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Challenges to the Effective Wastewater Reuse in Agriculture: The Case Study of Nicosia, Cyprus

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ABSTRACT

Water scarcity and pollution are among the most prominent global concerns. Rapid population growth that increases the water demand in industrial and agricultural sectors has also caused overexploitation of water resources. Water scarcity in arid or semi-arid regions such as Cyprus forces governmental authorities to consider using non-conventional resources, such as treated wastewater (TWW). The Nicosia wastewater treatment plant (WWTP) has been in bicommunal service since 1980. In the early 2000s, the facility's capacity became insufficient due to the increased population and was causing environmental pollution. The facility was modernized in 2013; since then, it has been discharging high-quality, tertiary-TWW. Although the water discharged is being used by some farmers to irrigate crops solely for livestock consumption, its usage is below its potential. Many challenges need to be addressed for this water resource's effective and efficient use. Previous studies have shown that social acceptance among farmers is one of the decisive factors influencing the effective reuse of wastewater. However, no studies focus on social acceptance, and hence, no empirical knowledge of the case of Nicosia. This study aimed to highlight the main challenges affecting wastewater reuse by reviewing the literature about countries facing similar issues and conducting interviews with farmers and experts. After the initial meetings and the literature review, the research objective was determined as evaluating the social acceptance and willingness to pay (WTP) among farmers regarding TWW. By conducting semi-structured interviews with experts in water management and the farmers in the region, the social acceptance of farmers has been evaluated. Contingent valuation method with open-ended questions was used to assess the WTP. Farmers generally have favourable opinions about TWW usage for irrigational purposes, mainly due to their awareness of water scarcity. However, perceived quality had no significant effect on their decision-making regarding TWW usage. Education and knowledge of water quality and treatment technology significantly impacted social acceptance among farmers. Perceived health risks also significantly impacted farmers' decision-making and social acceptance. The farmers' WTP is 1.55 TL/ton for the most likely scenario and educated people (Bachelor’s degree or higher) have indicated higher WTP for TWW. The open-ended nature of the interviews has also revealed several other challenges that hinder the effective reuse of wastewater, such as the lack of wastewater reuse policy and regulations, political issues due to the bi-communal tension, and high operational costs of the WWTP. The knowledge outlined in this research can be helpful in improving the practice of agricultural wastewater reuse in Nicosia and other water-scarce areas, where wastewater reuse is considered a non-conventional water resource.

Keywords: treated wastewater; wastewater reuse; wastewater irrigation; social acceptance; willingness to pay

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LIST OF ABBREVIATIONS

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
EEC	European Economic Community
EU	European Union
FAO	Food and Agriculture Organizations
MENA	Middle East and North Africa
TL	Turkish Lira
TRNC	Turkish Republic of Northern Cyprus
TSE	Treated sewage Effluent
TTW	Tertiary Treated Wastewater
TWW	Treated wastewater
UNDP	United Nations Development Programme
UNESCO	The United Nations Educational, Scientific, and Cultural Organization
WTP	Willingness to Pay
WTU	Willingness to Use
WWTP	Wastewater Treatment Plant

CHAPTER 1. INTRODUCTION

1.1. Background

Today one of the biggest global concerns is the water supply and quality degradation. Rapid population growth resulting in the increase in demand in industrial and agricultural sectors has caused the problem of overexploitation of water resources (*UN World Water Development Report 2017 | UN-Water*, 2017). Especially in arid and semi-arid climatic regions, this problem has reached an even more serious state, forcing authorities to consider using alternative non-conventional sources like treated urban wastewater (Mizyed, 2013).

Cyprus is one of the many countries in the middle east with a semi-arid, arid climate with an average annual precipitation of 516 mm (between 1961-1990) (Republic Of Cyprus Ministry Of Agriculture, 2019). According to the water stress index of Europe, Cyprus has the highest water stress levels in Europe (Hochstrat & Kazner, 2009). For a country facing water scarcity issues, making use of all water resources is essential to become sustainable in water use (Saliba et al., 2018). Reusing treated wastewater (TWW) in agriculture may be a solution for achieving sustainability in managing water resources in Cyprus. Many countries in the Mediterranean region have been using wastewater for irrigational purposes for a significant amount of time (Angelakis et al., 2003; Bixio et al., 2006).

Several factors should be considered for water reuse projects to be successful. These include public opinion, risk analysis, assessment of the financial rewards, WTP among farmers, and the environmental effects of reclaimed water (Lazarova et al., 2001). Many countries have faced the problem of public opposition to the adoption of projects regarding wastewater reuse for irrigation (Saliba et al., 2018). The success of the reuse of TWW depends on public acceptance and involvement; therefore, a thorough analysis and evaluation of the interactions between stakeholders are necessary (Saliba et al., 2018). Although high-quality TWW is being discharged from the Nicosia WWTP into the Kanli River (figure 1) since 2013, there has not been a attempt to address issues regarding the farmer's acceptance of using TWW in agriculture. Also, there are currently no standards or laws concerning wastewater reuse in the TRNC, and prolonged wastewater reuse has not been a typical practice.

Based on the scientific literature, there are several reasons why wastewater reuse in agriculture can be lower than intended, such as; trust in authorities, ease of access to wastewater canals, knowledge, perceived health, and environmental risks, etc. (Mizyed, 2013; Saliba et al., 2018; Lavee, 2010; Dolnicar et al., 2011). However, there is no empirical knowledge of the case of Haspolat, Nicosia. Such knowledge can be helpful to improve the practice of agricultural wastewater reuse in Nicosia, TRNC, and other water-scarce areas, where wastewater is a non-conventional water resource.

This thesis aims to examine the factors that affect farmers' WTU and WTP for TWW for irrigation. The study focuses on a wastewater treatment facility in the Northern part of Nicosia, Haspolat, a region with a rich agricultural tradition, where a group of farmers uses wastewater to irrigate crops. This is achieved by using micro-level data collection through interviews and a questionnaire in person with wastewater management experts and farmers in TRNC.

1.2. Study Area

Turkish Republic of Northern Cyprus (TRNC) is one of the many countries in the middle east facing water scarcity. TRNC's population and water potential data in 2011 shows that the amount of water available per person annually is 391 cubic meters. According to the Falkenmark index, this number places TRNC among the countries with absolute water scarcity (Maden, 2013). In the Turkish Republic of Northern Cyprus (TRNC), there is no specific data on water usage by sector, but through data analysis from similar countries, it is estimated that 79% of water is used for agriculture. (Maden, 2013). Agriculture plays a vital role in TRNC as approximately 14.5% of the population economically depends on agriculture, and 41% of all exports are agriculture based. However, climate conditions and water resource availability have been the limiting factors on the island, which adversely affect the development of the agricultural sector and, therefore, the economy in the TRNC (Gültekin, 2006).

The island has been divided through a buffer zone since 1974, and Nicosia is the world’s last divided capital city. The island’s northern part is administrated separately by all political and economic means. After the island's separation in 1974, through negotiations between the two communities, a common sewage system was constructed in 1980. The bi-communal wastewater management also serves a diplomatic function in supporting the ongoing peace on the island. Therefore, the European Union and the United Nations Development Programme (UNDP) have been promoting activities regarding this. Through their support and after negotiations between the leaders of the two communities, the construction of the new WWTP in Nicosia started in 2010 and finished in 2013 (UNDP Cyprus, 2018). The Nicosia WWTP uses a combination of primary, secondary, and tertiary treatment methods to purify the wastewater before it is released back into the environment. These methods are common in modern WWTP and are effective at removing a wide range of contaminants. The plant discharges high-quality treated sewerage effluent (TSE). TSE discharged from the WWTP complies with applicable irrigation standards and will positively impact the environment (UNDP Cyprus, 2018). The new WWTP in Nicosia, Cyprus, discharges treated sewerage effluent (TSE) to the old river basin (River Kanli) (UNDP Cyprus, 2018). Figure 1 shows the geographic location of the new and old Haspolat WWTP and the river Kanli.

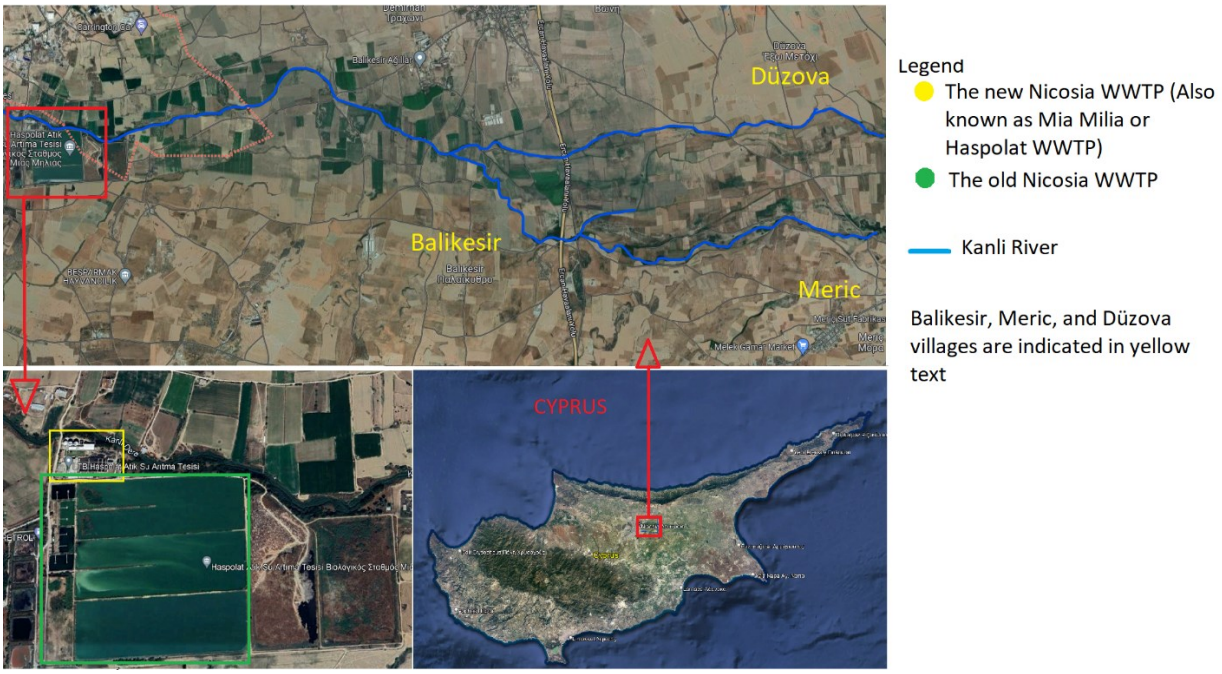

Figure 1- Geographic location of Nicosia wastewater treatment plant **(Source:**(Google, n.d.)**)**

1.3. Problem Statement

For a country facing water scarcity issues, making use of all water resources is essential to becoming sustainable in water use (Saliba et al., 2018). However, a significant amount of the discharged TWW ends up in the sea, especially in winter, Expert 1 suggested that this could be possibly due to low levels of social acceptance (Expert interview 1). The acceptance of TWW among farmers is influenced by a combination of cultural, religious, socio-demographic factors, as well as economic and technical considerations, including water prices, irrigation network design, and crop trends. (Ganoulis, 2012). The main obstacles to effective water management have been identified as social factors as opposed to technical ones (Ricart et al., 2019). Socio-demographic variables such as education and access to information have been found to significantly impact farmers' WTP for TWW (Abu Madi et al., 2003).

