N	saving-water_regarless-others	Ego	unlimitated_water_supply
Bio	Limit_my_use			N	guilty_waste-water
N	saving-water_regarless-others			N	if_saves-water_better-person

Note 1: In yellow are the common factors along the 3 regressions. In green are the common factors from VBN.

Note 2: Bio= biospheric, N= Norm

factors, which influence water use (Sanchez et al., 2023).

We could see that 'limit my use', a biospheric value, and the personal norm 'saving water regardless others' are the common VBN factors in *'wu'* and *'ST'*. However, the VBN factors for *'SD'* are different: one altruistic 'value limit-use for-other present&future', one egoistic 'unlimited water supply', and two personal norms: 'guilty waste-water' and 'if saves-water better-person'.

This could be because *'SD'* is driven by different VBN factors in the study zone. Since it is another type of domestic water use behaviour, where the water saving comes from high-efficiency water appliances or installed saving devices.

4.2.2 Significant parameters from the Hierarchical method

The hierarchical regression was conducted to investigate the contribution of the VBN factors to the variance explained by using the contextual factors as control factors. Specifically, with the aim to determine the extent to which psychological factors interact with contextual variables in explaining the variance in the three types of domestic water use studied and previously specified *('w'u, 'ST', 'SD')*.

The next subsections, 'hierarchical method for *wu*', 'hierarchical method for shower time *ST*' and 'hierarchical method for saving devices *SD*', present tables with results for statistically significant regression factors that are likely to have a real effect with a $p\_value < .05$ on the three dependent variables. The results, discussion and conclusion will be centred around the VBN significant variables.

Hierarchical method for wu

In this part, the results of the significant factors found in the hierarchical models run for *wu* and the variance explained are presented.

The first model, the control model, is predicting *''wu''* only from SEC variables. This accounts for a variance of Adj. $R^2 = .166, F(7, 793) = 16.82, p < .001(8.67E - 28)$, meaning that SEC is able to explain almost 17 % of the variance of *'wu'*. The addition of the second

Table 4.5: Hierarchical for *wu*

Model	Variable type	Significant Variables	β	p-value	R²	Adj. R²	Δ Adj R² per Block of variables	Δ R² Explain by VBN	% added value by VBN compared to SEC
SEC Model 1		zone_1.0	51.28	0.000	0.177	0.166	-	-	-
		inhab_house	-17.30	0.000					
		Gender_2	15.95	0.042					
		Education_level	24.23	0.000					
SEC+V Model 2		zone_1.0	56.29	0.000	0.206	0.185	0.019	-	-
		inhab_house	-17.26	0.000					
		Gender_2	15.56	0.046					
		Education_level	24.58	0.000					
	Bio	Limit_my_use	-12.93	0.008					
SEC+ VB Model 3		zone_1.0	52.02	0.001	0.21	0.181	-0.004	-	-
		inhab_house	-17.15	0.000					
		Gender_2	16.47	0.036					
		Education_level	24.23	0.000					
	Bio	Limit_my_use	-13.18	0.008					
VBNSEC Model 4		zone_1.0	48.52	0.004	0.221	0.186	0.005	0.020	12.048
		inhab_house	-16.94	0.000					
		Gender_2	15.29	0.052					
		Education_level	24.45	0.000					
	Bio	Limit_my_use	-12.66	0.011					
	N	saving-water_regarless-others	-10.36	0.043					

Note: Bio= biospheric, N= Norm

block of variables corresponding to 'values' slightly increased the variance accounted for in ''*wu*'', $Adj.R^2 = .185, F(17, 793) = 9.99, p < .001(1.11E-27)$. The third model, with the addition of the 'beliefs' factor, decreased the explained variance *'wu'*, $Adj.R^2 = .181, F(25, 793) = 7.24, p < .001(1.15E-24)$. The last model, considering the SEC and all VBN factors, led to an increase in the amount of explained variance of ''*wu*'', $Adj.R^2 = .186, F(32, 793) = 6.31, p < .001(4.33E-24)$ and overall accounted for approximately 19% of the variance in ''*wu*''. Only six of the 31 predictors were significant, $p < .05$, namely: 'zone_1.0', 'inhab_house', 'gender_2', 'education_level', 'limit_my_use' and 'saving-water_ regardless-others'. When all six predictors are equal to zero, ''*wu*'' is expected to be around $\beta_0 = 267.28[L * hab/day]$.

For *'wu'*, Table 4.5 shows that the total variance explained by SEC and VBN combined is 18.6%, of which SEC explains 16.6% and the Values, Beliefs, and Norms account for 2%. Values contribute 1.9% and norms add 0.5% to the explained variance. However, the 'beliefs' component decreases the explained variance by 0.4%. The added explanation by VBN on top of SEC is 12%. This is the relative increase of the variance explained by SEC, when the VBN factors are added.

Hierarchical method for ST

Table 4.6 shows that the first model, the control model, is predicting 'ST' from SEC, and accounts for a variance of Adj. $R^2 = 0.13, F(7, 793) = 12.5, p < .001(2.33E-20)$. In the second model, with the addition of 'values', the variance accounted for in *'ST'* increased slightly

$Adj.R^2 = 0.16, F(17, 793) = 8.34p < .001(1.85E-22)$. The third model, with the addition of the 'beliefs factor' decreased the explained variance for *'ST'*, $Adj.R^2 = 0.15, F(25, 793) = 6.13p < .001(5.75E-20)$. The last model, with the SEC and all VBN factors, led to an increase in the amount of explained variance of *'ST'*, $Adj.R^2 = 0.16, F(31, 793) = 5.42, p < .001(1E-19)$.

Table 4.6: Hierarchical for ST

Independent	Variable type	Significant Variables	β	p-value	R²	Adj. R²	Δ Adj. R² per Block of variables	Δ R² Explain by VBN	% added explanation by VBN on top of SEC
SEC Model 1	SEC	zone_1.0	3.62	0.000	0.138	0.127	-	-	-
	SEC	Education_level	1.52	0.000					
	SEC	Occupation_5	-1.54	0.052					
SEC+V Model 2	SEC	zone_1.0	3.83	0.000	0.178	0.156	0.029	-	-
	SEC	Education_level	1.58	0.000					
	Bio	Limit_my_use	-1.11	0.000					
SEC+ VB Model 3	SEC	zone_1.0	3.70	0.000	0.183	0.153	-0.003	-	-
	SEC	Education_level	1.55	0.000					
	Bio	Limit_my_use	-1.14	0.000					
VBNSEC Model 4	SEC	zone_1.0	3.53	0.001	0.196	0.16	0.007	0.033	25.98
	SEC	Education_level	1.57	0.000					
	Bio	Limit_my_use	-1.09	0.001					
	N	saving-water_regarless-others	-0.76	0.020					

Note: Bio= biospheric, N= Norm

The final model, SEC + VBN, accounted for approximately 16% of the variance in *'ST'*. Four of the 31 predictors were significant, $p < .05$, namely: 'zone_1.0', 'education_level', 'limit_my_use' and 'saving-water_ regardless-others'. When all four predictors are equal to zero, *'ST'* is expected to be around $\beta_0 = 7.15 minutes$.

For *'ST'*, the total variance explained by SEC and VBN combined is 16%, of which SEC explains 12.7% and the Values, Beliefs, and Norms account for 3.3%. Values contribute 2.9% and norms added 0.7%, while beliefs decreased the explained variance by 0.3%. The added explanation by VBN on top of SEC is 26%.

Hierarchical method for SD

Table 4.7 shows that the first model, the control model, is predicting '*'SD'*' from SEC factors alone and accounts for a variance of Adj. $R^2 = .27, F(7, 793) = 30.25, p < .001(1.82E-49)$. The addition of the second block of variables corresponding to 'values' slightly increased the variance accounted for in *'SD'*, $Adj.R^2 = 0.30, F(17, 793) = 18.34, p < .001(1.57E-52)$. The third model, with the addition of the beliefs factor slightly increased the explained variance for *'SD'*, $Adj.R^2 = 0.31, F(25, 793) = 13.5p < .001(1.01E-49)$. The last model, with all the SEC and VBN factors taken into account, led to an increase in the amount of explained variance of *'SD'*, $Adj.R^2 = 0.31, F(31, 793) = 11.45, p < .001(2.52E-48)$.

As can be seen in the table 4.7, the final model includes all the factors. Overall, the model accounted for approximately 31% of the variance in *'SD'*. Six of the 31 predictors were signif-

Table 4.7: Hierarchical for SD

Independent	Variable type	Significant Variables	β	p-value	R^2	Adj. R^2	Δ Adj. R^2 per Block of variables	Δ R^2 Explain by VBN	% added explanation by VBN on top of SEC
SEC Model 1	SEC	zone_1.0	-0.283	0.000	0.279	0.27	-	-	-
	SEC	Education_level	0.030	0.000					
SEC+V Model 2	SEC	zone_1.0	-0.287	0.000	0.322	0.305	0.035	-	-
	SEC	Education_level	0.027	0.000					
	Bio	Adequate_use	0.021	0.000					
	Alt	limit-use_for-others_present&future	0.063	0.000					
	Alt	aware_water_conflicts_1	0.028	0.015					
	Ego	unlimitated_water_supply	-0.013	0.002					
SEC+ VB Model 3	SEC	zone_1.0	-0.275	0.000	0.331	0.306	0.001	-	-
	SEC	Education_level	0.028	0.000					
	Bio	Adequate use	0.019	0.002					
	Alt	limit-use_for-others_present&future	0.063	0.000					
	Alt	aware_water_conflicts_1	0.025	0.040					
	Ego	unlimitated_water_supply	-0.016	0.000					
	Blf	waterproblems_responsability_Government	-0.022	0.045					
VBNSEC Model 4	SEC	zone_1.0	-0.249	0.000	0.339	0.31	0.004	0.040	14.81
	SEC	Education_level	0.028	0.000					
	Alt	limit-use_for-others_present&future	0.062	0.000					
	Ego	unlimitated_water_supply	-0.014	0.001					
	N	guilty_waste-water	-0.021	0.022					
	N	if_saves-water_better-person	0.021	0.020					

Note: Bio= biospheric, Alt=Altruistic, Ego=Egoistic, Blf=Beliefs, N= Norm

icant, $p < .05$, namely: 'zone_1.0', 'education_level', 'limit-use_for-others_present&future', 'unlimited_water_supply', 'guilty_waste-water' and 'if_saves-water_better-person'. When all six predictors are equal to zero, *'SD'* is expected to be around $\beta_0 = 15[\%]$.

For *'SD'*, the total explained variance by SEC and VBN combined is 31%, of which SEC explains 27% and the Values, Beliefs, and Norms account for 4%. Values contribute 3.5%, beliefs add 0.1% and norms 0.4% to the explained variance. The added explanation by VBN on top of SEC is 15%.

Hierarchical method comparison

The results show that the absolute increase of *'wu'* (2%), is the lowest compared to *'ST'* (3.3%) and *'SD'* (4%), as well as the relative increase (12%) versus 26% and 15% respectively. The increase of 3.3% for *'ST'* is lower than the absolute increase of *'SD'* is 4%, however, the relative increase of *'ST'* is approx. 26% while the relative of *'SD'* is only 15%. Therefore, however the absolute increase of *'SD'* is larger than *'ST'*, the added explanation of VBN on top SEC is the biggest for *'ST'*.