With the help of the European Commission, the representatives of both communities are cooperating and planning new projects regarding the reuse of treated water for irrigation (UNDP Cyprus, 2018). A new project includes the construction of a piping line about 6 km in length towards the south side and about 6km towards the north side, together with a reservoir on the northern part with a capacity of 30 million m^3 for delivering the TWW to both communities for reuse (Expert interviews 2, 1). Before designing and building reuse schemes, identifying possible consumers is insufficient; it must be assured that the target customers would be willing to use and pay for the TWW (Tanik, 2010). The support of the farmers is crucial for the acceptance and effective execution of wastewater reuse projects in agriculture (Deh-Haghi et al., 2020), but no studies have looked at the farmers' WTU and WTP for TWW in Nicosia. Hence, the present research provides empirical knowledge on farmers' social acceptance and WTP in the Haspolat region of Nicosia.

1.4. Research Objective

The objective of this research is to identify and evaluate the challenges that hinder the effective reuse of TWW. Due to the broad nature of this objective, the complicated nature of the political situation in TRNC, and to address issues that will be the most useful for policymakers and authorities, the objective had to be altered after the initial meetings I made with the experts and farmers. Therefore, this thesis has one primary and one secondary objective. The primary objective is to explain the social acceptance and WTP of farmers (using the contingent valuation method) regarding wastewater reuse. The secondary objective is to understand and briefly explain other challenges to effective TWW reuse, such as legislation on wastewater reuse in agriculture in TRNC, costs associated with the treatment facility operations and future projects, and political issues due to the bi-communal usage of the WWTP.

After the initial literature research and meetings, I decided to focus on the primary objective of explaining social acceptance and WTP. The research sub-questions are specifically formulated to achieve the primary objective.

1.5. Research Questions

To achieve the research objective, the main research question is defined as:

What are the challenges faced regarding the agricultural reuse of TWW in the case of Nicosia WWTP?

To answer the main research question, the following sub-questions are defined:

1. What is the current level of the agricultural reuse of TWW in Nicosia?
2. Which factors affect the social acceptance of TWW among farmers?
3. Which factors affect the farmers' WTP for TWW?
4. What are the regulations and policies on wastewater reuse, and how do they affect reuse?

1.6. Thesis Outline

The thesis is organized as follows: The relevant theories and key concepts are presented in Chapter 2. The research design is described in Chapter 3. The findings from the document analysis and interviews are presented in Chapter 4. The results in terms of the answers to the research questions and methodological limitations are discussed in Chapter 5. In conclusion, the final chapter of the thesis presents the overall conclusions drawn, suggestions for further action, and future research directions.

CHAPTER 2. LITERATURE REVIEW

In this chapter, I first review the literature on wastewater in irrigation, addressing the benefits, negative impacts, and risks. Then I elaborate on the experiences with wastewater reuse in agriculture around the world, focusing on factors influencing social acceptance of wastewater reuse and the willingness of farmers to pay for TWW.

2.1. Wastewater Reuse in Irrigation

Water scarcity is the insufficiency in the physical availability of water resources or insufficient access to safe water supplies due to a lack of infrastructure or problems in water-supplying institutions (Richey et al., 2015). Wastewater reuse is the process of making use of TWW. It is also referred to as wastewater recycling and wastewater reclamation (Mckenzie, 2005).

Using TWW for agricultural irrigation is a preferred method in arid and semi-arid regions and may solve water scarcity, allowing other high-quality sources to be used elsewhere. It can provide the necessary nutrients for plants due to the wastewater's nitrogen and phosphorus content. This would be economically beneficial for the farmers as it would reduce fertilizer costs. About 10% of global agricultural production is produced in farmlands irrigated with wastewater. However, less than 10% of this water is treated according to a standard that would certify it as safe for use in irrigation. In addition, some substances in wastewater may be present in concentrations that may be toxic to plants or harmful to the environment (Sheidaeia et al., 2016). There are various advantages and disadvantages to using wastewater in agriculture. Advantages, disadvantages, and possible risks should be evaluated together in the planning for the reuse of TWW for agricultural irrigation (Stephens & Fuller, 2009).

There are four main benefits of wastewater reuse in agriculture. Firstly, the wastewater's nutrient (nitrogen and phosphorus) content increases soil fertility and reduces fertilizer costs (Jaramillo & Restrepo, 2017). Secondly, wastewater is a permanent and reliable source of water; therefore, water scarcity can be reduced, especially in regions with seasonal drought (Jaramillo & Restrepo, 2017). Thirdly, applied wastewater allows the aquifers to be filled with infiltration from the soil (Grinshpan et al., 2021). And lastly, where wastewater is used for irrigation, it has been observed that the metabolic activities of microorganisms beneficial for soil cultivation are increased (Stephens & Fuller, 2009).

The use of wastewater in irrigation may have some disadvantages, and negative effects, for example; some substances in wastewater can be present in concentrations that may be toxic to plants and/or harmful to the environment (toxic chemicals)(Stephens & Fuller, 2009). Also, due to encountering toxic chemicals health problems can be experienced by farmers, such as blistering, skin infection, injuries to hands and lower legs.

Prolonged exposure to these chemical contaminants is known to cause health problems such as cancer (Sheidaeia et al., 2016). Furthermore, the yield and quality of crops could be adversely affected by irrigation with TWW if significant quantities of toxic chemicals accumulate in the plant and soil (Petousi et al., 2019), also TWW irrigation can cause a considerable accumulation of soil salinity (Gao et al., 2021). And finally, TWW can damage irrigation systems such as drip irrigation and sprinkler irrigation (Ungureanu et al., 2020).

The appropriate treatment of wastewater can reduce the risks associated with reuse in agriculture however, due to excessive costs associated with wastewater treatment, many developing countries use untreated or partially TWW in agriculture (Sheidaeia et al., 2016).

The Nicosia WWTP uses a membrane filtration technology combined with a chlorine contact tank to produce high-quality treated sewerage effluent (TSE). TSE discharged from the WWTP complies with applicable irrigation standards and will positively impact the environment (UNDP Cyprus, 2018). Although the irrigation water quality standards set by Food and Agriculture Organizations (FAO) guidelines are met by Nicosia WWTP, there are various studies (Christou, Karaolia, et al., 2017), (Christou, Agüera, et al., 2017) which suggest that long-term usage of TWW within the standards in crop irrigation might have harmful effects on the environment and human health. However, the studies made by Christou et al. indicate that over the time of their experimentation, the build-up of toxic chemicals, in this case namely, pharmaceutically active compounds was not enough to cause any threat to human health. But results of the studies indicate that the amount of PhACs in the soil and vegetables/fruits increases as the duration of irrigation increases, which suggests the need for more studies over more extended periods to have a definitive answer. The study by Schipper (1996) show that TTW usage for irrigation over a period of 2 years increased soil pH, invertase activity, and nitrate levels but these changes are not enough to adversely affect the biological functioning of the soil.

To sum up, if some possible long-term effects are neglected, and the irrigation water quality standards set by FAO are considered as a baseline for reusing TWW, the reuse of appropriately TWW in agriculture is beneficial.

2.2. Social Acceptance of Wastewater Reuse among Farmers

Traditionally decisions on wastewater management projects were made depending on efficiency, safety, and cost-effectiveness. However, other relevant factors had to be included in the decision-making process to achieve sustainable water development. Therefore, a holistic methodology that enables all stakeholders' opinions to be heard and includes an analysis of social factors in the initial stages of the projects is needed to achieve successful implementation (Saad et al., 2017). Nowadays, many experts realize that the successful implementation of

wastewater reuse projects highly depends on social acceptance (Dolnicar et al., 2011). Social acceptance is the common understanding and acceptance of the public on project scope.

The research by Saliba et al. (2018) highlighted the factors influencing farmers' decisions on using TWW in the village of Apulia in Italy. The results indicate that farmers' decision to use wastewater for irrigation mainly depends on their knowledge of the reuse, perception and understanding of the quality of water, trust in the treatment and reuse system, crop water demand, and knowledge of the advantages of the reuse. The paper also proposed approaches that can enhance the acceptance and usage of TWW in agriculture, the main suggestion being the involvement of stakeholders in the earliest stages of the project. It has also been noted that change in perception can only be achieved through discussion with different stakeholders. An individual party usually does not have the power to take the initiative in decision-making to achieve sustainability in water re-usage, indicating the importance of social learning through stakeholder involvement (Saliba et al., 2018).

In the research by Saliba et al. (2018), stakeholders related to wastewater were asked to share their opinions on the steps that could be implemented to promote the reuse of TWW in agriculture. Depending on the stakeholders' views, the cognitive map shown in Figure 2 was constructed. The actions are represented in rectangular boxes, and influencing factors are represented in oval lines. The actions identified were classified into four main categories; dissemination and information actions, actions related to the costs for the TWW to be used in agriculture, actions related to the regulations governing the sector, and actions that address the structural and/or organizational aspects of the whole system of water treatment. Influencing factors that directly affect wastewater reuse are; policies for licensing and effective control mechanisms on groundwater withdrawals, a collaboration between and enhancing water resources in the context of land protection. The figure is also a visual representation of their findings.

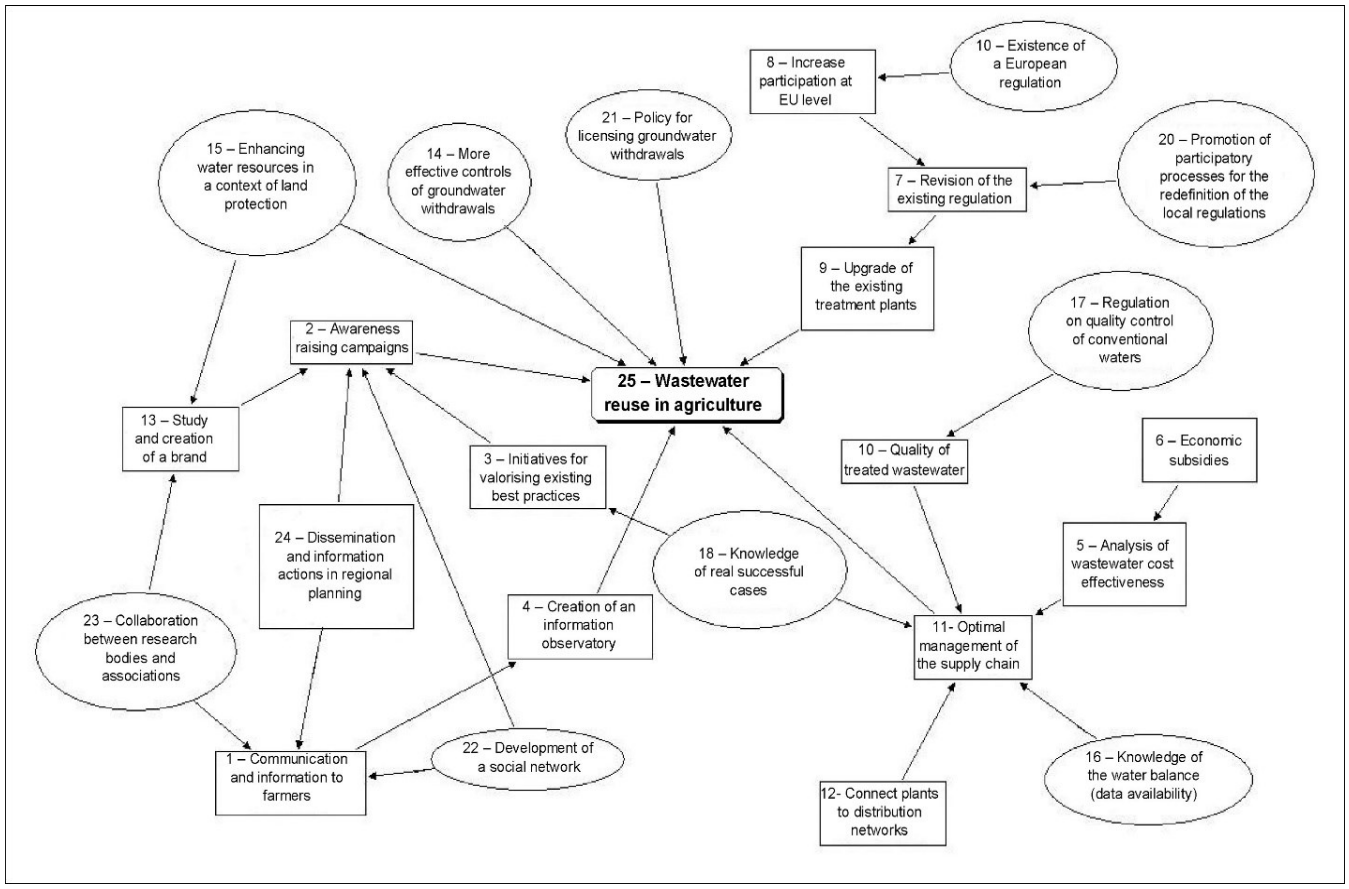

Figure 2 - Stakeholders' cognitive map on the reuse of wastewater in agriculture in Apulia, Italy,

(Source: Saliba et. al. 2018: p.66)

The effective use of water resources highly depends on the regulations, laws, and administrative framework in place (Young & Haveman, 1985). The government's capacity to construct an effective regulatory, and administrative framework is essential for water resource management (Loucks & van Beek, 2017). Several authors have made similar statements in the past (Rahaman & Varis, 2017; Salman & Bradlow, 2006), and it can be concluded that the actions of the governing authorities can have a direct and decisive effect on wastewater reuse.

Dolnicar et al. (2011) linked personal characteristics to the level of acceptance. The factors that influence the public acceptance of TWW identified by (Dolnicar et al., 2011) are trust in authorities associated with wastewater reuse, knowledge/information, risk perception, experience with an alternative water source, health concerns, and perception of good water quality. The socio-demographic variables (personal characteristics) assessed include age, gender, and education level (having a higher education degree). The study's results confirmed that the identified factors influenced public acceptance and showed that increased education and knowledge make people more accepting of wastewater reuse. Also, it has been observed that older people are more accepting than the young population (Dolnicar et al., 2011).

Fielding & Roiko (2014) study identified the effect of information campaigns on decision-making regarding wastewater reuse. They compared the responses of those in a control group who did not receive information

about recycled water with those in groups that received information of differing complexity about wastewater reuse. Compared to participants who do not get information on recycled water, individuals who learn about recycled water will be more knowledgeable and show more favourable cognitive, emotional, and behavioural reactions to recycled water (Fielding & Roiko, 2014).

While it has been discovered that being more educated increases public acceptance (Alhumoud et al., 2003), the age factor has produced contradictory findings. Some writers claim that older people have higher acceptance (Dolnicar et al., 2011), while others claim the contrary (McKay, 2003; Lohman & Milliken, 1985). According to Lavee (2010), uncertainty in water supply induces farmers to prefer dryland farming crops with lower profitability but require little to no water. This is because a shortage of water can result in the loss of all agricultural investment, and the costs of capital investments for multi-seasonal crops requiring more water are greater than those for dryland farming crops. The profits from multi-seasonal crops are significantly higher than dryland crops, but to create change in the type of crops used by farmers, the risks associated with water supply have to be minimized. As a solution to this problem, Lavee (2010) suggests increasing the use of TWW in agriculture as it is a constant and reliable water source. By examining the costs associated with 22 wastewater reuse facilities, it is concluded that switching to more profitable crops through the help of wastewater reuse can make the construction of such treatment facilities economically beneficial (Lavee, 2010).

The successful implementation of wastewater reuse projects depends a lot on the farmers, who are the potential users of the TWW. A study on farmers' attitudes towards wastewater reuse in Iran has shown that a complex set of factors influence farmers' decisions. The most significant factors found in this research are; perceived health and environmental risks of wastewater reuse, knowledge, ease of access to wastewater canals, and value orientation (Sheidaeia et al., 2016).

The risk and benefit perceptions of the public are crucial to the acceptance of new technology. The commercialization and use of new technology are often negatively affected by low public acceptance. Concerns about public health, water quality, governance, reliability, and financial risks are identified as barriers to the acceptance of new sanitation technologies (Poortvliet et al., 2018). Adopting appropriate incentives, such as price reductions for high-quality TWW, testing for physio-chemical characteristics and microbiological contamination, and extensive training programs can encourage farmers to utilize TWW for crop irrigation (Deh-Haghi et al., 2020).

The literature reviewed above identifies several common factors affecting the acceptance of wastewater reuse (Poortvliet et al., 2018; Lavee, 2010; Dolnicar et al., 2011; Saad et al., 2017; Saliba et al., 2018; Sheidaeia et al., 2016). These factors can be categorized as follows:

- Availability of other water resources and ease of access to treated water.

- Risk and benefit perceptions: concerns about reliability, public health, and water quality
- Trust in governmental authorities that are responsible for wastewater management
- Socio-demographic factors, such as; education level, income and age
- Information provided to the public by the governing authorities about the TWW and WWTP
- Type of crops grown by farmers

These factors constitute a complex web, influencing social acceptance and farmers' decision-making regarding the use of TWW in agriculture, and they are interlinked in a way that a change in one factor might affect several other factors.

2.3. Farmers' Willingness to Pay for Treated Wastewater

The support of the farmers is crucial for the acceptance and successful implementation of wastewater-reuse projects in agriculture. However, no studies have reviewed the farmers' WTU and WTP for TWW in TRNC Nicosia. Consequently, a deeper comprehension of the key elements that determine farmer acceptance and WTP for TWW is required. To clarify, WTP is the maximum price a customer is willing to pay for a product or service.

Abu Madi et al. (2003) found that in Tunisia and Jordan, farmers are not willing to pay more than 0.05 $/ton for TWW primarily because of quality concerns, comparatively easy access to fresh water, and price. The study used the contingent valuation method together with logistic regression analysis to correlate the qualitative data gathered through the contingent method into monetary stimuli. A dichotomous questioning methodology is used in this study to achieve higher estimates of the willingness of farmers to pay for TWW. One of the major factors affecting farmers' decision-making on wastewater reuse was found to be the availability or accessibility of freshwater resources. And the amount farmers were willing to pay was mostly affected by the pricing of the wastewater and the farmland's profitability. It was also found that the amount farmers are willing to pay hardly covers the operational costs of distributing TWW.

Deh-Haghi et al., 2020 analysed farmers' WTU and WTP for TWW in western Iran, Khorramabad, by using the Contingent Valuation Method and a binary probit model. The binary probit model was used because the number of farmers was high, and the dependent variable chosen in the study was dichotomous. By suggesting three degrees of wastewater quality and three prices to chose from, the study evaluated farmers' acceptance of TWW, their WTU and WTP for TWW in crop irrigation, and factors influencing farmers' decision-making were determined. In the study, socio-economic variables had the most impact on WTP of farmers. These variables were education, information, location of the farmland, and pricing.

Harun et al. (2015) interviewed 236 farmers from Kurdistan Regional Government to analyse the factors influencing farmers' WTP and WTU for TWW in crop irrigation. The data has been divided into two groups according to the precipitation rates. The contingent valuation method was used to analyse the WTP for irrigation water. The bid amounts, the scale used to evaluate the water deficit, the source of water used for irrigation, the cultivated area, the respondents' ages and educational backgrounds, and the primary agricultural activity were all potential independent variables that could affect farmers' decisions. The study has confirmed that low water availability in the region correlates to a higher WTP. The accessibility to water resources was the main difference between the two groups. The other potentially important variables, such as the economic characteristics of the regions, were not analysed.

The reviewed literature shows that contingent valuation is the common method used by researchers for assessing the WTP for TWW. Although contingent valuation has been criticized for not reflecting the truth, researchers and policymakers increasingly recognise contingent valuation as a flexible and effective methodology for estimating respondents' WTP (Spash, 2008). The respondents' WTP can be assessed in different ways, such as (a) through an open-ended question, (b) through a single referendum question, or (c) using a bidding game (Smith, 2000). In an open-ended inquiry, the responder is prompted to indicate the highest price at which he or she is ready to pay; in a referendum, the respondent is given a posted price and the option of accepting or rejecting it. Moreover, by repeatedly offering higher and higher prices, the bidding game seeks to limit the respondent's maximal WTP (Smith, 2000).

CHAPTER 3. RESEARCH DESIGN

Research design is explained by Creswell (2009), as “the set of methods and procedures used in collecting and analysing measures of variables specified in the problem research”. This chapter will describe all the methods and procedures that were used to conduct this research.

3.1. Research Framework

The research framework is a “schematic presentation of the research objective and includes the appropriate step that needs to be taken to achieve it” (Verschuren & Doorewaard, 2013).

1. Characterization of the objective of the research project

The objective of this research is to identify the challenges faced in wastewater reuse in agriculture in the case of the Nicosia treatment plant by evaluating farmers' social acceptance and WTP.

2. The definition of the research object

The research objects are farmers in the Haspolat region with farms neighbouring the Kanli River, and experts in the field of water management in TRNC were also used as sources of information.

3. Nature of the research perspective

This research will outline the possible reasons why wastewater reuse in agriculture is lower than intended through interviews and literature study. Qualitative research methods were used to understand farmers' decision-making processes regarding wastewater reuse, and quantitative data, which includes farmers' age, education level, water usage statistics and crop type, were also collected. Finally, the relationships between the quantitative and qualitative data were investigated.

4. The sources of the research perspective

Three types of documents were reviewed: guidance documents, grey literature, and published studies (scientific literature). The grey literature includes governmental documents, reports, laws, and policies (regarding wastewater and other water resources), newspaper reports on Nicosia WWTP, and other relevant information about the Haspolat Region. Published studies were identified through searching on Scopus, Google Scholar, and Science Direct. The theoretical framework of this research is developed after reviewing the scientific literature and through the discussions made with government officials related to wastewater management.

5. Schematic presentation of the research framework

The framework of this research is schematically presented in Figure 3.