Chapter 5

Discussion

In this chapter, the key results will be discussed. Firstly, a summary of the results will be provided. In the second section the results will be interpreted, and compared with other studies and the implications of the findings will be discussed. Finally, the limitations of this study will be presented and suggestions and recommendations will be made for future research. Contextual factors will not be discussed in this chapter as they have been studied extensively and were proven to have a significant influence on domestic water use as mentioned in the literature review. The focus will therefore be on VBN factors and their significant relationship with domestic water use in the study area.

5.1 Results recap

Summarizing the results of the previous regressions for the three dependent variables (*'wu'*, *'ST'* and *'SD'*), we can observe that 'Zone' and 'Education level' are the contextual factors that were found to be significant variables in all three regressions. It was expected that 'Zone' and 'Education level' are significant parameters in domestic water use in the study area since several other studies have found these contextual factors are relevant and influence water use behaviour (Callejas Moncaleano et al. (2023);Corbella and i Pujol (2009)).

Regarding the VBN factors, the results show that the biospheric value 'limit my use', and the personal norm 'saving water regardless others' are the VBN factors which significantly influence the total water use *'wu'* and shower time *'ST'* behaviour. However, the *'SD'* regression did not share significant VBN factors with the *'wu'* and *'ST'* regressions. The significant factors associated with *'SD'* are the altruistic 'value limit-use for-other present&future', the egoistic value 'unlimited water supply' and two personal norms: 'guilty waste-water' and 'if saves-water better-person'. In the next sections, each of the significant parameters associated with the domestic water use behaviour in the study zone will be discussed.

5.2 Discussion forced entry method

In this section, the results of the forced entry method will be discussed, taking into account the three dependent variables: total water use per day *'wu'*, shower time *'ST'*, and an index for water saved through water-saving devices *'SD'*. The discussion focuses on the significant VBN factors influencing these three variables, as the relevance of contextual factors has been researched extensively and this study aims to contribute by providing more insights into the psychological behavioural factors.

5.2.1 Total Water Use *'wu'*

Two VBN factors were identified that significantly influenced the total daily water use. The first one is the biospheric value: 'Limit my use' ($\beta = -12.66, p = 0.011$). This indicates that people with a strong commitment to limit water use or natural resources in general, for environmental reasons, tend to use less water. This supports the VBN theory's proposition that biospheric values drive pro-environmental behaviour, as in this case using less water and water conservation.

The second significant VBN factor influencing *'wu'* is the norm: 'Saving water regardless of others' ($\beta = -10.35, p = 0.043$). Meaning that individuals who feel a moral obligation to save water, independent of the actions of others, use less water. This inverse relationship can be explained by several considerations. Firstly, people who have strong personal norms related to water conservation often develop more sustainable and conscious habits regarding the use of natural resources and pro-environmental behaviour. This personal norm could indicate a high level of internalisation of pro-environmental values (like limit my use), which means that these individuals do not rely on social pressure or the actions of their community to act in an environmentally responsible manner. This is in line with the VBN theory's emphasis on personal norms as key motivators of pro-environmental behaviour.

5.2.2 Shower Time *'ST'*

Regarding the time individuals spend in the shower, the same two VBN factors as *'wu'* were identified as having significant influence. First, the biospheric value: 'Limit my use' ($\beta = -1.09, p = 0.001$). This means that individuals with strong biospheric values, are committed to limit the use of scarce resources, and tend to reduce their shower time and take shorter showers, reinforcing the idea that biospheric values consistently advance water-saving behaviour.

The other significant factor is the personal norm: 'Saving water regardless of others' ($\beta = -0.76, p = 0.020$). The person must be aware of the consequences, plus accept personal responsibility, these two activate their personal norm. The personal norm then activates their behavioural intentions and behaviours. The indication from the research is that 'feeling obliged to save water regardless of others', leads to shorter shower times, aligning with the VBN theory's focus on personal norms influencing specific pro-environmental actions.

5.2.3 Water Saving Devices *'SD'*

Regression results for the water-saving devices *'SD'* index show significant relationships with several values and personal norms. The implications of these findings are discussed below. Four

VBN factors significantly influenced the *'SD'* index, an altruistic value, an egoistic value, and two norms.

The altruistic value, 'Limit use for others present & future' ($\beta = 0.062, p < 0.001$) is interpreted as individuals who consider limiting water use for the benefit of others are more likely to install water-saving devices. This is measured by the importance of sustainable water use to ensure short- and long-term well-being for the whole community, which means the bigger the index of *'SD'* the more water is saved in the household due to the installation of water-saving appliances. This index reflects the volume of water saved through the installation of water-saving devices in the households in the study zone. This is consistent with the VBN theory's assertion that altruistic values drive pro-environmental behaviour.

The second significant factor is 'Unlimited water supply' an egoistic value ($\beta = -0.014, p = 0.001$). There is a significant inverse relationship between this egoistic value and the index of water-saving devices. As a result, it shows that people who desire an unlimited water supply are less likely to install water-saving devices, indicating that egoistic values negatively impact water-saving actions.

The observation that people who desire an unlimited water supply are less likely to install water-saving devices, indicating that egoistic values negatively impact water-saving actions, is supported by several studies as mentioned in the literature review. Egoistic values focus on personal benefits and gains. Individuals with strong egoistic values tend to prioritise their immediate comfort and convenience over long-term environmental benefits. Consequently, they may be less inclined to adopt practices they perceive as limiting their comfort or convenience, such as installing water-saving devices. This behaviour contrasts with those driven by altruistic or biospheric values, who are more likely to engage in pro-environmental behaviours because they prioritise the well-being of others and the planet.

Research has shown that individuals with high egoistic values often need additional incentives, such as cost savings, to motivate them to adopt environmentally friendly practices. For example, the study by Wan Hussain et al. (2021) indicates that while egoistic values can contribute to pro-environmental behaviour, they are often less effective than altruistic values unless supported by other benefits. Similarly, another study by Sarpong et al. (2021) suggests that perceived benefits, which appeal to egoistic values, can influence the willingness to purchase efficient water-saving appliances, but these benefits must be significant enough to outweigh the perceived inconvenience.

Furthermore, the norm 'Guilty for wasting water' ($\beta = -0.021, p = 0.022$) also has a significant inverse relationship with the index of water-saving devices *'SD'*, which is an interesting finding. This result may seem contradictory at first, but it offers several perspectives for discussion, as this means individuals who feel guilty about wasting water are less likely to install water-saving devices. Feeling guilty about wasting water can, in some cases, lead to a lack of action if the guilt is not translated into constructive behaviours (Tangney et al., 1996). People may feel powerless to make significant changes, decreasing the likelihood of installing water-saving devices. Another possible reason is that people with a strong personal norm towards water saving may be more aware of the need for efficient water use. That is, although they may spend more time in the shower, they are using techniques to minimise water waste, such as low-flow showering, turning off the tap while soaping, or employing quick and efficient soaping techniques. Finally, an explanation could be that they would like to save water but do not have the budget or means to buy *'SD'*. This contradicts the role of guilt as a personal norm in driving pro-environmental behaviour (Tangney et al., 1996).

The last significant factor is the norm 'If saves water, better person' ($\beta = 0.021, p = 0.020$) is deemed significant in the results. It shows the belief that saving water makes one a better person and also promotes the installation of water-saving devices, showing how personal norms can positively influence water conservation actions.

5.2.4 VBN theory

The findings align well with VBN theory, which states that values, beliefs, and norms are critical in shaping pro-environmental behaviour. The significant impact of biospheric values and personal norms on total water use and shower time illustrates the applicability of theory to understanding these behaviours. However, the different set of significant VBN factors for the *'SD'* index suggests that the motivations behind adopting technical water-saving measures may be more complex and varied, involving altruistic and egoistic values as well as different personal norms.

5.3 Discussion Hierarchical method

5.3.1 Hierarchical for Total Water Use *'wu'*

The hierarchical regression for total water use *'wu'* showed that the SEC factors explained approximately 17% of the variance in water use. Adding values slightly increased the explained variance to 18.5%, but the inclusion of beliefs slightly reduced it to 18.1%. Finally, including norms, resulted in an adjusted R^2 of 18.6%, indicating that VBN factors together contributed an additional 2% of the variance. The added explanation by VBN on top of SEC is 12%. The significant predictors were zone_1.0, inhab_house, Gender_2, Education_level, Limit_my_use, and saving-water_regardless-others.

The modest increase in variance explained by the VBN factors suggests that while values and norms do play a role, still socioeconomic factors are stronger predictors of total water use. This aligns with previous studies indicating that demographic and contextual factors, such as household size and education level, are critical determinants of water usage. Even though the impact of VBN factors on water use may be small compared to socioeconomic factors, their inclusion in analysis is crucial for a holistic understanding of water consumption behaviors. VBN factors provide insights into the psychological, cultural, and moral behaviour that SEC factors cannot. This can enable more targeted, effective, and sustainable interventions by policymakers.

5.3.2 Hierarchical for Shower Time *'ST'*

For shower time *'ST'*, SEC factors explained 13% of the variance. After including values, the explained variance increased to 16%, while adding beliefs reduced it to 15%. The final state, including norms, accounted for 16% of the variance. The added explanation by VBN on top of SEC is 26%. Significant predictors included zone_1.0, Education_level, Limit_my_use, and saving-water_regardless-others.

The fact that values contributed 3% and norms 0.7% to the explained variance highlights the importance of personal environmental values and norms in determining specific water use behaviours like shower time. This is consistent with the VBN theory, which states that values influence beliefs about environmental conditions and our relationship with the environment, which in turn shape personal norms (feelings of moral obligation) to engage in pro-environmental actions (Stern, 2000).

5.3.3 Hierarchical for Saving Devices *'SD'*

The hierarchical regression results for saving devices *'SD'* showed that SEC factors accounted for 27% of the variance. Adding values to the SEC factors increased this to 30%, and the inclusion of beliefs slightly increased it further to 31%. The final model, including norms, maintained an explained variance of 31%. Significant predictors were zone_1.0, Education_level, limit-use_for-others_present&future, unlimited_water_supply, guilty_waste-water, and if_saves-water_better-person.

The VBN factors explained an additional 4% of the variance, with values contributing 3.5%, beliefs 0.1%, and norms 0.4%. The added explanation by VBN on top of SEC is 15%. This suggests that the adoption of water-saving devices is more strongly influenced by personal values and norms compared to the other behaviours studied. Previous research supports this finding, the adoption of environmental technologies often correlates with strong environmental values and norms (Bamberg and Möser, 2007).

Comparing these results, *'wu'* has the lowest absolute 2% and relative 12% increase in variance explained by VBN, whereas *'ST'* shows a lower absolute increase (3.3%) compared to *'SD'* (4%), but a higher relative increase (26% vs 15%). Thus, despite the larger absolute increase in *'SD'*, the added explanation of VBN on top of SEC is most significant for *'ST'*. This result suggests that the VBN framework is more applicable in explaining specific, environmentally motivated actions (like installing saving devices) and shower time *'ST'* compared to more general behaviours like overall water use *'wu'*. Installing water-saving devices is a one-time action with high impact that aligns with individuals' values and beliefs. People who hold strong biospheric and altruistic values are more likely to make substantial commitments to reduce their environmental footprint, such as installing water-saving devices (Steg and Vlek, 2009) if having the means to buy this water-saving appliances (Addo et al., 2018a).

Curtailment behaviours, such as reducing shower time, require ongoing effort, and as results suggested, may be influenced by immediate biospheric values and personal norms and contextual factors. While values and norms play a role, the daily routine is more susceptible to changes in motivation and externals such as social norms and immediate convenience. Thus, strategies to encourage water-saving through curtailment should not only emphasize values and norms but also consider habit formation (Verplanken and Wood, 2006).

The modest contribution of VBN factors to the variance explained in total water use *'wu'* shows the complexity of influencing total water use behaviour. Since the socioeconomic factors explained a significant portion of the variance, this highlights the importance of considering demographic and contextual influences when designing interventions aimed at reducing water use. The significant predictors, zone, number of inhabitants per household, gender, and education level suggest that targeted policies should consider these demographic characteristics.

The hierarchical regression analysis demonstrates that while the VBN framework contributes to explaining domestic water use behaviours, the impact varies across different types of behaviours. The framework is particularly effective for predicting the adoption of water-saving devices and shower time. For *'SD'*, personal values and norms play a significant role. For curtailment behaviours like reducing shower time, a combination of values, norms, and contextual factors should be considered. These findings underscore the importance of tailored interventions that align with the specific drivers of each type of water use behaviour.

5.4 Compare results to other studies

In this section, the results of the thesis will be discussed and compared to previous research and studies. First, the variables 'Total Water Use' and 'Shower Time' will be analysed based on the significant found biospheric values and personal norms. Secondly, the variable Water Saving Devices will be discussed based on the significant altruistic and egoistic values and personal norms.

5.4.1 Total Water Use *'wu'* and Shower Time *'ST'*

Biospheric Values

The biospheric value 'Limit my use' was found to significantly reduce total water use per day ($\beta = -12.66, p = 0.011$) and shower time ($\beta = -1.09, p = 0.001$). The research performed by (Jorgensen et al., 2009) has shown that individuals with strong environmental values tend to engage in water-saving behaviours. These studies reported that biospheric values are associated with reduced household water consumption, aligning with the findings (Saurí, 2013). This is in line with the research of (De Groot and Steg, 2010) which determined that individuals with biospheric values were more self-determined to act pro-environmentally.

Personal Norms

The personal norm 'saving water regardless of others' was significant for both total water use ($\beta = -10.35, p = 0.043$) and shower time ($\beta = -0.76, p = 0.020$). (Dolnicar and Hurlimann,

2010) found that personal norms, such as feeling a moral obligation to conserve water, are strong predictors of water-saving behaviours. Similarly, the study by (Russell and Fielding, 2010) emphasize the role of personal norms in motivating individuals to adopt water conservation practices.

5.4.2 Saving Devices *'SD'*

Altruistic Values

The altruistic value 'limit-use for others present and future' positively influenced the installation of water-saving devices ($\beta = 0.062, p < 0.001$). Studies by (Clark and Finley, 2007) and (Lam, 2006) have demonstrated that altruistic values, such as concern for future generations and the community, are linked to higher adoption rates of water-saving technologies. Another research found that the more respondents were altruistically oriented the more they were self-determined to act pro-environmentally (De Groot and Steg, 2010).

Egoistic Values

The egoistic value 'unlimited water supply' had a negative relationship with the adoption of water-saving devices ($\beta = -0.014, p = 0.001$). (De Groot and Steg, 2008) found that individuals with strong egoistic values are less likely to engage in water-saving behaviours. This suggests that those who prioritize immediate needs and comforts may resist installing water-saving devices. Furthermore, a following study by De Groot and Steg (2010) found that people who endorse egoistic values were less likely to act in a pro-environmental manner compared to others.

Personal Norms

The results of this study show that the norms 'guilty wasting water' ($\beta = -0.021, p = 0.022$) and 'if saves-water better-person' ($\beta = 0.021, p = 0.020$) significantly influenced the adoption of water-saving devices. (Gkargkavouzi et al., 2019) reported that feelings of guilt and personal moral obligations are significant predictors of adopting water-saving practices and technologies. This supports that personal norms are crucial in motivating the adoption of water-saving devices.

5.5 Implications of findings

In this section, the implications of the findings for water conservation and awareness will be discussed, as well as practical situations where these can be implemented.

5.5.1 Implications for water conservation and awareness

The results suggest that promoting biospheric and altruistic values, along with reinforcing personal norms about water conservation, could contribute in reducing water use and encourage the adoption of water-saving devices. Campaigns and educational programs aimed at strengthening these values and norms could play a crucial role in fostering sustainable water use behaviours. By highlighting the importance of sustainable use of water for the community, initiatives can promote greater installation of saving devices, thus contributing to sustainable water management in rural areas. This result is consistent with the VBN theory, which postulates that personal values can significantly influence environmental actions. In this case, the altruistic value acts as a catalyst for the adoption of devices that contribute to water conservation.

In agreement with the results from this study, the biospheric values such as 'limit my use' play a crucial role in shaping sustainable behaviours related to domestic water use. This study reinforces the importance of considering psychological factors as values in the design of water conservation interventions and policies.

The reduction in shower time *'ST'* is particularly relevant, given that showers account for a significant share of domestic water consumption. According to previous studies, showers can account for up to 20% of total household water use (WaterSense, 2017). Therefore, the fact that individuals with high concern for the biospheric value (limit my use) tend to shorten their shower time may have a considerable impact on domestic water conservation.

The personal norm 'saving water regardless of others' suggests that environmental education campaigns and programs that seek to promote water conservation could benefit from focusing on strengthening personal norms related to water conservation. When water conservation is driven by personal norms, the behaviour tends to be more sustainable over the long term. This is because it is not dependent on external factors, such as social pressure or temporary incentives, which might decrease over time.

For example, campaigns in Australia that emphasized the importance of individual action in water conservation (regardless of what others or the community was doing) helped maintain water-saving behaviours even after the immediate crisis had passed (Fielding et al., 2012). During periods of severe drought, many Australian cities implemented educational campaigns that focused on personal responsibility for water conservation. These campaigns, which appealed to personal norms and the moral duty to conserve water, were successful in significantly reducing water use (California Department of Water Resources, 2017). The promotion of such personal norms can be crucial in reducing overall water use and addressing the challenges related to water resource management in rural areas of Valle del Cauca and Restrepo.

The positive relationship between the altruistic value 'limit-use for-others present' and *'SD'* underlines the importance of community awareness in the adoption of pro-environmental behaviours (represented through the installation of water-saving appliances). People who recognize the importance of rational use of water for the well-being of the entire community are more motivated to take concrete measures to save water, through the implementation of technologies to save water, such as installing water-saving devices. This finding highlights the power of altruistic values in promoting sustainable practices and it is in line with the VBN theory argument that altruistic values are also linked with the encouragement of pro-environmental behaviours. Adopting these technologies can significantly reduce water use, relieving pressure on local water resources and ensuring a more equitable supply for all community members.

In communities where common well-being is highly valued, these values are likely to translate into actions, such as the adoption of water-saving devices. Understanding these dynamics can help design more effective strategies to promote sustainable practices. In summary, the direct relationship between altruistic value and the water-saving devices index highlights the importance of personal values in the adoption of sustainable technologies. Promoting altruistic values that emphasize the importance of rational water use for community access may be an effective strategy to increase the adoption of water-saving devices in rural areas. This approach not only benefits individual households but also contributes to water sustainability and the well-being of the entire community.

The egoistic value 'Unlimited Water Supply' with has an indirect relationship with *'SD'* indicating that the desire for unlimited water supply could discourage sustainable behaviour. People with this egoistic value may perceive water-saving measures as unnecessary or restrictive, reducing their willingness to adopt water-conserving technologies, or believe that water is an unlimited resource, and they are less likely to see the need for conservation. This is in line with expectations, the VBN theory considers egoistic values as drivers of unsustainable or less pro-environmental behaviour.

Environmental education campaigns should address this egoistic value, highlighting the importance of water conservation even when supply appears plentiful. For example, to effectively address this the campaigns should employ strategies that connect personal benefits with sustainable practices, such as showing water conservation not only as an environmental responsibility, but it also has financial benefits. For instance, campaigns can highlight how water savings devices can lead to significant cost savings on utility bills.

The significant direct relationship between the personal norm of believing that 'if you save water, you are a better person' and the water-saving devices *'SD'* index underlines the positive impact of personal norms on the adoption of conservation technologies.

These findings highlight how personal norms that associate water saving with a sense of positive and moral identity can drive pro-environmental behaviours, which is in line with the VBN theory (Stern, 2000). People who believe that saving water makes them better people are more inclined to take concrete steps, such as installing water-saving devices. Campaigns that encourage this personal norm can be effective in increasing the adoption of water-saving technologies. Messages that reinforce the connection between water conservation and the development of a positive, moral identity can motivate more individuals to engage in sustainable practices.

Furthermore, these results could have practical implications for water management policies and community leaders. Awareness campaigns that promote biospheric values could be effective in encouraging water-saving behaviours. For example, campaigns that highlight the importance of limiting the use of natural resources at home tasks, provide practical strategies for reducing water use and reinforce the personal norm of saving water regardless of others. This will be further discussed in the next section.

5.5.2 Practical Implications

These findings have important implications for policy formulation and implementation of water conservation programs. Given that biospheric values appear to be a significant factor, educational and awareness-raising campaigns that reinforce these values could be effective in encouraging more sustainable water use. However, it is also crucial to address contextual factors that may facilitate or hinder the adoption of pro-environmental behaviours.

To implement these findings, community-based programs should focus on:

- Educational initiatives: Raising awareness about the environmental impacts of water use and the importance of conservation
- Norm reinforcement: Encouraging social norms that prioritize water saving, such as public commitments and social recognition for water-saving behaviours
- Technical support: Providing access to and information about water-saving devices to facilitate their adoption

To turn feelings of guilt into positive actions, it is essential to provide people with the tools and support necessary to adopt water conservation technologies. Programs that offer subsidies, accessible information, and technical assistance can facilitate the transition toward more sustainable behaviours. The reason is that some people would like to save water but does not have the budget to buy water saving appliances and people could just give up and stop feeling guilty.

Together, these results underscore the importance of understanding how personal values and norms influence the adoption of water-saving technologies. Intervention strategies should consider both positive motivators, such as the 'better person' norm, and potential obstacles, such as selfish values and guilt. By addressing these complex dynamics, more effective programs can be designed to encourage sustainable water use in rural areas, which goes in line with the VBN theory.