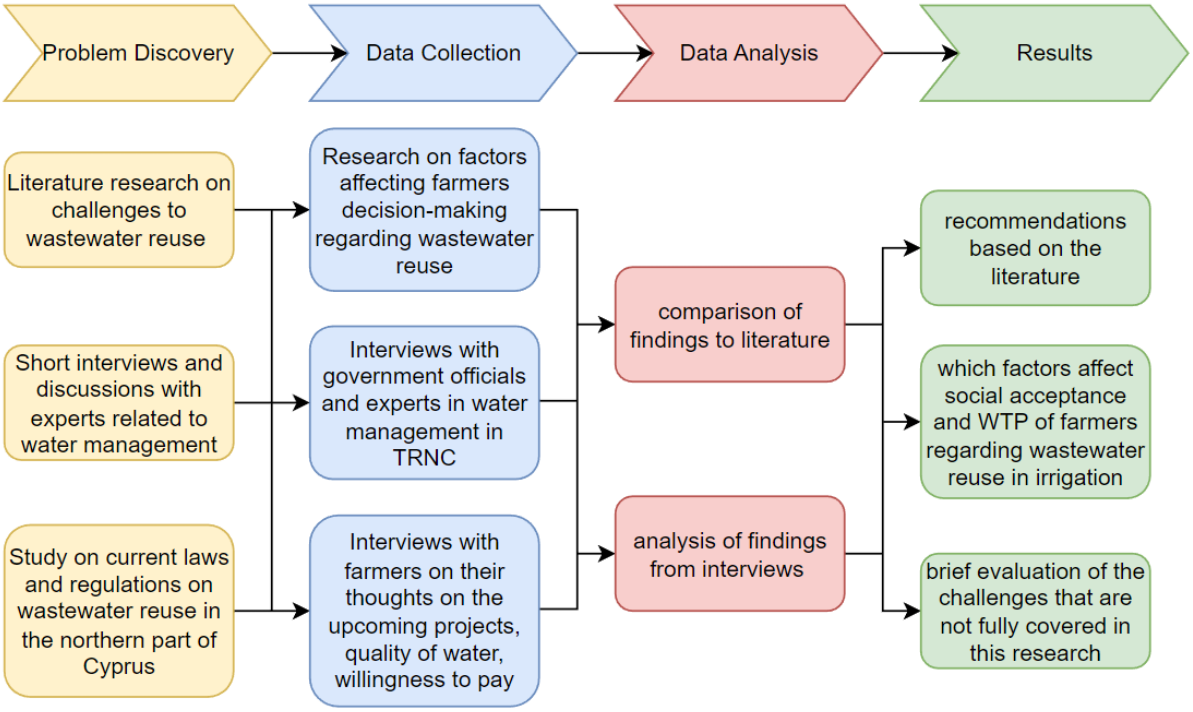

Figure 3- The schematic presentation of the research framework

6. Formulate the research framework in the form of an elaborate argument

The course of this research is formulated with the following steps:

Problem Discovery

Literature review on the challenges to wastewater reuse in agriculture to provide a theoretical basis for the interviews and analysis.

Desk research on the reuse of wastewater in agriculture in similar countries - focusing on social acceptance among farmers and farmers' WTP for TWW.

Having discussions and short interviews with experts working closely with wastewater management to gain an insight

Data Collection

Semi-structured interviews with farmers to determine the challenges faced in using TWW. The sample was selected depending on the location of the farmland. Attributes such as land ownership/size, crop choice, irrigated/rainfed agriculture, education, and alternative income was also collected and analysed.

Semi-structured interviews with government officials and EU commission representatives in Cyprus were conducted to gain insight on potential challenges to wastewater reuse in the region, current managerial situation and to crosscheck the findings of the interviews with the farmers.

Desk research on the current laws and regulations regarding wastewater management was carried out.

Data Analysis

Empirical findings were compared to the literature, and the final findings were analysed by using Microsoft Excel through comparing the responses of the interviewees to the chosen variables.

Results

Factors affecting social acceptance of wastewater among farmers

Factors affecting farmers' WTP for TWW

7. **Check whether the model necessitates any changes**

After the initial talks with the experts, it was realized that the model had to be changed due to the complicated nature of the situation. Although the farmers were using this water, the perceived quality of TWW was still low. Initially, the assumption that farmers were not using enough of this water was made; however, this was not the case, and the model has been updated accordingly.

3.2. Research Strategy

The research strategy used for this thesis is the single case study approach, and farmers were used as research units. In this thesis, factors affecting farmers' social acceptance of the WTP regarding wastewater reuse have been identified using qualitative and quantitative methods; data were collected through interviews with farmers and experts and desk research.

Firstly, a theoretical framework has been developed on factors affecting social acceptance and WTP through desk research. Secondly, due to the limited data availability online, experts in the field of water and wastewater management in TRNC have been interviewed to gain a better insight into the current level of wastewater reuse in the Haspolat Region. And thirdly, farmers were interviewed in a semi-structured way, using open-ended questions. The qualitative and quantitative data from the interviews were analysed and used to identify factors affecting farmers' decision-making. Finally, the results of both sets of interviews were used as a guide to construct a general picture of the challenges faced regarding wastewater reuse.

3.2.1. Research Unit

The research objective and questions focus on the decision-making and behaviour of farmers that use TWW. Therefore, the research unit of this study is farmers, both in terms of a unit of observation and a unit of analysis.

In addition to farmers as the main data source, experts in the field of water and wastewater management in TRNC and the relevant TRNC laws and regulations regarding wastewater reuse were used as a source of data.

3.2.2. Selection of Research Unit

The main selection criterium for the farmers to be interviewed was the geographic location of their farmland. Only farmers with farmlands neighbouring the Kanli River, which are localised after the point of wastewater discharge, have been interviewed. The interviewees were then categorized according to the age, level of education, and crop choice, which are predicted to influence the decision-making process. The selection of the experts in the field of water and wastewater management in TRNC was based on their perceived accountability and knowledge of the region and subjects of interest.

3.2.3. Selection of the Case

Nicosia is the capital of Cyprus and the world's last divided capital city. The bi-communal WWTP project, which the EU partly funded, serves a diplomatic function in supporting the island's ongoing peace and confidence-building process. At the same time, the area is harshly hit by climate change and water scarcity, which are increasingly becoming an issue for farmers, especially in the island's northern part. Considering the economic significance of agriculture for TRNC, the effective use of wastewater from the Nicosia WWTP is crucial. Because of all these factors, I decided to select the case of the Nicosia WWTP for my thesis research.

3.2.4. Research Limitations and Boundaries

I started my research in the summer of 2020 during the first year of the Covid-19 pandemic, which affected the research process significantly. The major limitations of the research are as follows:

1. Limited time at the case study location. I had limited time on the island, which made reaching out to the relevant individuals more challenging.
2. Limited data is available on the subject. Some crucial data for this research, such as the amount of water withdrawn from the river Kanli, is not being recorded, and the number of research papers regarding wastewater reuse on the island is limited.
3. Most interviews had to be conducted in Turkish and only translated into English for citation purposes in the thesis.
4. Some of the interviews had to be conducted online due to the restrictions brought on by the Covid-19 pandemic.
5. Some of the data about farmers had to be collected through an online questionnaire as I had a limited time stay on the island.
6. Although small monetary incentives were offered and meetings were tried to be arranged at their preferred locations, some farmers avoided the interviews. After learning that the interview was for a thesis, some did not answer their phones.

By considering the limitations, the following research boundaries were set:

- The targeted number of interviews with farmers is limited to 10, the research aims for depth in information gathered rather than breadth.
- The targeted number of interviews with experts is limited to 7. After an initial meeting with 3 experts to gain an insight into the situation, a selective (strategic) sampling method was used for the selection of the interviewees to be able to gather the most relevant and in-depth knowledge of the situation.
- The number of cases to be examined for the analysis is limited to 1, i.e., the case of the Northern part of Nicosia.

3.3. Data Collection

Both primary and secondary data are used in this study. While interviews provided the core data, desk research provided the secondary data. The interviews were categorised into 2, farmer and expert interviews.

Table 1 - Research material and collection method

Research sub-questions	Data/information required to answer	Source of data	Collection method
1. What is the current level of the agricultural reuse of treated wastewater in Nicosia?	The quality and amount of water being extracted from the treated wastewater discharged from Nicosia WWTP	Primary data	Interviews with experts Interviews with farmers
		Secondary data	Desk research of documents from the municipality and the government reports
2. Which factors affect the social acceptance of treated wastewater among farmers?	Farmer's opinion on the agricultural reuse of treated wastewater from Nicosia WWTP	Primary data	Interviews with farmers
	Knowledge on factors affecting farmers' behaviours regarding agricultural wastewater reuse in other places	Secondary data	Desk research on the scientific literature and grey literature
3. Which factors affect the willingness of farmers to pay for treated wastewater?	The amount of money that farmers are willing to pay for TSE and what affects that amount	Primary data	Interviews with farmers
	Knowledge on factors affecting farmers' behaviours regarding agricultural wastewater reuse in other places	Secondary data	Desk research on the scientific and grey literature
4. What are the regulations and policies on wastewater reuse and how do they affect reuse?	regulations and policies on wastewater reuse in legislation	Primary data	Desk research on grey literature and TRNC laws and regulations
	Farmers' ideas and expert's opinions on policies and regulations on wastewater reuse	Secondary data	Interviews with experts Interviews with farmers

Interviews with farmers and experts were conducted between June 2020 and October 2022. Before the interviews, I clearly described my identity and research objectives and then requested the consent of the participants after informing them that their involvement in the research was voluntary and free from any use of coercion, fraud, or deception. During the vis-a-vis interviews, notes and audio recordings were taken under the consent of the interviewees for the documentation of the responses. The interviews with the farmers were based on both a framework of questions aiming to analyse the sociodemographic profile and general characteristics of the farmers as well as hypothetical scenarios to analyse the factors affecting the decision-making process of the farmers. The expert interviews were rather based on open-ended questions and were used as guidance in the progress of the thesis.

3.3.1. Document Review

Three types of documents were reviewed: guidance documents, grey literature, and published studies (scientific literature). Guidance documents were used as a tool to achieve a solid thesis structure, such as Creswell (2009). The grey literature includes governmental documents, reports, laws, and policies (regarding wastewater and other water resources), newspaper reports on Nicosia WWTP, and other relevant information about the Haspolat Region. Published studies were identified through searching on Scopus, Google Scholar, and Science Direct for the terms; “wastewater treatment plant”, “Social acceptance”, “wastewater reuse”, “irrigation”, “willingness to pay”, “MENA”, “Mediterranean” and “farmer” and citation chasing within the most relevant studies. The abstracts of the published documents were read for the preliminary selection to find the most relevant studies. The methodology sections of the most relevant published documents were then read, to determine key methodological stages.

3.3.2. Interviews with Farmers

The questionnaire in Appendix C is used as a guide for the interviews with farmers and mostly consists of open-ended questions. There are three main components of the questionnaire. Basic details about the characteristics of the farmers and their farms are requested in the first section for assessing which characteristics influenced decision-making. Including farm location, primary crops, age and education level, concerns with water quality and availability. For assessing the farmers’ social acceptance, farmers were asked to make a qualitative judgment on water quality and the effects of TWW on their farmland. For assessing perceived water quality, the respondents could choose from the following options: Very bad, poor, sufficient, good, and don't know. Questions in the second section inquire about farmers' knowledge of the following: the wastewater treatment facility; water and sludge sale at the WWTP and the possible future project which includes the construction of a pipeline. Additionally, their opinions on the advantages and disadvantages of using wastewater are solicited particularly regarding their

knowledge and experience in farming. The last section asks farmers if they are in favour of the piping project to deliver this water to their farms and aims to figure out what would affect the mindset of the farmers on the project.