5.6 Limitations

One of the limitations of the research performed is the data being self-reported. The reason for this approach is that it was not feasible to install water meters or retrieve the data from water utility companies. This is not a perfectly accurate measurement as there is reliance on the participant to be able to remember the usage correctly and be honest about their water use. In general, self-reported data can be influenced by a social desirability bias, which is a response bias that has the tendency of survey respondents to answer questions in a manner that will be viewed favourably by others thereby overstating their positive behaviour. Social desirability is not always visible in environmental behaviours (Milfont, 2009), but the results of this research should be interpreted with caution given that we did not measure social desirability directly. Additionally, it is important to note that the data for this study was collected during the COVID-19 pandemic.

The fact that one person in the household was interviewed for this study can be seen as another limitation. The research assumes that the behaviour of the individual interviewed is similar to the rest of the household inhabitants or that this person can guess the total water use of the household reasonably accurately.

It is important to take into account that before making a strong statement about causality in statistics caution is necessary. Since, there are limitations and challenges in causal inference, such as the presence of unobserved variables, the risk of spurious correlation, and the possibility of bias. Causal inference relies on a combination of theoretical knowledge, statistical methods, and careful consideration of research designs. For example, it is not possible to determine the relationship between water conservation intention and behaviour and water-efficient infrastructure without longitudinal data, and the installation of water-saving devices does not always result in the expected reductions in water use (Stewart et al., 2010). Longitudinal studies involve repeated observations of the same variables over long periods of time.

Finally, the survey questions generally align well with the components of the VBN theory's values, beliefs, and norms. However, there are areas where adjustments could further enhance their clarity and effectiveness.

For example, some questions addressing biospheric, and altruistic values may benefit from more precise wording to ensure that respondents clearly understand the intended value being targeted. The questions 'Do you try to limit or reduce your water use while performing household tasks?' and 'How necessary is it for you to use water adequately or rationally?' (biospheric value) might be open to varying interpretations. In general, a possible answer to this question could be linked to a biospheric, altruistic, or egoistic value. The value behind the person's behaviour can not be certain obtained from this question. Therefore, the questions should be more explicitly linked to specific values that are to be considered. This is to ensure that the respondents' answers focus only on the given questions and are not open to interpretation. For example, the first question above mention could be linked directly with biospheric values if it is asked as 'How important is it for you to conserve water to protect the environment?'

The current set of questions covers many critical aspects of beliefs related to water use, particularly regarding ascription of Responsibility (AR) and awareness of Consequences (AC). However, questions regarding the New Environmental Paradigm (NEP) are not included in the survey. To fully implement the VBN theory, it would be helpful to add questions that explicitly address the NEP to capture the general environmental beliefs of the study zone. This comprehensive approach will provide a more robust understanding of the applicability of the VBN framework in explaining domestic water use behaviour.

The questions assessing norms are well aligned with the VBN theory, particularly in how they focus on personal moral obligations and feelings of guilt related to water use and conservation behaviours. However, the question "Anyone could do any action to use water rationally" might be more relevant to beliefs rather than norms, since it addresses what people think is possible rather than what they feel morally obliged to do. To further strengthen these questions, it could be considered to ensure that they directly address personal moral norms, as these are central to the VBN framework. Including scenarios or specific examples to contextualise these norms could also enhance the respondents' understanding.

5.7 Recommendations for future research

Future research that can access data retrieved from metered records would be desirable to verify these results using observational rather than self-reported data. Furthermore, it should aim to deepen the understanding of how the VBN theoretical framework interacts with other contextual and socioeconomic factors to influence domestic water use behaviour. For example, future studies could explore additional variables that may mediate or moderate the relationship between VBN factors and water use, such as cultural influences, social norms, and economic incentives.

Although the VBN theory traditionally has a linear progression from values to beliefs to norms, emerging evidence suggests that the relationships among these factors might be more complex and bidirectional in certain areas. While the VBN theory proposes that values shape beliefs, which in turn activate norms, research in social psychology indicates that norms themselves can also influence beliefs and values over time (Ly, 2024). For example, when individuals consistently engage in pro-environmental behaviours due to normative pressure (social expectations or personal moral obligations), these behaviours can lead to a shift in their underlying beliefs and values. This is sometimes referred to as cognitive dissonance reduction and suggests that people often adjust their beliefs to align with their behaviours to maintain internal consistency (Harmon-Jones and Mills, 2019).

Norms can act as catalysts for change in values, particularly when individuals recognise that their behaviours are consistent with values, they might not have previously prioritised. Understanding that norms can influence values and beliefs is crucial for designing interventions aimed at promoting pro-environmental behaviours. Interventions that initially focus on establishing strong social norms around environmentally friendly practices, such as water conservation, could eventually lead to deeper, more sustainable changes in the underlying values and beliefs of individuals. For example, studies by Keizer and Schultz (2018) and Farrow et al. (2017) discuss how pro-environmental behaviours driven by social norms can lead to the development of more robust environmental values and beliefs. This perspective not only broadens the applicability of VBN theory but also provides a strategic framework for designing interventions that aim to foster lasting pro-environmental change. Therefore, it would be recommended for future research to explore these bidirectional relationships between the VBN factors.

Additionally, it is important to highlight that while the VBN theory focuses on personal norms, these norms do not exist in a vacuum. Social norms, as part of contextual factors, indirectly shape personal norms through socialisation and shared community values (Bamberg et al., 2015; Schwartz, 1977). Therefore, the recommendation is that future research considers social norms as an integral part of the theoretical framework alongside the VBN theory when analysing pro-environmental behaviour (Ly, 2024).

Longitudinal studies could provide insights into how changes in values and norms over time impact water use behaviours. A longitudinal approach that also includes participant interviews would provide a more nuanced understanding of how householders interact with water efficient infrastructure and the subsequent effect on household water use and captures shifts in behaviour. This approach would offer deeper insights into how behavioural changes evolve and what triggers them.

Furthermore, expanding the geographical scope of the research to include diverse rural and peri-urban settings could help generalise the findings and identify region-specific drivers of water conservation behaviours. This expansion will help in identifying region-specific drivers of water conservation behaviours, allowing for the development of more targeted and effective interventions.

Future research could further enhance the clarity and effectiveness of the survey questions targeting values and add questions that explicitly address the New Environmental Paradigm to capture broader environmental beliefs. Furthermore, by addressing personal moral obligations and norms and including scenarios or specific examples to contextualise these norms, the respondents' understanding could be enhanced, and thereby the results.

Also, a mixed-method approach combining quantitative analysis with qualitative insights from interviews or focus groups could offer a more comprehensive understanding of the motivations and barriers individuals face regarding water conservation.

The lack of significant influence of beliefs suggests the need to further explore the complex interactions between values, beliefs, norms and behaviour. This could involve exploring alternative belief constructs or measuring beliefs in different ways (with other questions) in addition to adding the NEP questions that do not take part in these survey questions. Comparative studies with different populations or settings could also shed light on why beliefs may play a more or less significant role in different contexts.

Finally, intervention-based studies that test the effectiveness of different educational and policy initiatives informed by the VBN framework could provide practical guidance for developing strategies and policies to promote sustainable water use at the community level. These policies could include incentives for the adoption of water-efficient technologies, regulations on water use, or educational programmes that align with the values and norms identified through the VBN framework. By following these recommendations and actions, future research can validate the current findings but also provide more detailed insights into the complex dynamics that drive domestic water use behaviour. This would ultimately contribute to the development of more effective strategies for promoting sustainable water use in various contexts.

Chapter 6

Conclusion

The purpose of this exploratory study was to determine to what extent the theoretical framework of Values, Beliefs, and Norms (VBN) contributes to the understanding of domestic water use in rural areas, with a specific focus on the municipalities of Restrepo and Cali in Colombia. To achieve this, three main objectives were set: background study of the VBN theory, adapting the VBN theoretical framework to the context of domestic water use and assessing whether the VBN framework could explain domestic water use behaviours in rural areas of Valle del Cauca.

The study followed a structured approach, beginning with an extensive literature review to understand the current state of the VBN theory. The VBN framework was then used to study domestic water use behaviour, conceptualizing that beyond basic needs, the amount of water used for household tasks can be viewed as a form of environmental behaviour. This conceptual framework was empirically tested using multi-linear regression analysis. Two regression methods were used: forced entry to identify significant factors influencing domestic water use, and hierarchical regression to determine the amount of variance in water use behaviours explained by VBN factors.

The forced entry regression analysis revealed several significant predictors of domestic water use. For total water use (*'wu'*), significant predictors included awareness of water use limitations and personal norms regarding saving water, with these VBN factors contributing to a reduction in perceived water use. Socioeconomic factors such as education level, gender, and living zone also played significant roles. For shower time (*'ST'*), predictors included awareness of water use, personal norms, education level, and living zone. For the use of water-saving devices (*'SD'*), predictors included altruistic values, egoistic beliefs about unlimited water supply, and personal norms related to water conservation.

The hierarchical regression analysed the contribution of VBN factors in explaining variance in domestic water use. The VBN theory accounted for an additional 2% of the variance in total water use, 3.3% in shower time, and 4% in the use of water saving devices, in addition to the variance explained by socioeconomic factors. Values were the most consistent contributors across the different behaviours, while beliefs had minimal impact.

The conducted research has shown that psycho-social, behavioural, sociodemographic and contextual variables all have a role in determining household water conservation intentions and domestic water use. Contextual factors such as household size and income are important determinants of water use but cannot be controlled by policymakers. However, this study clearly shows that psycho-social and behavioural factors are also modest determinants of water conservation intentions and household water use and should be considered as well.

The findings of this study indicate that the VBN theoretical framework contributes to understanding domestic water use behaviours in rural areas, although its impact varies by the type of behaviour. VBN factors play a significant role in specific water use behaviours, such as shower time and the adoption of water-saving devices, where personal values and norms are more directly connected to individual actions. However, for broader measures of water use, such as total household water consumption, the influence of VBN factors is more diffused and less pronounced.

The findings suggest that interventions aimed at promoting water conservation should be tailored to the type of behaviour being targeted. For specific curtailment behaviours and the adoption of water-saving technologies, campaigns should leverage the existing environmental values and personal norms within the community. Education and awareness programs can be particularly effective in enhancing these values and norms, thereby encouraging water-saving behaviours.

For broader water usage, integrating socioeconomic factors with strategies to gradually shift values and norms may be more effective. Policymakers and environmental educators should focus on reinforcing the importance of individual actions in contributing to collective water conservation goals. By highlighting the connections between water use behaviour and broader environmental impacts, it is possible to promote a more sustainable approach to domestic water use in rural areas.

In conclusion, while the VBN framework provides valuable insights into specific water use behaviours, its overall impact on total domestic water use is moderated by a range of contextual and socioeconomic factors. Future research should continue to explore these dynamics, with an emphasis on developing tailored interventions that address both the psychological and contextual determinants of water use behaviour.

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APPENDICES

Appendix A

Variables coding

Variable	**Final scale**
Limit_my_use, limit_use_conservation	1: never 2: rarely 3: sometimes 4: often 5: always
Adequate_use	1: it is not very much necessary 2: it is not necessary 3: Neutral 4: It is necessary 5: It is very much necessary
limit-use_for-others_present&future, limit-use_Everyone_right_Water, limit-use_Water_conservation	1: not at all important 2: low importance 3: Neutral 4: Important 5: very important
unlimited_water_supply, interest_Own_supply, waterproblems_responsibility_everyone, waterproblems_responsibility_Aqueduct, waterproblems_responsibility_Government, waterproblems_responsibility_environmental-authority, waterproblems_responsibility_economic sector, Droughts_Village, Droughts_Only_Property, Excessive_w.intake_region, saving-water_regardless-others, everyone_can-save-water, guilty_waste-water, if_$_buy-Saving-Device, Obligation_save-water_d.activities, if_saves-water_better-person	1: strongly disagree 2: disagree 3: neutral 4: agree 5: strongly agree

Variable	Final scale
aware_water_conflicts	0: yes 1: No
Zone	0: Rural 1: Peri-urban
Gender	1: Male 2: Female
Vulnerable_people_water	1: not at all concerned 2: a little concerned 3: neutral 4: very concerned 5: extremely concerned
inhab_house	Numerical
Education_level	1: none 2: incomplete/completed primary School 3: incomplete/completed secondary School 4: incomplete/completed technician 5: completed professional/Master
altitude	1: altitude ≤ 989 2: $989 >$ altitude ≤ 1173 3: $1173 >$ altitude ≤ 1381 4: $1381 >$ altitude ≤ 1612 5: altitude > 1612
Occupation	1: full time/ part time employed/Independent / self-employed 2: Full time student / study only 3: household labours / engagement in home duties 4: unemployed 5: volunteer work and other e.g., social leader / retired / pensioner / option 7 and other between 1 & 9

Variable	**Final scale**
Age	1: age $<$ 24
	2: 24 $>$ age $<$ 35
	3: 35 $>$ age $<$ 45
	4: 45 $>$ age $<$ 55
	5: age $>$ 55

Appendix B

Phyton code

In the following code, the multilinear regression for the forced entry and hierarchical methods are presented next to their results.

Note: in the phyton coding, 'wuse' stands for *'wu'*.

```
endog = df_vbnsec['wuse']
exog = sm.add_constant(df_vbnsec[['Limit_my_use', 'Adequate_use', 'limit_use_conservation',
        'limit-use_for-others_present&future', 'limit-use_Everyone_right_Water',
        'limit-use_Water_conservation', 'Vulnerable_people_water', 'aware_water_conflicts_1',
        'unlimitated_water_supply', 'interest_Own_supply',
        'waterproblems_responsability_everyone',
        'waterproblems_responsability_Aqueduct',
        'waterproblems_responsability_Government',
        'waterproblems_responsability_environmental-authority',
        'waterproblems_responsability_economic sector', 'Droughts_Village',
        'Droughts_Only_Property', 'Excesive_w.intake_region',
        'saving-water_regarless-others', 'everyone_can-save-water',
        'guilty_waste-water', 'if_$_buy-Saving-Device',
        'Obligation_save-water_d.activities', 'if_saves-water_better-person',
        'zone_1.0', 'inhab_house',
        'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
        'Occupation_4', 'Occupation_5', 'altitud']])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.1: forced entry method code for *'wu'* depending on VBN and SEC

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   wuse   R-squared:                       0.221
Model:                            OLS   Adj. R-squared:                  0.186
Method:                 Least Squares   F-statistic:                     6.310
Date:                Sat, 16 Mar 2024   Prob (F-statistic):           4.33e-24
Time:                        14:33:55   Log-Likelihood:                -4674.4
No. Observations:                 793   AIC:                             9419.
Df Residuals:                     758   BIC:                             9582.
Df Model:                          34
Covariance Type:            nonrobust
==========================================================================================================================
                                                     coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------------------------------------------------
const                                            267.2768     52.216      5.119      0.000     164.772     369.782
Limit_my_use                                     -12.6567      4.950     -2.557      0.011     -22.374      -2.940
Adequate_use                                      -2.9379      3.628     -0.810      0.418     -10.061       4.185
limit_use_conservation                            -2.3672      4.612     -0.513      0.608     -11.421       6.687
limit-use_for-others_present&future                0.5555      9.752      0.057      0.955     -18.588      19.699
limit-use_Everyone_right_Water                     8.5625     12.949      0.661      0.509     -16.858      33.983
limit-use_Water_conservation                       9.5019     12.096      0.786      0.432     -14.244      33.248
Vulnerable_people_water                            2.7683      3.997      0.693      0.489      -5.078      10.614
aware_water_conflicts_1                            7.5507      7.319      1.032      0.303      -6.816      21.918
unlimitated_water_supply                           2.6054      2.622      0.993      0.321      -2.543       7.754
interest_Own_supply                               -3.9004      2.734     -1.427      0.154      -9.267       1.466
waterproblems_responsability_everyone              0.8048      5.507      0.146      0.884     -10.007      11.616
waterproblems_responsability_Aqueduct             -2.2704      4.811     -0.472      0.637     -11.715       7.175
waterproblems_responsability_Government           -3.3158      6.535     -0.507      0.612     -16.145       9.513
waterproblems_responsability_environmental-authority 0.7110   6.260      0.114      0.910     -11.579      13.001
waterproblems_responsability_economic sector       3.9065      5.088      0.768      0.443      -6.082      13.895
Droughts_Village                                  -2.7085      3.242     -0.836      0.404      -9.072       3.655
Droughts_Only_Property                            -1.8476      3.510     -0.526      0.599      -8.738       5.043
Excesive_w.intake_region                           1.0779      3.121      0.345      0.730      -5.049       7.205
saving-water_regarless-others                    -10.3557      5.108     -2.028      0.043     -20.382      -0.329
everyone_can-save-water                           -9.0858      5.925     -1.534      0.126     -20.717       2.545
guilty_waste-water                                 1.7776      5.469      0.325      0.745      -8.959      12.514
if_$_buy-Saving-Device                             4.1273      5.111      0.808      0.420      -5.905      14.160
Obligation_save-water_d.activities                 6.4585      5.836      1.107      0.269      -4.999      17.916
if_saves-water_better-person                      -5.0494      5.455     -0.926      0.355     -15.758       5.659
zone_1.0                                          48.5215     16.913      2.869      0.004      15.320      81.723
inhab_house                                      -16.9444      2.426     -6.985      0.000     -21.707     -12.182
Age                                               -0.2956      3.062     -0.097      0.923      -6.307       5.716
Gender_2                                          15.2922      7.855      1.947      0.052      -0.128      30.713
Education_level                                   24.4509      4.125      5.928      0.000      16.354      32.548
Occupation_2                                       9.8994     13.560      0.730      0.466     -16.720      36.519
Occupation_3                                      -6.3472      9.038     -0.702      0.483     -24.089      11.395
Occupation_4                                       1.4362     19.291      0.074      0.941     -36.433      39.306
Occupation_5                                     -17.8972     12.347     -1.450      0.148     -42.136       6.341
altitud                                           -4.3594      5.191     -0.840      0.401     -14.550       5.831
==============================================================================
```

Figure B.2: forced entry method results for *'wu'* depending on VBN and SEC

```
endog = df_vbnsec['S_T']
exog = sm.add_constant(df_vbnsec[['Limit_my_use', 'Adequate_use', 'limit_use_conservation',
       'limit-use_for-others_present&future', 'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water', 'aware_water_conflicts_1',
       'unlimitated_water_supply', 'interest_Own_supply',
       'waterproblems_responsability_everyone',
       'waterproblems_responsability_Aqueduct',
       'waterproblems_responsability_Government',
       'waterproblems_responsability_environmental-authority',
       'waterproblems_responsability_economic sector', 'Droughts_Village',
       'Droughts_Only_Property', 'Excesive_w.intake_region',
       'saving-water_regarless-others', 'everyone_can-save-water',
       'guilty_waste-water', 'if_$_buy-Saving-Device',
       'Obligation_save-water_d.activities', 'if_saves-water_better-person',
       'zone_1.0', 'inhab_house', 'Age', 'Gender_2',
       'Education_level', 'Occupation_2', 'Occupation_3', 'Occupation_4', 'Occupation_5',
       'altitud']])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results_ST = mod.fit()
print(results_ST.summary())
```

Figure B.3: forced entry method code for *'ST'* depending on VBN and SEC

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    S_T   R-squared:                       0.196
Model:                            OLS   Adj. R-squared:                  0.160
Method:                 Least Squares   F-statistic:                     5.423
Date:                Wed, 21 Aug 2024   Prob (F-statistic):           1.00e-19
Time:                        15:22:56   Log-Likelihood:                -2491.4
No. Observations:                 793   AIC:                             5053.
Df Residuals:                     758   BIC:                             5216.
Df Model:                          34
Covariance Type:            nonrobust
==========================================================================================================================
                                                            coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------------------------------------------------
const                                                     7.1504      3.328      2.148      0.032       0.616      13.684
Limit_my_use                                             -1.0927      0.316     -3.463      0.001      -1.712      -0.473
Adequate_use                                             -0.1367      0.231     -0.591      0.555      -0.591       0.317
limit_use_conservation                                   -0.2139      0.294     -0.728      0.467      -0.791       0.363
limit-use_for-others_present&future                      -0.1685      0.622     -0.271      0.786      -1.389       1.052
limit-use_Everyone_right_Water                            0.6729      0.825      0.815      0.415      -0.947       2.293
limit-use_Water_conservation                              0.6998      0.771      0.908      0.364      -0.814       2.213
vulnerable_people_water                                   0.2038      0.255      0.800      0.424      -0.296       0.704
aware_water_conflicts_1                                   0.3899      0.467      0.836      0.404      -0.526       1.306
unlimitated_water_supply                                  0.2279      0.167      1.363      0.173      -0.100       0.556
interest_Own_supply                                      -0.3044      0.174     -1.747      0.081      -0.646       0.038
waterproblems_responsability_everyone                     0.0154      0.351      0.044      0.965      -0.674       0.705
waterproblems_responsability_Aqueduct                    -0.2669      0.307     -0.870      0.384      -0.869       0.335
waterproblems_responsability_Government                  -0.1538      0.417     -0.369      0.712      -0.972       0.664
waterproblems_responsability_environmental-authority     -0.1667      0.399     -0.418      0.676      -0.950       0.617
waterproblems_responsability_economic sector              0.2204      0.324      0.679      0.497      -0.416       0.857
Droughts_Village                                         -0.2090      0.207     -1.011      0.312      -0.615       0.197
Droughts_Only_Property                                   -0.0504      0.224     -0.225      0.822      -0.490       0.389
Excesive_w.intake_region                                  0.1849      0.199      0.929      0.353      -0.206       0.575
saving-water_regarless-others                            -0.7571      0.326     -2.325      0.020      -1.396      -0.118
everyone_can-save-water                                  -0.5157      0.378     -1.365      0.173      -1.257       0.226
guilty_waste-water                                        0.1287      0.349      0.369      0.712      -0.556       0.813
if_$_buy-Saving-Device                                    0.1659      0.326      0.509      0.611      -0.474       0.805
Obligation_save-water_d.activities                        0.4469      0.372      1.201      0.230      -0.283       1.177
if_saves-water_better-person                             -0.3068      0.348     -0.882      0.378      -0.989       0.376
zone_1.0                                                  3.5285      1.078      3.273      0.001       1.412       5.645
inhab_house                                              -0.0909      0.155     -0.588      0.557      -0.394       0.213
Age                                                      -0.0189      0.195     -0.097      0.923      -0.402       0.364
Gender_2                                                  0.8228      0.501      1.643      0.101      -0.160       1.806
Education_level                                           1.5659      0.263      5.956      0.000       1.050       2.082
Occupation_2                                              0.6650      0.864      0.769      0.442      -1.032       2.362
Occupation_3                                             -0.1504      0.576     -0.261      0.794      -1.281       0.981
Occupation_4                                             -0.4279      1.230     -0.348      0.728      -2.842       1.986
Occupation_5                                             -1.2551      0.787     -1.595      0.111      -2.800       0.290
altitud                                                  -0.2223      0.331     -0.672      0.502      -0.872       0.427
==============================================================================
```

Figure B.4: forced entry method results for *'ST'* depending on VBN and SEC