In this study contingent valuation through open-ended questions was chosen as the method of assessing the farmer's WTP for TWW. Open-ended questions tend to result in lower estimates than the other ways of questioning (Loomis, 1990). However due to the low number of respondents and based on the initial interviews with Expert 1 and 2, I could guide the interviewees towards the actual marketing price, and hence open-ended questioning model was chosen as the method of assessment.

The contingent valuation has 3 key elements; (1) a detailed description of a good or service being valued and the hypothetical change regarding the good or service, (2) questions about WTP for a good or service being valued, and (3) questions about respondents' characteristics (age, income, education, etc) (Sagoff, 2007). In this research, the high-quality TWW is the good being valued and the hypothetical changes are;

- WTP increases as the availability of other water resources decreases
- WTP pay increases as the quality of water increases, enough to be used on higher-yielding crops (suitable for human consumption)
- WTP decreases as price increases

The following measures were taken to ensure the gathering of accurate data through the interviews:

- Emphatic and positive initial questions were asked to gain the farmers' trust and enhance the likelihood of receiving trustworthy and in-depth information.
- Precise questioning methods were carried out in order to avoid misleading responses.

The lists of interviewed farmers is shown in Table 2.

Table 2 - List of interviewed farmers

Farmer No	Interview date	Age	Education Level
1	17 July 2020	49	Bachelor's degree
2	22 June 2022	47	High-school
3	21 October 2022	39	High-school
4	01 November 2022	44	Bachelor's degree
5	06 November 2022	31	High-school
6	09 November 2022	36	Doctorate/ professional degree
7	09 November 2022	51	High-school
8	11 November 2022	68	High-school
9	12 November 2022	71	Masters degree
10	14 November 2022	52	High-school

3.3.3. Interviews with Experts

To gain insight on the current management practices and stakeholder connections regarding wastewater reuse, in-depth, semi-structured interviews were held with experts in the water and wastewater management field in TRNC. The expert interview guide which is given in the appendix E was used as guide during the interviews. The average duration of interviews was 50 minutes, and respondents' responsibilities and relationships with other stakeholders on wastewater and farmers were initially asked. Then, follow-up questions were shaped depending on their expertise and answers to the main questions.

Table 3 - List of interviewed Experts

No	Name	Position/Role	Institution	Interview date
1	Pinar Erengin	Manager of Sewage works	Nicosia Turkish municipality	13 august 2020 and 10 June 2022
2	Tarkan Ceki	General manager	General Directorate of State Water Works	9 July 2020
3	Mustafa Beyoglu	General Secretary	Cyprus Turkish Farmers Union	27 June 2022
4	Emir Akyillar	Technical Staff	Ministry of Tourism and Environment, TRNC	24 June 2022
5	Mehmet Avkan	Former general manager	State Production Farms, TRNC	16 July 2020
6	Evren Cavdir	Representative responsible for the wastewater project development	EU Coordination Center, TRNC	17 June 2020
7	Osman Gultekin	Commissioned head of the Irrigation union for Balikesir village	Ministry of Agriculture	22 June 2022

3.4. Data Analysis

After the collection of relevant data, I proceeded with the data analysis. This research uses the qualitative and quantitative methods of data analysis in order to gain a thorough understanding of the factors impacting farmers' decisions regarding wastewater reuse.

3.4.1. Method of Data Analysis

Table 4 - Method of Data Analysis

Research sub-question	Data required to answer	Method of analysis
1. What is the current level of the agricultural reuse of treated wastewater in Nicosia?	The quality and quantity of water extracted from the Kanli river (treated wastewater discharged from Nicosia WWTP). The main purpose of water extraction	Quantitative and Qualitative: Checking water quality against EU regulations. Analysing the farmer's preferred water resources against their perceived wastewater quality and sociodemographic characteristics
2. What affects the social acceptance of treated wastewater among farmers?	Farmer's opinions and knowledge on the agricultural reuse of treated wastewater from Nicosia WWTP	Qualitative and Quantitative: analysing farmers' perceptions of quality and eagerness to use treated wastewater based on characteristics such as education level, age, land size, crop types, and location of farmland
	Knowledge on factors affecting farmers' behaviours regarding agricultural wastewater reuse in other places	Qualitative: comparison of findings from the interviews to the literature
3. What affects the willingness of farmers to pay for treated wastewater?	The amount of money that farmers are willing to pay for TSE and what affects that amount	Qualitative and Quantitative: analysing factors affecting farmers' decision making
	Knowledge on factors affecting farmers' behaviours regarding agricultural wastewater reuse in other places	Qualitative: comparison of findings from the interviews to the literature
4. What are the regulations and policies on wastewater reuse, and how do they affect reuse?	Regulations and policies on wastewater reuse in legislation	Qualitative: comparison of findings from the interviews to the legislation in place
	Farmers' ideas and expert's opinions on policies and regulations on wastewater reuse	Qualitative: analysing and grouping of farmers' and experts' opinions

I mainly used qualitative data analysis methods, the exceptions were sociodemographic data of farmers and how it relates to social acceptance, and the quality and amount of the discharged TWW, provided that the necessary data was present.

Excel software was used for data analysis. Data from the farmer interviews was imported into an Excel spreadsheet and due to the low number of respondents data was not assessed through statistical methods. The data were analysed for each farmer individually to investigate the link between farmers' perceived water quality and age and educational level. General socio demographic characteristics (age, education level etc.) and data which can be expressed in terms of percentages (such as the proportion of farmers' perceived water quality rating) were presented with pie charts. The data was also categorized under each socio demographic variable to examine the factors affecting farmers' decision making. The outcomes of these analysis were used to spot any trends or patterns in the data and make inferences regarding the elements that affect farmers' views of the quality of the water. Overall, the data gathered from the farmer interviews could be accurately and efficiently analysed using Excel and no statistical methods due to the low number of respondents.

3.4.2. Validation of Data Analysis

Data analysis was validated by making cross-checks between the result analysis of the interviews with farmers, interviews with experts (government officials, municipality workers, people working for the EU coordination office regarding this matter, etc.), and the academic literature. Two types of data verification were applied; confirming that the data collected from the farmers matched the ones gathered through the experts, confirming the results were in line with the literature and using a set of questions with direct and indirect answers to ensure consistency within an interview. If one farmer's response is found to contradict one or more experts' responses, the response to that question was not used within the thesis.

3.5 Ethical Considerations

The study made sure that ethical considerations were taken into account during the data collection and analysis as well as during the preparation and presentation of the final thesis script. Before deciding on the data collection strategy, the Behavioural, Management, and Social Sciences (BMS) Ethics Committee was consulted. Interviews were carried out only after receiving ethical approval. An information sheet (Appendix A) and a consent form (Appendix B) were designed and handed over to the interviewees before the beginning of the interviews to eliminate ethical concerns. The consent form was designed to protect the privacy and confidentiality of the interviewees fully and ensure the participants that the collected data will be exclusively used for the completion of the thesis.

CHAPTER 4. RESULTS

This chapter presents the results of the interviews with ten farmers in the Haspolat region and seven experts in the field of water and wastewater management in TRNC and document analysis regarding wastewater reuse practices. Socio-demographic and general characteristics (age, education level, type of crops etc.) of the farmers that were interviewed are represented in the first section. Then, the other sections are formulated to provide answers to the stated research sub-questions.

4.1 Socio-demographic and General Characteristics

Due to the low number of respondents, the socio-demographic results were cross-checked with the data at the Cyprus Turkish farmers union to ensure that the results were representative of reality. However, the education level of farmers that are registered with the union is not recorded and cannot be cross-checked. According to the unions database, the average age of farmers within the Balıkesir, Meric and Düzova villages is 51.

The average age of the farmers interviewed is 49, and farmers over 65 form 20% of the study group. On the other hand, young farmers (under 35 years old) represent only 10% of respondents.

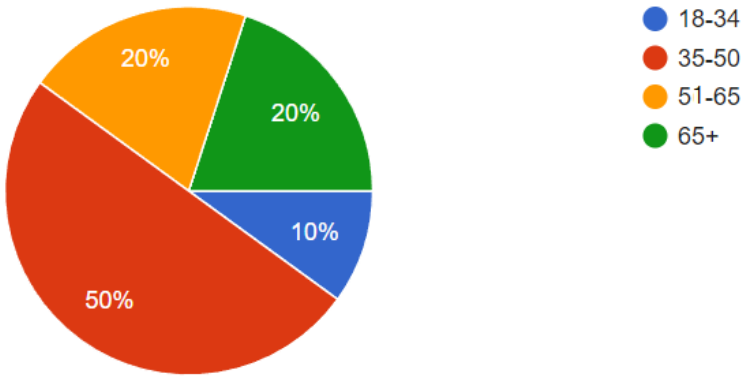

Figure 4 - Age of farmers that were interviewed

As shown in Figure 5, all the respondents are at least high school graduates, but the percentage of farmers with higher education (bachelor's and above) is %40.

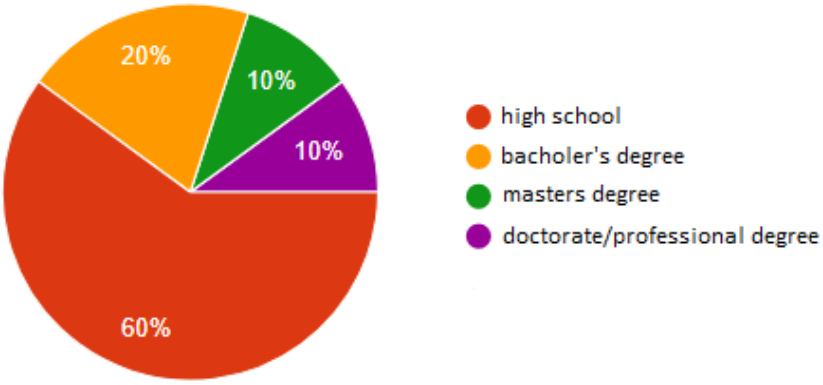

Figure 5 - Education level of farmers that were interviewed

The majority of farmers (90%) grow more than a single type of crop, and cultivated crops from the most cultivated to the least cultivated are clover, wheat, maze, barley, and fodder plants. 80% of the farmers are growing clover, and 60% are growing mazes mainly for feeding their livestock.

80% of the farmers are willing to continue their farming activities in the next ten years, from which 30% consider changing their crops according to water availability. Another 30% are willing to change their crops according to customer demand and production costs. The remaining 20% of farmers are unsure about proceeding with farming activities.