```
endog = df_vbnsec['S_D']
exog = sm.add_constant(df_vbnsec[['Limit_my_use', 'Adequate_use', 'limit_use_conservation',
       'limit-use_for-others_present&future', 'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water', 'aware_water_conflicts_1',
       'unlimitated_water_supply', 'interest_Own_supply',
       'waterproblems_responsability_everyone',
       'waterproblems_responsability_Aqueduct',
       'waterproblems_responsability_Government',
       'waterproblems_responsability_environmental-authority',
       'waterproblems_responsability_economic sector', 'Droughts_Village',
       'Droughts_Only_Property', 'Excesive_w.intake_region',
       'saving-water_regarless-others', 'everyone_can-save-water',
       'guilty_waste-water', 'if_$_buy-Saving-Device',
       'Obligation_save-water_d.activities', 'if_saves-water_better-person',
       'zone_1.0', 'inhab_house', 'Age', 'Gender_2',
       'Education_level', 'Occupation_2', 'Occupation_3', 'Occupation_4', 'Occupation_5',
       'altitud']])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results_SD = mod.fit()
print(results_SD.summary())
```

Figure B.5: forced entry method code for *'ST'* depending on VBN and SEC

```
==============================================================================
Dep. Variable:                    S_D   R-squared:                       0.339
Model:                            OLS   Adj. R-squared:                  0.310
Method:                 Least Squares   F-statistic:                     11.45
Date:                Wed, 21 Aug 2024   Prob (F-statistic):           2.52e-48
Time:                        15:23:03   Log-Likelihood:                 398.22
No. Observations:                 793   AIC:                            -726.4
Df Residuals:                     758   BIC:                            -562.8
Df Model:                          34
Covariance Type:            nonrobust
=====================================================================================================================
                                                           coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------------------------------------------
const                                                    0.1516      0.087      1.742      0.082      -0.019       0.323
Limit_my_use                                             0.0021      0.008      0.250      0.802      -0.014       0.018
Adequate_use                                             0.0183      0.006      3.024      0.003       0.006       0.030
limit_use_conservation                                   0.0037      0.008      0.483      0.629      -0.011       0.019
limit-use_for-others_present&future                      0.0616      0.016      3.787      0.000       0.030       0.093
limit-use_Everyone_right_Water                          -0.0171      0.022     -0.794      0.427      -0.060       0.025
limit-use_Water_conservation                            -0.0305      0.020     -1.513      0.131      -0.070       0.009
Vulnerable_people_water                                 -0.0024      0.007     -0.356      0.722      -0.015       0.011
aware_water_conflicts_1                                  0.0267      0.012      2.192      0.029       0.003       0.051
unlimitated_water_supply                                -0.0143      0.004     -3.280      0.001      -0.023      -0.006
interest_Own_supply                                      0.0083      0.005      1.831      0.067      -0.001       0.017
waterproblems_responsability_everyone                   -0.0094      0.009     -1.029      0.304      -0.027       0.009
waterproblems_responsability_Aqueduct                    0.0112      0.008      1.393      0.164      -0.005       0.027
waterproblems_responsability_Government                 -0.0208      0.011     -1.912      0.056      -0.042       0.001
waterproblems_responsability_environmental-authority     0.0163      0.010      1.562      0.119      -0.004       0.037
waterproblems_responsability_economic sector            -0.0068      0.008     -0.806      0.421      -0.023       0.010
Droughts_Village                                         0.0063      0.005      1.165      0.244      -0.004       0.017
Droughts_Only_Property                                   0.0006      0.006      0.098      0.922      -0.011       0.012
Excesive_w.intake_region                                -0.0079      0.005     -1.520      0.129      -0.018       0.002
saving-water_regarless-others                            0.0083      0.009      0.977      0.329      -0.008       0.025
everyone_can-save-water                                 -0.0037      0.010     -0.372      0.710      -0.023       0.016
guilty_waste-water                                      -0.0209      0.009     -2.296      0.022      -0.039      -0.003
if_$_buy-Saving-Device                                   0.0004      0.009      0.050      0.960      -0.016       0.017
Obligation_save-water_d.activities                      -0.0085      0.010     -0.879      0.380      -0.028       0.011
if_saves-water_better-person                             0.0212      0.009      2.334      0.020       0.003       0.039
zone_1.0                                                -0.2491      0.028     -8.837      0.000      -0.304      -0.194
inhab_house                                              0.0009      0.004      0.228      0.820      -0.007       0.009
Age                                                      0.0062      0.005      1.213      0.225      -0.004       0.016
Gender_2                                                -0.0046      0.013     -0.354      0.723      -0.030       0.021
Education_level                                          0.0275      0.007      4.001      0.000       0.014       0.041
Occupation_2                                            -0.0299      0.023     -1.321      0.187      -0.074       0.015
Occupation_3                                            -0.0228      0.015     -1.512      0.131      -0.052       0.007
Occupation_4                                            -0.0284      0.032     -0.884      0.377      -0.092       0.035
Occupation_5                                             0.0055      0.021      0.269      0.788      -0.035       0.046
altitud                                                 -0.0105      0.009     -1.208      0.227      -0.027       0.007
==============================================================================
```

Figure B.6: forced entry method results for *'SD'* depending on VBN and SEC

```python
endog = df_vbnsec['wuse']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
        'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
        'Occupation_4', 'Occupation_5', 'altitud']])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.7: Hierarchical method code for *'wu'* depending on SEC

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   wuse   R-squared:                       0.177
Model:                            OLS   Adj. R-squared:                  0.166
Method:                 Least Squares   F-statistic:                     16.82
Date:                Sat, 16 Mar 2024   Prob (F-statistic):           8.67e-28
Time:                        14:33:54   Log-Likelihood:                -4696.0
No. Observations:                 793   AIC:                             9414.
Df Residuals:                     782   BIC:                             9465.
Df Model:                          10
Covariance Type:            nonrobust
===================================================================================
                      coef    std err          t      P>|t|      [0.025      0.975]
-----------------------------------------------------------------------------------
const             228.3658     29.363      7.777      0.000     170.727     286.005
zone_1.0           51.2824     14.653      3.500      0.000      22.518      80.046
inhab_house       -17.3029      2.406     -7.191      0.000     -22.027     -12.579
Age                -1.0372      2.943     -0.352      0.725      -6.814       4.740
Gender_2           15.9506      7.839      2.035      0.042       0.563      31.338
Education_level    24.2316      4.062      5.965      0.000      16.258      32.205
Occupation_2        8.4157     13.489      0.624      0.533     -18.064      34.895
Occupation_3      -10.4141      8.975     -1.160      0.246     -28.032       7.204
Occupation_4        1.1875     19.279      0.062      0.951     -36.656      39.032
Occupation_5      -22.0021     12.337     -1.783      0.075     -46.220       2.216
altitud            -4.5694      5.032     -0.908      0.364     -14.447       5.308
==============================================================================
```

Figure B.8: Hierarchical method results for *'wu'* depending on SEC

```python
endog = df_vbnsec['wuse']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
       'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
       'Occupation_4', 'Occupation_5', 'altitud', 'Limit_my_use', 'Adequate_use',
       'limit_use_conservation', 'limit-use_for-others_present&future',
       'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water',
       'aware_water_conflicts_1', 'unlimitated_water_supply',
       'interest_Own_supply' ]])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.9: Hierarchical method code for *'wu'* depending on SEC and V

```
==============================================================================
Dep. Variable:                   wuse   R-squared:                       0.206
Model:                            OLS   Adj. R-squared:                  0.185
Method:                 Least Squares   F-statistic:                     9.990
Date:                Sat, 16 Mar 2024   Prob (F-statistic):           1.11e-27
Time:                        14:34:00   Log-Likelihood:                -4682.0
No. Observations:                 793   AIC:                             9406.
Df Residuals:                     772   BIC:                             9504.
Df Model:                          20
Covariance Type:            nonrobust
=========================================================================================================
                                          coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------------------------------
const                                 221.7111     43.093      5.145      0.000     137.118     306.304
zone_1.0                               56.2920     15.030      3.745      0.000      26.788      85.796
inhab_house                           -17.2614      2.419     -7.137      0.000     -22.009     -12.514
Age                                    -0.9235      3.038     -0.304      0.761      -6.888       5.041
Gender_2                               15.5577      7.784      1.999      0.046       0.277      30.838
Education_level                        24.5786      4.077      6.029      0.000      16.576      32.581
Occupation_2                            8.3763     13.427      0.624      0.533     -17.982      34.734
Occupation_3                           -7.2030      8.945     -0.805      0.421     -24.762      10.356
Occupation_4                            3.3904     19.118      0.177      0.859     -34.139      40.919
Occupation_5                          -19.8227     12.276     -1.615      0.107     -43.921       4.275
altitud                                -3.7744      5.103     -0.740      0.460     -13.792       6.243
Limit_my_use                          -12.9317      4.854     -2.664      0.008     -22.460      -3.403
Adequate_use                           -3.7176      3.518     -1.057      0.291     -10.624       3.189
limit_use_conservation                 -4.4395      4.387     -1.012      0.312     -13.051       4.172
limit-use_for-others_present&future    -0.3769      9.680     -0.039      0.969     -19.379      18.625
limit-use_Everyone_right_Water          9.3298     12.824      0.728      0.467     -15.844      34.504
limit-use_Water_conservation            8.5476     12.025      0.711      0.477     -15.059      32.154
Vulnerable_people_water                 1.1779      3.857      0.305      0.760      -6.394       8.750
aware_water_conflicts_1                12.7072      6.771      1.877      0.061      -0.584      25.998
unlimitated_water_supply                2.4251      2.424      1.001      0.317      -2.333       7.183
interest_Own_supply                    -4.1232      2.684     -1.536      0.125      -9.392       1.145
==============================================================================
```

Figure B.10: Hierarchical method results for *'wu'* depending on SEC and V

```
endog = df_vbnsec['wuse']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
       'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
       'Occupation_4', 'Occupation_5', 'altitud', 'Limit_my_use', 'Adequate_use',
       'limit_use_conservation', 'limit-use_for-others_present&future',
       'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water',
       'aware_water_conflicts_1', 'unlimitated_water_supply',
       'interest_Own_supply', 'waterproblems_responsability_everyone',
       'waterproblems_responsability_Aqueduct',
       'waterproblems_responsability_Government',
       'waterproblems_responsability_environmental-authority',
       'waterproblems_responsability_economic sector', 'Droughts_Village',
       'Droughts_Only_Property', 'Excesive_w.intake_region' ]])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.11: Hierarchical method code for *'wu'* depending on SEC and VB

```
==============================================================================
Dep. Variable:                   wuse   R-squared:                       0.210
Model:                            OLS   Adj. R-squared:                  0.181
Method:                 Least Squares   F-statistic:                     7.243
Date:                Sat, 16 Mar 2024   Prob (F-statistic):           1.15e-24
Time:                        14:34:00   Log-Likelihood:                -4679.9
No. Observations:                 793   AIC:                             9418.
Df Residuals:                     764   BIC:                             9553.
Df Model:                          28
Covariance Type:            nonrobust
========================================================================================================================
                                                         coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------------------------------------------------
const                                                243.7776     50.394      4.837      0.000     144.851     342.705
zone_1.0                                              52.0229     15.904      3.271      0.001      20.802      83.243
inhab_house                                          -17.1532      2.428     -7.066      0.000     -21.919     -12.388
Age                                                   -0.7814      3.057     -0.256      0.798      -6.783       5.220
Gender_2                                              16.4730      7.860      2.096      0.036       1.043      31.903
Education_level                                       24.2322      4.116      5.887      0.000      16.152      32.312
Occupation_2                                           8.3549     13.528      0.618      0.537     -18.201      34.911
Occupation_3                                          -6.1217      9.060     -0.676      0.499     -23.908      11.664
Occupation_4                                           1.4345     19.312      0.074      0.941     -36.476      39.345
Occupation_5                                         -19.5369     12.361     -1.581      0.114     -43.802       4.728
altitud                                               -4.2589      5.169     -0.824      0.410     -14.406       5.888
Limit_my_use                                         -13.1786      4.921     -2.678      0.008     -22.839      -3.518
Adequate_use                                          -3.4392      3.622     -0.949      0.343     -10.550       3.672
limit_use_conservation                                -4.6675      4.456     -1.047      0.295     -13.416       4.081
limit-use_for-others_present&future                   -0.0717      9.730     -0.007      0.994     -19.173      19.029
limit-use_Everyone_right_Water                         9.9189     12.887      0.770      0.442     -15.378      35.216
limit-use_Water_conservation                           7.9678     12.113      0.658      0.511     -15.810      31.746
Vulnerable_people_water                                1.4369      3.962      0.363      0.717      -6.341       9.215
aware_water_conflicts_1                                9.3610      7.209      1.299      0.194      -4.791      23.513
unlimitated_water_supply                               3.2904      2.586      1.272      0.204      -1.787       8.368
interest_Own_supply                                   -4.0571      2.738     -1.482      0.139      -9.432       1.318
waterproblems_responsability_everyone                 -0.7879      5.472     -0.144      0.886     -11.530       9.954
waterproblems_responsability_Aqueduct                 -2.6120      4.800     -0.544      0.586     -12.035       6.811
waterproblems_responsability_Government               -3.4255      6.546     -0.523      0.601     -16.276       9.426
waterproblems_responsability_environmental-authority   0.7103      6.266      0.113      0.910     -11.591      13.012
waterproblems_responsability_economic sector           4.7103      5.082      0.927      0.354      -5.266      14.687
Droughts_Village                                      -3.4397      3.172     -1.084      0.279      -9.666       2.787
Droughts_Only_Property                                -1.9176      3.453     -0.555      0.579      -8.696       4.860
Excesive_w.intake_region                               0.6980      3.109      0.224      0.822      -5.406       6.801
==============================================================================
```

Figure B.12: Hierarchical method results for *'wu'* depending on SEC and VB

```
endog = df_vbnsec['S_T']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house', 'Age', 'Gender_2',
        'Education_level', 'Occupation_2', 'Occupation_3', 'Occupation_4', 'Occupation_5',
        'altitud']])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.13: Hierarchical method for *'ST'* depending on SEC

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    S_T   R-squared:                       0.138
Model:                            OLS   Adj. R-squared:                  0.127
Method:                 Least Squares   F-statistic:                     12.52
Date:                Wed, 21 Aug 2024   Prob (F-statistic):           2.33e-20
Time:                        15:22:56   Log-Likelihood:                -2518.8
No. Observations:                 793   AIC:                             5060.
Df Residuals:                     782   BIC:                             5111.
Df Model:                          10
Covariance Type:            nonrobust
===================================================================================
                      coef    std err          t      P>|t|      [0.025      0.975]
-----------------------------------------------------------------------------------
const               2.6758      1.886      1.419      0.156      -1.026       6.377
zone_1.0            3.6235      0.941      3.851      0.000       1.776       5.471
inhab_house        -0.1193      0.155     -0.772      0.440      -0.423       0.184
Age                -0.1063      0.189     -0.562      0.574      -0.477       0.265
Gender_2            0.8402      0.503      1.669      0.095      -0.148       1.828
Education_level     1.5182      0.261      5.820      0.000       1.006       2.030
Occupation_2        0.5393      0.866      0.623      0.534      -1.161       2.240
Occupation_3       -0.3419      0.576     -0.593      0.553      -1.473       0.789
Occupation_4       -0.3996      1.238     -0.323      0.747      -2.830       2.031
Occupation_5       -1.5392      0.792     -1.943      0.052      -3.094       0.016
altitud            -0.2676      0.323     -0.828      0.408      -0.902       0.367
==============================================================================
Omnibus:                      473.138   Durbin-Watson:                   1.917
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             6469.175
Skew:                           2.439   Prob(JB):                         0.00
Kurtosis:                      16.115   Cond. No.                         60.9
==============================================================================
```

Figure B.14: Hierarchical method results for *'ST'* depending on SEC

```
endog = df_vbnsec['S_T']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
       'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
       'Occupation_4', 'Occupation_5', 'altitud', 'Limit_my_use', 'Adequate_use',
       'limit_use_conservation', 'limit-use_for-others_present&future',
       'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water',
       'aware_water_conflicts_1', 'unlimitated_water_supply',
       'interest_Own_supply' ]])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.15: Hierarchical method code for *'ST'* depending on SEC and V

```
==============================================================================
Dep. Variable:                    S_T   R-squared:                       0.178
Model:                            OLS   Adj. R-squared:                  0.156
Method:                 Least Squares   F-statistic:                     8.342
Date:                Sat, 16 Mar 2024   Prob (F-statistic):           1.85e-22
Time:                        14:34:01   Log-Likelihood:                -2500.1
No. Observations:                 793   AIC:                             5042.
Df Residuals:                     772   BIC:                             5140.
Df Model:                          20
Covariance Type:            nonrobust
=========================================================================================================
                                           coef    std err          t      P>|t|      [0.025      0.975]
---------------------------------------------------------------------------------------------------------
const                                    3.3561      2.751      1.220      0.223      -2.044       8.756
zone_1.0                                 3.8301      0.959      3.992      0.000       1.947       5.714
inhab_house                             -0.1107      0.154     -0.717      0.473      -0.414       0.192
Age                                     -0.0673      0.194     -0.347      0.729      -0.448       0.313
Gender_2                                 0.8258      0.497      1.662      0.097      -0.150       1.801
Education_level                          1.5776      0.260      6.062      0.000       1.067       2.088
Occupation_2                             0.5490      0.857      0.640      0.522      -1.134       2.232
Occupation_3                            -0.1535      0.571     -0.269      0.788      -1.274       0.967
Occupation_4                            -0.1990      1.220     -0.163      0.871      -2.595       2.197
Occupation_5                            -1.4011      0.784     -1.788      0.074      -2.939       0.137
altitud                                 -0.2187      0.326     -0.671      0.502      -0.858       0.421
Limit_my_use                            -1.1072      0.310     -3.573      0.000      -1.715      -0.499
Adequate_use                            -0.2052      0.225     -0.914      0.361      -0.646       0.236
limit_use_conservation                  -0.3352      0.280     -1.197      0.232      -0.885       0.215
limit-use_for-others_present&future     -0.2259      0.618     -0.366      0.715      -1.439       0.987
limit-use_Everyone_right_Water           0.7112      0.819      0.869      0.385      -0.896       2.318
limit-use_Water_conservation             0.6219      0.768      0.810      0.418      -0.885       2.129
Vulnerable_people_water                  0.0764      0.246      0.310      0.757      -0.407       0.560
aware_water_conflicts_1                  0.7666      0.432      1.773      0.077      -0.082       1.615
unlimitated_water_supply                 0.2128      0.155      1.375      0.169      -0.091       0.516
interest_Own_supply                     -0.3188      0.171     -1.861      0.063      -0.655       0.017
==============================================================================
```

Figure B.16: Hierarchical method results for *'ST'* depending on SEC and V

```python
endog = df_vbnsec['S_T']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
       'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
       'Occupation_4', 'Occupation_5', 'altitud', 'Limit_my_use', 'Adequate_use',
       'limit_use_conservation', 'limit-use_for-others_present&future',
       'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water',
       'aware_water_conflicts_1', 'unlimitated_water_supply',
       'interest_Own_supply', 'waterproblems_responsability_everyone',
       'waterproblems_responsability_Aqueduct',
       'waterproblems_responsability_Government',
       'waterproblems_responsability_environmental-authority',
       'waterproblems_responsability_economic sector', 'Droughts_Village',
       'Droughts_Only_Property', 'Excesive_w.intake_region' ]])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.17: Hierarchical method code for *'ST'* depending on SEC and VB

```
==============================================================================
Dep. Variable:                    S_T   R-squared:                       0.183
Model:                            OLS   Adj. R-squared:                  0.153
Method:                 Least Squares   F-statistic:                     6.127
Date:                Wed, 21 Aug 2024   Prob (F-statistic):           5.75e-20
Time:                        15:22:53   Log-Likelihood:                -2497.4
No. Observations:                 793   AIC:                             5053.
Df Residuals:                     764   BIC:                             5188.
Df Model:                          28
Covariance Type:            nonrobust
==========================================================================================================
                                                   coef    std err          t      P>|t|      [0.025      0.975]
----------------------------------------------------------------------------------------------------------
const                                            5.7530      3.214      1.790      0.074      -0.557      12.063
zone_1.0                                         3.6966      1.014      3.644      0.000       1.705       5.688
inhab_house                                     -0.1017      0.155     -0.657      0.511      -0.406       0.202
Age                                             -0.0526      0.195     -0.270      0.787      -0.435       0.330
Gender_2                                         0.9034      0.501      1.802      0.072      -0.081       1.888
Education_level                                  1.5480      0.263      5.896      0.000       1.033       2.063
Occupation_2                                     0.5848      0.863      0.678      0.498      -1.109       2.279
Occupation_3                                    -0.1419      0.578     -0.246      0.806      -1.276       0.993
Occupation_4                                    -0.4469      1.232     -0.363      0.717      -2.865       1.971
Occupation_5                                    -1.3700      0.788     -1.738      0.083      -2.918       0.178
altitud                                         -0.2271      0.330     -0.689      0.491      -0.874       0.420
Limit_my_use                                    -1.1399      0.314     -3.632      0.000      -1.756      -0.524
Adequate_use                                    -0.1745      0.231     -0.755      0.450      -0.628       0.279
limit_use_conservation                          -0.3685      0.284     -1.296      0.195      -0.926       0.190
limit-use_for-others_present&future             -0.2194      0.621     -0.353      0.724      -1.438       0.999
limit-use_Everyone_right_Water                   0.7383      0.822      0.898      0.369      -0.875       2.352
limit-use_Water_conservation                     0.5982      0.773      0.774      0.439      -0.918       2.115
Vulnerable_people_water                          0.1192      0.253      0.472      0.637      -0.377       0.615
aware_water_conflicts_1                          0.5069      0.460      1.102      0.271      -0.396       1.410
unlimitated_water_supply                         0.2664      0.165      1.615      0.107      -0.057       0.590
interest_Own_supply                             -0.3180      0.175     -1.821      0.069      -0.661       0.025
waterproblems_responsability_everyone           -0.0783      0.349     -0.224      0.823      -0.763       0.607
waterproblems_responsability_Aqueduct           -0.2863      0.306     -0.935      0.350      -0.887       0.315
waterproblems_responsability_Government         -0.1661      0.418     -0.398      0.691      -0.986       0.654
waterproblems_responsability_environmental-authority  -0.1571  0.400   -0.393      0.694      -0.942       0.628
waterproblems_responsability_economic sector     0.2702      0.324      0.833      0.405      -0.366       0.907
Droughts_Village                                -0.2533      0.202     -1.252      0.211      -0.650       0.144
Droughts_Only_Property                          -0.0672      0.220     -0.305      0.760      -0.500       0.365
Excesive_w.intake_region                         0.1554      0.198      0.783      0.434      -0.234       0.545
==============================================================================
```

Figure B.18: Hierarchical method results for *'ST'* depending on SEC and VB