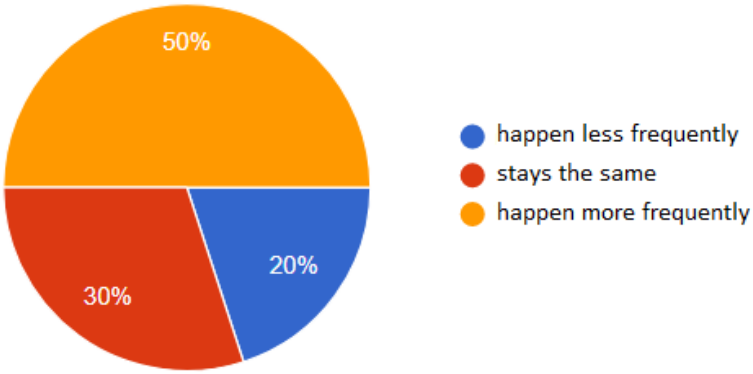

Figure 6 - Responses to the question; When you think about the next ten years, how often do you anticipate that problems related to limited water availability will occur compared to now?

Figure 6 demonstrates the farmer's prediction of water availability problems in the next ten years. Half of the respondents have a pessimistic view and expect water scarcity to be a more significant problem in the future.

4.2 Current Level of Wastewater Reuse

The Nicosia WWTP uses a membrane filtration technology combined with a chlorine contact tank (tertiary treatment), allowing it to produce high-quality treated sewerage effluent (TSE). TSE discharged from the WWTP complies with applicable irrigation standards and will positively impact the environment (UNDP Cyprus, 2018). Based on the initial interviews with experts and farmers and questionnaire results, the wastewater discharged into the river Kanli is being withdrawn through individual pumps by farmers for irrigational purposes. Sprinkle, drip, and flood irrigation methods are used to grow crops such as clover, maze, wheat, and barley. The crops are primarily used for feeding livestock.

The municipality in the northern part of Nicosia currently sells this wastewater at a price of 2 TL/ton at the treatment facility. However, the results indicate that 60% of farmers interviewed are unaware that the municipality is selling TWW. This evidence suggests that a lack of marketing and information sharing, rather than problems with accessibility or social acceptance, is what accounts for the municipality's low sales volume. One of the experts claimed that these issues might be the cause of the low amount of sales (Expert interview 1). Expert 1 also added that "the success of the second phase of the Nicosia WWTP project highly depends on farmers' WTP for TWW, due to the high operational costs of the treatment plant and the high capital costs associated with the piping and reservoir project".

4.2.1 Water Quantity

I contacted the Cyprus Turkish Farmers' Union and the Ministry of Agriculture to request the water withdrawal data for the Balikesir, Meric, and Duzova villages from the River Kanli. However, I have been told there is no accurate data since most farmers withdraw water using privately owned pumps. Gokcekus et al. (2020) claim that, on average, 150,000 m^3 of water is reused in irrigation per month from the Nicosia WWTP. On average, the treatment plant discharges 900,000m^3 of water every month; the claim by Gokcekus et al. (2020) suggests that 17% of the discharged water is used for irrigation. However, the data was not referenced and could not be confirmed through other publicly available sources. The expert 1 stated that the State Production Farms is the leading purchaser of TWW; however, the quantity of water supplied was not shared.

Four respondents indicated that they are not using the water in the river basin, which is stream mixed with wastewater (Farmer interviews 2, 6, 8, 9). Three farmers only use the water from the Kanli river (Farmer interviews 1, 5, 7). The other three use a mix of well and river water (Farmer interviews 3, 4, 10). All of them use the water with the help of their privately owned water pumps. Only two of the farmers interviewed provided their yearly average water withdrawal data (Farmer interviews 4, 10), whereas the others did not know their amount of water consumption. Therefore, the amount of water withdrawn was not analysed in this study.

Farmer interviewees 1, 3, 5, 7, 10 and expert interviewees 3, 7 have all stated that high evaporation rates and inefficient usage (flood irrigation) cause the Kanli River to dry up during summer months even though the treatment plant discharges water continuously. Farmer interviewees 1, 3, 7, 10 and expert interviewees 3, 7 have shared information on the agreement between the villages neighbouring river kanli in the Haspolat region, which aims to overcome problems related to the right of water resources in the times of draughts. According to the interviewees, the agreement states that each village (Balikesir, Meric and Düzova) can use the water only within the agreed periods (8h for each village in a day).

Farmer interviewees 3, 10 and expert interviewees 2, 5 also stated that a significant quantity of water ends up in the sea during winter. Farmers addressed this issue, and both suggested collecting and preserving the wastewater, especially against droughts in autumn (cultivation months) (Farmer interview 3, 10).

4.2.2 Water Quality

The inlet water and the treated water (outlet) quality data at the Haspolat WWTP was gathered via the expert 1 in the Nicosia Turkish municipality and can be found in Appendix D (for the dates between January 2022 and April 2022). During the interview, the expert from the Nicosia Turkish municipality stated that the discharged water quality was within the standards stated by the EU.

To be applied to all water reuse projects at the EU level, minimum reclaimed water quality requirements for reuse in irrigation have been developed, together with preventative measures to minimize the hazards to human and animal health from ingesting crops irrigated with reclaimed water (Urban Wastewater Directive - Council Directive 91/271/EEC, 1991).

Upon checking the outlet effluent data against the standards set by the EU (Urban Wastewater Directive - Council Directive 91/271/EEC, 1991), the parameters, biochemical oxygen demand without nitrification (BOD5 at 20 °C), chemical oxygen demand, total suspended solids, and total nitrogen were significantly

lower than the stated allowed maximums. However, for a few days, the total phosphorus was slightly higher (4 mg/l was the highest recorded concentration between January 2022 and April 2022) than the concentration limit of 2 mg/l set by the EU.

4.2.3 Current Projects

The leading purchaser of TWW is the State Production Farms. TWW is pumped to the State Production Farms at a rate of 250-300 m³/hour through the old pipeline available (Turkish Republic of Northern Cyprus, 2017). According to expert interview 2, due to agreements between the TRNC, the Republic of Cyprus, and the EU, the old pipeline cannot be used to transport water to other locations. The TRNC water master plan states that, state production farms are experimenting with different types of crops and irrigation methods with the TWW from the Haspolat WWTP. These projects are implemented to set an example for the farmers. A total of 3000 acres of farmland are irrigated in the project's first stage. For the continuity of the project and further experiments, the State Production Farms Directorate and the Nicosia Turkish Municipality signed a protocol (Turkish Republic of Northern Cyprus, 2017).

It is claimed by the expert 1 that the new WWTP project has the potential to overcome the challenges regarding ease of access to wastewater, the high cost of operating the treatment facility, and quality concerns. The project includes the construction of a pipeline about 6 km in length towards the south side and about 6 km towards the north side, together with a reservoir on the northern part with a capacity of 30 million m^3 (Expert interview 2, 1). Expert interviewee 1 stated: "as the construction of the treatment plant was done by the UNDP and EU commission and as it is a collaborative project between the Turkish Cypriot and Greek Cypriot communities, the continuation of the projects regarding the Nicosia WWTP on any side of the border requires the approval and funding from all parties involved. Disagreement between the parties, combined with the project's estimated cost being higher than expected, has decelerated the pace of progress in the project."

It is believed that the proper usage of this water is crucial to farming in the region. Expert interview 2 stated: "The municipality wants to increase its wastewater sales as the operational costs of running a wastewater treatment facility are high. However, our management is not promoting this sale or running informational campaigns to increase TWW usage because no policies exist." The municipality in the northern part of Cyprus is unable to pay its share of the treatment plant's operating expenses. It is claimed by the municipality that the sale of this wastewater is crucial for covering the operational costs (as cited in Expert interview 1; BRTK, 2022). It is claimed that, given the circumstances, the assessment of farmers' WTP for TWW is decisive for the success of the new pipeline and reservoir project.

The total budget for designing and building the Nicosia WWTP is 29.3 million Euros (funded by: the European Commission - 8.2 million Euros and the Sewage board of Nicosia – 21 million Euros), and the operating costs of the treatment plant are around 4.3 million Euros a year (UNDP & Sewerage Board of Nicosia, 2009). The southern side pays 70% of operational costs, and 30% is paid by the northern part of the island. The Nicosia Turkish Cypriot Municipality is responsible for covering the operational costs in the northern part of the island and is currently struggling to pay its share (BRTK, 2022). Expert interviewee 1 stated that if the new piping project is realized and if WTP for TWW is low, the burden of covering the operational costs might increase rather than decrease. This is thought to also mean that the municipality would have to spend additional tax money on operating expenses that could be used in other ways.

The expert 1 also stated that the current biggest challenge regarding the implementation of the new piping project is the high initial investment costs. The project designing and building phase are estimated to cost over 20 million euros (Expert interview 1 and 2).

4.3 Social Acceptance Among Farmers

Overall, age did not have a significant impact on the social acceptance of farmers. Farmers in the age group 51-65 only perceived the water quality as sufficient or good; all five respondents within the age group 35-50 had different perceived water quality levels (1 for each option: good, poor, and very bad and 2 for sufficient), one of the respondents above the age of 65 have indicated the quality as poor, and the other one indicated the quality as good. The interviewee below the age of 35 indicated a poor water quality (see Figure 7).

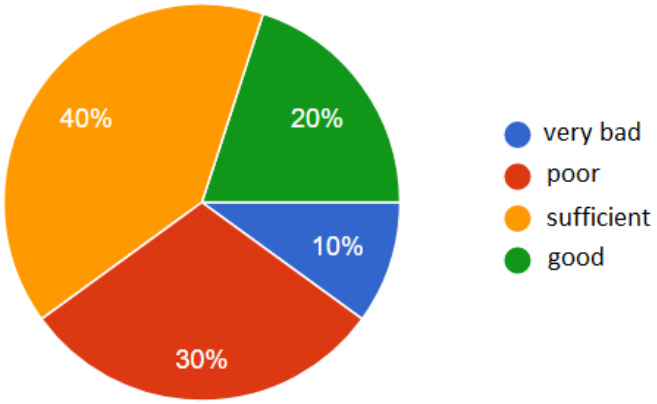

Figure 7 - Responses to the question: How do you evaluate the wastewater quality from the Haspolat treatment plant?

The farmers with higher education (Bachelor or higher) only indicated the water quality as sufficient or good, suggesting that the perceived quality of water increases as education level increases. Although the

perceived quality level is higher among educated, only two people with an education higher than high school prefer to use the wastewater, whereas 4 out of 6 high school graduates actively use the TWW for crop irrigation.

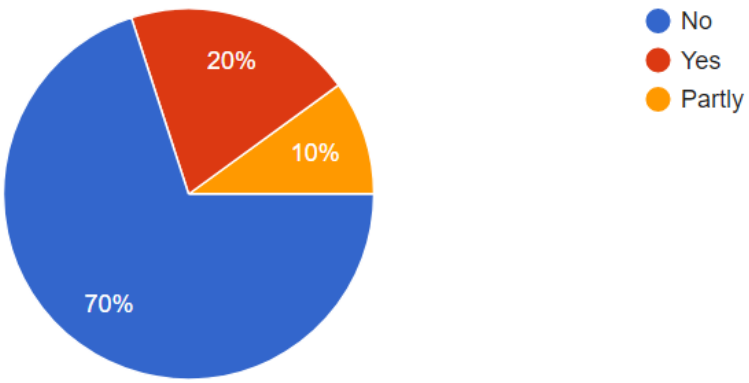

Figure 8 - Responses to the question; Do you know how the Haspolat WWTP works?