```python
endog = df_vbnsec['S_D']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house', 'Age', 'Gender_2',
        'Education_level', 'Occupation_2', 'Occupation_3', 'Occupation_4', 'Occupation_5',
        'altitud']])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.19: Hierarchical method code for *'SD'* depending on SEC

```
==============================================================================
Dep. Variable:                    S_D   R-squared:                       0.279
Model:                            OLS   Adj. R-squared:                  0.270
Method:                 Least Squares   F-statistic:                     30.25
Date:                Wed, 21 Aug 2024   Prob (F-statistic):           1.82e-49
Time:                        15:23:02   Log-Likelihood:                 363.56
No. Observations:                 793   AIC:                            -705.1
Df Residuals:                     782   BIC:                            -653.7
Df Model:                          10
Covariance Type:            nonrobust
===================================================================================
                      coef    std err          t      P>|t|      [0.025      0.975]
-----------------------------------------------------------------------------------
const               0.2405      0.050      4.834      0.000       0.143       0.338
zone_1.0           -0.2830      0.025    -11.396      0.000      -0.332      -0.234
inhab_house         0.0029      0.004      0.720      0.472      -0.005       0.011
Age                 0.0088      0.005      1.768      0.077      -0.001       0.019
Gender_2            0.0010      0.013      0.074      0.941      -0.025       0.027
Education_level     0.0295      0.007      4.284      0.000       0.016       0.043
Occupation_2       -0.0311      0.023     -1.360      0.174      -0.076       0.014
Occupation_3       -0.0285      0.015     -1.874      0.061      -0.058       0.001
Occupation_4       -0.0263      0.033     -0.804      0.421      -0.090       0.038
Occupation_5        0.0016      0.021      0.076      0.939      -0.039       0.043
altitud            -0.0059      0.009     -0.698      0.486      -0.023       0.011
==============================================================================
Omnibus:                      264.280   Durbin-Watson:                   1.717
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1262.045
Skew:                           1.454   Prob(JB):                    8.92e-275
Kurtosis:                       8.453   Cond. No.                         60.9
==============================================================================
```

Figure B.20: Hierarchical method results for *'SD'* depending on SEC

```
endog = df_vbnsec['S_D']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
       'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
       'Occupation_4', 'Occupation_5', 'altitud', 'Limit_my_use', 'Adequate_use',
       'limit_use_conservation', 'limit-use_for-others_present&future',
       'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water',
       'aware_water_conflicts_1', 'unlimitated_water_supply',
       'interest_Own_supply' ]])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.21: Hierarchical method for *'SD'* depending on SEC and V

Dep. Variable:	S_D	R-squared:	0.322
Model:	OLS	Adj. R-squared:	0.305
Method:	Least Squares	F-statistic:	18.34
Date:	Wed, 21 Aug 2024	Prob (F-statistic):	1.57e-52
Time:	15:22:54	Log-Likelihood:	388.03
No. Observations:	793	AIC:	-734.1
Df Residuals:	772	BIC:	-635.9
Df Model:	20		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.1380	0.072	1.915	0.056	-0.003	0.279
zone_1.0	-0.2869	0.025	-11.414	0.000	-0.336	-0.238
inhab_house	0.0013	0.004	0.331	0.741	-0.007	0.009
Age	0.0071	0.005	1.394	0.164	-0.003	0.017
Gender_2	-0.0023	0.013	-0.179	0.858	-0.028	0.023
Education_level	0.0270	0.007	3.959	0.000	0.014	0.040
Occupation_2	-0.0313	0.022	-1.392	0.164	-0.075	0.013
Occupation_3	-0.0248	0.015	-1.656	0.098	-0.054	0.005
Occupation_4	-0.0292	0.032	-0.912	0.362	-0.092	0.034
Occupation_5	0.0027	0.021	0.130	0.897	-0.038	0.043
altitud	-0.0106	0.009	-1.245	0.213	-0.027	0.006
Limit_my_use	0.0032	0.008	0.399	0.690	-0.013	0.019
Adequate_use	0.0208	0.006	3.536	0.000	0.009	0.032
limit_use_conservation	0.0006	0.007	0.086	0.931	-0.014	0.015
limit-use_for-others_present&future	0.0627	0.016	3.873	0.000	0.031	0.094
limit-use_Everyone_right_Water	-0.0231	0.021	-1.078	0.281	-0.065	0.019
limit-use_Water_conservation	-0.0262	0.020	-1.304	0.193	-0.066	0.013
Vulnerable_people_water	-0.0043	0.006	-0.664	0.507	-0.017	0.008
aware_water_conflicts_1	0.0275	0.011	2.429	0.015	0.005	0.050
unlimitated_water_supply	-0.0128	0.004	-3.147	0.002	-0.021	-0.005
interest_Own_supply	0.0069	0.004	1.547	0.122	-0.002	0.016

Figure B.22: Hierarchical method results for *'SD'* depending on SEC and V

```
endog = df_vbnsec['S_D']
exog = sm.add_constant(df_vbnsec[['zone_1.0', 'inhab_house',
       'Age', 'Gender_2', 'Education_level', 'Occupation_2', 'Occupation_3',
       'Occupation_4', 'Occupation_5', 'altitud', 'Limit_my_use', 'Adequate_use',
       'limit_use_conservation', 'limit-use_for-others_present&future',
       'limit-use_Everyone_right_Water',
       'limit-use_Water_conservation', 'Vulnerable_people_water',
       'aware_water_conflicts_1', 'unlimitated_water_supply',
       'interest_Own_supply', 'waterproblems_responsability_everyone',
       'waterproblems_responsability_Aqueduct',
       'waterproblems_responsability_Government',
       'waterproblems_responsability_environmental-authority',
       'waterproblems_responsability_economic sector', 'Droughts_Village',
       'Droughts_Only_Property', 'Excesive_w.intake_region' ]])

# Fit and summarize OLS model
mod = sm.OLS(endog, exog)
results = mod.fit()
print(results.summary())
```

Figure B.23: Hierarchical method for *'SD'* depending on SEC and VB

Dep. Variable:	S_D	R-squared:	0.331
Model:	OLS	Adj. R-squared:	0.306
Method:	Least Squares	F-statistic:	13.49
Date:	Wed, 21 Aug 2024	Prob (F-statistic):	1.01e-49
Time:	15:22:54	Log-Likelihood:	393.21
No. Observations:	793	AIC:	-728.4
Df Residuals:	764	BIC:	-592.8
Df Model:	28		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.1902	0.084	2.265	0.024	0.025	0.355
zone_1.0	-0.2754	0.026	-10.394	0.000	-0.327	-0.223
inhab_house	0.0013	0.004	0.323	0.747	-0.007	0.009
Age	0.0066	0.005	1.293	0.197	-0.003	0.017
Gender_2	-0.0068	0.013	-0.518	0.605	-0.032	0.019
Education_level	0.0283	0.007	4.133	0.000	0.015	0.042
Occupation_2	-0.0292	0.023	-1.295	0.196	-0.073	0.015
Occupation_3	-0.0225	0.015	-1.494	0.136	-0.052	0.007
Occupation_4	-0.0253	0.032	-0.787	0.431	-0.088	0.038
Occupation_5	0.0065	0.021	0.318	0.751	-0.034	0.047
altitud	-0.0113	0.009	-1.317	0.188	-0.028	0.006
Limit_my_use	0.0022	0.008	0.274	0.784	-0.014	0.018
Adequate_use	0.0187	0.006	3.098	0.002	0.007	0.031
limit_use_conservation	0.0019	0.007	0.254	0.799	-0.013	0.016
limit-use_for-others_present&future	0.0625	0.016	3.854	0.000	0.031	0.094
limit-use_Everyone_right_Water	-0.0225	0.021	-1.048	0.295	-0.065	0.020
limit-use_Water_conservation	-0.0281	0.020	-1.391	0.165	-0.068	0.012
Vulnerable_people_water	-0.0028	0.007	-0.431	0.666	-0.016	0.010
aware_water_conflicts_1	0.0247	0.012	2.056	0.040	0.001	0.048
unlimitated_water_supply	-0.0161	0.004	-3.734	0.000	-0.025	-0.008
interest_Own_supply	0.0085	0.005	1.873	0.062	-0.000	0.017
waterproblems_responsability_everyone	-0.0088	0.009	-0.964	0.335	-0.027	0.009
waterproblems_responsability_Aqueduct	0.0121	0.008	1.512	0.131	-0.004	0.028
waterproblems_responsability_Government	-0.0219	0.011	-2.005	0.045	-0.043	-0.000
waterproblems_responsability_environmental-authority	0.0172	0.010	1.644	0.101	-0.003	0.038
waterproblems_responsability_economic sector	-0.0089	0.008	-1.053	0.293	-0.026	0.008
Droughts_Village	0.0042	0.005	0.797	0.426	-0.006	0.015
Droughts_Only_Property	0.0014	0.006	0.244	0.807	-0.010	0.013
Excesive_w.intake_region	-0.0068	0.005	-1.321	0.187	-0.017	0.003

Figure B.24: Hierarchical method results for *'SD'* depending on SEC and VB

Appendix C

Definitions

wu: Self perceived total amount of water use per habitant in a day [L*hab/day]

ST: Shower time minutes

SD: saving devices index [%]

VBN: Values Beliefs & Norm theory

V: Values

B: Beliefs

N: Norms

SEC: contextual factors used in this study

NEP: New Environment Paradigm

h: altitude

TPB: Plan behaviour theory