Most farmers (70%) did not know how the WWTP works; one of the farmers stated that he had partial knowledge, and the rest claimed to know how it works (Figure 8). All the farmers who claimed to know or partly know how the treatment plant works evaluated the water quality as sufficient.

Expert interviews (1, 2, 6, and 7) revealed that there were no information campaigns regarding wastewater reuse since the construction of the new treatment plant was finished. Expert 1 stated that this is mainly due to the lack of regulations in legislation; she said, “without any regulations or laws in legislation in place, it is not conceivable to carry out information campaigns by a government entity”.

According to the interviews with farmers, the most significant environmental impacts of a WWTP include; bad smell, bacteria accumulation, increased mosquito population, and the potential damage to the natural soil habitat. One of the farmers implicated severe health concerns: “Before the new treatment plant was constructed, I was using the wastewater to irrigate my crops. But back then, after working in the farmland, I was getting red spots that itch on my legs and hands” (farmer interview 7). Another farmer stated that he had taken samples from the water in the river basin in 2017, and the lab results showed the presence of E.coli (Farmer interview 10). Another farmer expressed concerns about whether all the wastewater is thoroughly processed in the treatment plant and suspects that some wastewater is directly released from the treatment plant into the river Kanli without being completely processed (Farmer interview 8). Only two farmers stated that the environmental impact of the WWTP is negligible. 20% of

respondents have indicated that they are unwilling to use the water due to health concerns for themselves or their livestock that will consume the crops.

However, the results of interviews do not incite a clear relationship between wastewater reuse and the perception of quality. 50% of the interviewees using the TWW for irrigational purposes have indicated a perceived quality of bad or very bad, while the other 50% indicated good or sufficient. The only respondent with a perceived wastewater quality of very bad is using the wastewater for irrigation purposes. However, he has stated that he only uses it for a small portion of his farmland. Further questions have revealed that he is using this water for barley and clover production, which is only used for feeding the livestock.

Three farmers only use the water from the Kanli river (Farmer interviews 1, 5, 7). The other three use a mix of well and river water (Farmer interviews 3, 4, 10). Two of the farmers who only rely on the water from the river basin perceived the water quality as poor (Farmer interviews 5 and 7), and one farmer perceived the water quality as sufficient (Farmer interview 1).

During the interview, Expert no 7 (also an ex-farmer) stated that he has little information on the quality of TWW. However, he said, “before I quit farming, between 2007 and 2018, I was also using the wastewater for irrigating my crops. Even though the quality improved after the treatment plant construction, I do not think the water quality was sufficient for long-term usage.”. He asked if I had the quality results, and I provided the data to him; after checking the data, his concerns about environmental and health issues related to water quality appeared to diminish. A similar thought process on water quality was observed with a farmer, whose initial response to water quality was bad (Farmer interview 10). However, after the interview, I provided him with the water quality data, and his verbal feedback indicated that his perceived water quality had been positively altered.

4.4 Willingness of Farmers to Pay for Treated Wastewater

The Turkish municipality of Nicosia sells the wastewater at the WWTP at 2TL/ton. According to the experts at the municipality, however, only a small fraction of farmers prefers to buy this TWW (Expert interview 1). Therefore, I asked the farmers if they knew about the wastewater being sold, and 60% said they were unaware of such a practice. The 40% that were aware of the sales, stated that they did not consider buying the wastewater. They all stated that it is not economically viable as the water is sold only at the WWTP and requires the self-transportation of the TWW.

For assessing farmers' WTP for TWW and to determine what affects their decision-making, three hypothetical case scenarios were presented to the farmers; 1) The piping project is implemented in a way that the water is delivered to the farmland at high pressures and the amount of water in the river basin does not change 2) piping project is implemented as in the first scenario, but the amount of water in the river basin decreases 3) the quality of wastewater being delivered increases allowing irrigation of more profitable crops (potentially suitable for human consumption).

If the piping project is implemented and the water is delivered to the farmer's farmland, the data shows that most farmers are willing to pay for TWW (90%). However, 60% of farmers stated that they would only pay a price equal to or less than the amount they are currently spending for gas and electricity to withdraw from the river through their pumps. Only 30% of farmers are willing to pay a higher price than the cost of withdrawing water from the river basin. Most farmers (70%) are unaware of their spending on pumping the wastewater on a per-ton basis. However, they added that it is possible to calculate. The 30% who were aware of their rough spending on withdrawing indicated a range of different costs to withdraw water from the canal (0.5TL/ton, 0.70TL/ton, 0.90 TL/ton).

The contingent valuation method results indicate that if the piping project is implemented and the water is delivered to their farmland, and if the amount of water in the river does not change, the average price they are willing to pay is 1.23 TL/ton. If the project substantially reduces the water in the river basin, the maximum price farmers are willing to pay for TWW is 1,55 TL/ton on average. Finally, in the scenario where wastewater quality is high enough to be used on crops for human consumption, the maximum price they are willing to pay is 1,60TL/ton. In this last scenario, most farmers (70%) did not change their answers.

If the piping project is realised, water quantity in the river basin will likely decrease significantly (Expert interview 2). Hence, the case scenario where water quantity in the river basin decreases after the completion of the pipeline project was used to study education in correlation to WTP. We categorized the farmers into two, according to their degree of education as high school graduates and bachelor or higher education. The WTP of high school graduates were 20% less than the farmers with bachelor's or higher education.

Farmer 5 and 9 have explicitly emphasised that the ease of access to water resources is the utmost important factor affecting their decision-making regarding water resource selection. Both added that they favour the piping project. Six farmers have indicated that they are against the piping project, three due to their political views and past environmental damages, and three due to a possible decrease in water

availability. 50% of respondents have stated that their decision-making regarding water resource selection is mainly based on costs. 80% of the respondents that find cost the most decisive factor are against the piping project because of the possibility of increased costs and a decrease in water availability.

4.5 Regulations and Policies on Wastewater Reuse

This section addresses challenges related to the regulations in the TRNC regarding wastewater reuse. The challenges are outlined through expert and farmer interviews and the examination of regulatory documents.

The laws and regulations regarding wastewater reuse in agriculture in TRNC were last updated in 1987. The law approved in January 1987 in TRNC (02/1987) (kanalizasyon sularinin tarimsal amaçlarla kullanmasini yasaklayan yasa s.02-1987, 1987) forbid the use of any wastewater in irrigation regardless of its quality and it was followed by the law 03/1987 (kanalizasyon sularinin tarimsal amaçlarla kullanilmasini yasaklayan kararnamenin yürürlülkten kaldirilmasina ilişkin yasa S.03-1987, 1987) which states the abolition of law 02/1987. Currently, no policies or laws address the reuse of TWW in agriculture. The policy for reusing wastewater was aimed to be developed until April 2020. However, due to the Covid-19 pandemic, it has been postponed, and the completion time is unknown based on the information gained within Expert interview 2. The draft policy was obtained through the General Directorate of State water works of TRNC, and according to the document, the first version of the draft was written in 2011. The engineering consultancy company Grontmij was also consulted during the development of the draft policy (Expert interview 2).

4 out of 7 experts who were interviewed criticized the lack of legal background regarding wastewater reuse, and four farmers have indicated that strict regulations are needed before the piping project to ensure effective, safe, and fair wastewater reuse (Expert interviews 1, 4, 5, 7, and farmer interviews 2, 4, 7, 10).

One of the farmers claims that another farmer used an excavator to change the river's course so that a little stream could be created within his farmland. Although the interviewee has made a complaint, the authorities have not contacted the accountable party (Farmer interview 8).

According to the TRNC Law 34/2002, an irrigation union can be formed by anyone who uses water from a source for irrigation purposes regardless of any other law (overrules any other law). Regional water committees are responsible for determining the type of production that irrigation unions and their members will grow using irrigation water, the area of the land they can use, the irrigation system they will

apply, and the amount of water they will need (Sulama Örgütleri ve Tarımsal Amaçlı Su Kullanım Yasası S.34/2002, 2002). Regional water committees are only formed if necessary for a region through a collaborative decision by the Ministry of Environment and the Ministry of Agriculture. There is currently no regional water committee for the Haspolat region; therefore, the irrigation unions and their members in the region can decide on the crop selection, water source, etc., on their own.

The initial meetings with farmers and experts suggest that the farmers in the Balikesir region use flood irrigation technique for irrigating their crops (Farmer 6 has stated that flood irrigation technique has been banned for the past couple of years but a legislative search on this matter showed that flood irrigation is not banned). Usage of inefficient methods combined with the high evaporation rates during summer months has caused the river Kanli to dry up past Balikesir village (Farmer interviews 1, 3, 4, 5, 6, 7, 9, and Expert interviews 5, 7). In addition, farmers from the villages of Duzova and Meric (Figure 1) have expressed dissatisfaction over the lack of water in the river canal (Farmer interviews 6, 7, 9). An agreement has been made between the irrigation unions of Balikesir, Meric, and Duzova villages; it has been decided that each village can make water withdrawals during the agreed 8-hour period allocated to them within a day.

4.6 Political Challenges

Although political challenges were not within the scope of this research, political statements on the issue were made by both experts and farmers during the interviews. The data in this results section has not been analysed by any scientific method. Moreover, due to the low number of respondents and the fact that research questions and methodology does not concern political issues, results in this section are not further discussed in chapters 5 and 6.

While commenting on the progress of the new projects on wastewater, an expert who has otherwise permitted to be quoted with his name within the thesis specifically asked to remain anonymous for this specific quotation: “It is hard to agree with the Republic of Cyprus officials; they do not care about the Northern side of the island as long as they receive what they want. I think it is better to elongate the negotiations for the piping project”.

The interviews with the farmers revealed that the political conflict is not only on the administrative level. Six farmers stated that they do not want the discharged wastewater to be sent to the southern side of the border. Three of those six stated that they have been dealing with the WWTP's environmental consequences (bad smells, toxic materials, etc.) since 1980, and they both added that there should be a

price to pay for the environmental damages. One farmer stated, "The old treatment plant and the discharged water polluted the area and caused discomfort to the residents and farmers for a long time, and I still think that it continues to cause harm, although to a lesser extent. I do not think it would be fair to send the water back to the southern side considering that TRNC has been dealing with the environmental consequences of the sewage effluent coming from the southern side for a long time." (Farmer interview 6). Another farmer stated, "I do not want to give my water or any other belonging to the Republic of Cyprus, and if the piping project requires that, I am against that." (Farmer interview 5). He also added that he supports one of the political parties that is against the unification of the Island and said, "I do not think any good will come from the southern side and I do not think we can work together on large scale projects." Only one farmer appears to be strictly against any collaboration based on his political view; however, due to the small sample size, it could not be ignored. All other respondents that did not want the wastewater to be sent to the southern side stated that their thought process only considered the reduction in water quantity and was not political. Two respondents stated that the water quantity in the river basin is barely enough for the neighbouring villages, and a 70% decrease in availability would cause many farmers to face water scarcity during the summer months. Another respondent stated that the southern side has enough water resources and has built dams on a few main rivers flowing from south to north; therefore, it would be better not to pump the water to the southern part.

The interviews with the manager of the general directorate of state water works of TRNC have revealed that during the planning phase of projects, he does not want to include anyone from farmers and regional water unions because he thinks that farmers' involvement in the decision-making phase may further decelerate already slow-moving procedures. He also stated that the conflicts that hindered the project's progress had minimal damage to the TRNC and that the Greek Cypriot administration would not be able to access this water before the project was completed. The expert working for the European Commission and manager of the general directorate of state water stated that the course of the new projects highly depends on the conditions of the water master plan TRNC makes with Turkey.

CHAPTER 5. DISCUSSION

The agricultural reuse of TWW has the potential to provide a valuable source of irrigation water and reduce the demand on finite water resources. However, the implementation of TWW reuse programs can be complex and involve a range of challenges. The findings of this study provide insights into the challenges faced in the agricultural reuse of TWW in Nicosia and offer recommendations for addressing these challenges. In the following discussion, the results of the study will be presented and analysed in relation to each of the sub-research questions. To what extent each research sub-question is answered is also discussed within its respective part in section 5.5, along with research limitations. Finally, recommendations for future research projects were provided.

5.1 Sub-question 1: Current Level of Wastewater Reuse

The first sub-question entails investigating the current level of the agricultural reuse of TWW in Nicosia. The initial hypothesis regarding this sub-question was that the current level of wastewater reuse among the farmers in the area is below its potential. This hypothesis was formulated based on the interviews with experts 1 and 2. However, as mentioned in section 4.2, the authorities do not know the exact amount of water being withdrawn from the river basin. The interviews with farmers have shown that this data is also not known by the farmers themselves. The limited data availability hinders answering this research sub-question to the full extent. Therefore, due to solely relying on data based on interviews with farmers and experts, the credibility and reliability of the answer to this research sub-question is reduced.

The initial interviews with experts suggested low levels of perceived quality and reuse. The results of interviews indicate that 60% of farmers use wastewater for irrigation purposes. Considering that there is a consensus between farmers for the right to water resources (as mentioned in section 4.6), during summer months, the level of wastewater usage might be higher than the experts' expectations (Expert interview 1, 2). The results do not contradict with the initial hypothesis of low usage; however, it does not confirm it either. If the right regulations are implemented such that the farmers are required to quantify their water withdrawals from the river basins, it would be easier for the governmental authorities and future researchers to determine the level of wastewater reuse. Without any quantitative data and a limited number of respondents, answering questions related to the level of reuse is challenging.

The quality of wastewater discharged was said to be suitable for reuse in irrigation (Expert interview 2). The data on the quality of the inlet and outlet wastewater was retrieved through the communication I

made with the municipality. As mentioned in section 4.2.1, the wastewater quality is well within the boundaries set by the EU regulations for reuse in irrigation. Considering the results of the studies by Christou, Karaolia, et al. (2017) and Schipper et al. (1996) use of the wastewater from Nicosia WWTP in irrigation would cause no immediate environmental or health effects. Studies investigating the effect of high-quality wastewater in irrigation over longer periods (more than three years) are needed to conclude the effects of long-term usage.

Interviews also indicate that a significant quantity of water ends up in the sea during winter. Two farmers addressed this issue, and both suggested collecting and preserving the wastewater (Farmer interviews 3, 10). The collection of wastewaters might solve the water scarcity issues during summer. In accordance with this, the EU project mentioned in previous chapters also includes the construction of a reservoir for storing the water in the river basin (Expert interviews 1 and 2). However, the effects and effectiveness of storing water against droughts are not within the scope of this research, and no literature has been reviewed on this matter.

5.2 Sub-question 2: Social Acceptance Among Farmers

The second sub-question entails the level of social acceptance on wastewater reuse in irrigation among farmers in the Haspolat region. An appropriate metric to measure social acceptance is chosen to be conducting interviews, using a questionnaire and obtaining opinions of farmers on the quality of wastewater in this region.

Overall, the results show that farmers in the Haspolat region focus on the advantages rather than the hazardous aspects of wastewater reuse. The interviews reveal that 60% of farmers use wastewater for irrigation purposes. However, half of the farmers who use the TWW for irrigation have a perceived quality of poor or very bad. Furthermore, among the users of the TWW who rely solely on the water in the river basin, the perceived quality varies (number of responses: 1 sufficient and 2 poor). These results indicate that the perceived quality of the water resource is not a factor of utmost importance affecting the farmer's decision-making while selecting water resources.

The results indicate that farmers' social acceptance of wastewater reuse is significantly affected by education level and knowledge. Farmers with higher education had higher perceived water quality, which is in line with the study by Dolnicar et al. (2011), who found a strong correlation between knowledge/information and social acceptance.

The results show no correlation between age and perceived quality or preferred water source as opposed to the findings by Dolnicar et al. (2011), McKay (2003), and Lohman & Milliken (1985). Dolnicar et al. (2011) have observed that older people are more accepting than the young population. On the other hand, McKay (2003) and Lohman & Milliken (1985) have observed that the young population is more accepting than older people. Therefore, the contradictory results among researchers for the age parameter suggest that age does not play a role in social acceptance.

The results of the interviews indicate that the ease of access to the wastewater canal has a significant impact on the farmers' decision-making regarding wastewater reuse. The verbal feedback from the interviews suggest that as ease of access to TWW increases, TWW reuse increases. However, due to the absence of a methodological approach to evaluate the effect of ease of access on farmers decision making combined with the low number of respondents, this result cannot be validated. This result is in accordance with the study by Sheidaeia et al. (2016), who assessed farmers' attitudes towards wastewater reuse in Fars Province, Iran. They suggest that knowledge, farm distance to the wastewater canal (closeness), and value orientation are the most important factors influencing farmers' perceptions of the value of wastewater, and the health and environmental risks.

The study by Lavee (2010) indicates that unreliable water sources (both in quantity and quality) motivate farmers to prefer crops with lower profitability requiring little to no water. Farmer interviews 4 and 10 indicated that if the authorities guarantee the quality and quantity of the water being supplied, they might switch to more water-reliant and profitable crops. In line with this finding, Deh-Haghi et al. (2020) suggest that regular testing of physio-chemical characteristics and microbiological contamination can encourage farmers to use TWW for crop irrigation, especially if combined with information campaigns and training programs. However, the crop selection of the interviewed farmers shows little to no variation. Other factors that might affect the interviewees' responses are not within the scope of this research, and the data set is only limited to ten respondents. Therefore, it is not possible to fully demonstrate what Lavee (2010) and Deh-Haghi et al. (2020) suggest in their studies, with the results of this study solely relying on two interviewees. Although the results are aligned with the previous literature, a more comprehensive study with a larger sample size is needed.

5.3 Sub-question 3: The willingness of Farmers to Pay for Treated Wastewater

The third sub-question evaluates farmers' WTP for TWW. As outlined in sections 3.3.2 and 4.4, the farmers were given three hypothetical scenarios to assess their WTP for TWW. If the piping project is realized,

most farmers (90%) are willing to pay for TWW. This finding aligns with Deh-Haghi et al. (2020), who suggests a WTP of 91% for the lowest price in the survey. In the first scenario – where the piping project is implemented, the water is delivered to farmers' land, and the amount of water in the river does not change - the average price that the farmers are willing to pay is 1.23 TL/ton. Although the implementation of the project relieves the workload on farmers (for example, by eliminating the requirement of regular maintenance of water pumps), most farmers are not willing to pay more than their cost of electricity or gas for self-withdrawals. This implies that the farmers prioritise costs over workload, which is also consistent with the initial hypotheses that WTP decreases as price increases. In the second scenario - where the piping project substantially reduces the amount of water in the river basin - the maximum price they are willing to pay for TWW is 1.55 TL/ton. In the last scenario, where wastewater quality is high enough to irrigate crops for human consumption, they are willing to pay a maximum price of 1.60TL/ton. In this last scenario, most farmers (70%) did not change their answers, meaning the water does not influence their WTP.

The results of the second scenario suggest that WTP increases as the availability of other water resources decreases, which is in accord with the study by Harun et al. (2015). As long as the amount of TWW stays constant in the Kanli River, most farmers are unwilling to pay more than their pumping costs.

Only 30% of farmers are willing to pay a higher price than the cost of withdrawing water from the river basin. The farmers have indicated a range of costs from 0.5TL/ton to 0.9 TL/ton for withdrawing water from the canal. Although there is no exact data for the operational cost of pumping and selling at the WWTP, Expert interview 1 stated that the current price of 2TL/ton is barely enough to cover the pumping costs to the state production farms (which is located 8km to the east of the WWTP). According to the interviews, the prices farmers are willing to pay would not be enough to cover the operational costs after the piping project is completed. For comparison, although circumstances are different for each scenario, the study by Deh-Haghi et al. (2020) indicates that 56% of farmers are willing to pay a price approximately equal to the freshwater irrigation charge. The WTP of farmers who are high school graduates were 20% less than the farmers with bachelor's or higher education. This result is in accordance with the results of Deh-Haghi et al. (2020), which declared that information and education had the most significant impact on WTP.

5.4 Sub-question 4: Regulations and Policies on Wastewater Reuse

The fourth and final sub-question is on the regulations and policies on wastewater reuse are and how they affect reuse in general. There is a lack of legislative background on wastewater reuse in TRNC. The

interviews have revealed that the development of a policy addressing wastewater reuse has been going on for the last 11 years with no clear indication of the expected completion time. The results also suggest that the lack of regulations and policies prevents the municipality from carrying out information campaigns on wastewater sales. The general manager of the General Directorate of State Water Works stated that due to the lack of regulations and policies, it is not officially possible to carry out information campaigns on water sales by the municipality. As a result, TWW sale is not acknowledged by 60% of the farmers interviewed, from this it can be suggested that the lack of legislation regarding wastewater reuse indirectly hinders the knowledge and awareness of farmers in the region. Although direct marketing of wastewater sales is said to be not possible, carrying out general information campaigns on the quality of wastewater could be useful in increasing social acceptance. As the literature in section 2.2 suggests, knowledge and information campaigns significantly affect social acceptance.

The regulations and policies regarding wastewater reuse in agriculture in Northern Cyprus appear to be lacking. While there were laws in place in 1987 that forbid the use of any wastewater in irrigation, these laws were later abolished. However, no policies or laws have been put in place to address the reuse of TWW in agriculture. The development of a draft policy for wastewater reuse has been ongoing, but it has been delayed due to the Covid-19 pandemic and the completion time is currently unknown.

Several experts have criticized the lack of legal background on wastewater reuse, and some farmers have indicated that strict regulations are needed before the implementation of the piping project in order to ensure the effective, safe, and fair reuse of wastewater. This highlights the importance of establishing clear policies and regulations for wastewater reuse to ensure its safe and responsible use in agriculture.

The effective use of water resources highly depends on the regulations, laws, and administrative framework in place (Young & Haveman, 1985). The government's capacity to construct an effective legal, regulatory, and administrative framework is essential for water resource management (Loucks & van Beek, 2017). Several authors have made similar statements in the past (Rahaman & Varis, 2017; Salman & Bradlow, 2006), and therefore, it is possible to suggest that the lack of laws and/or policies (administrative framework) regarding wastewater reuse in TRNC is one of the main factors hindering the effective reuse of wastewater.

5.5 Reflections on Research Methods

Reflection on research methodology is essential for my thesis because it provides an opportunity to assess the effectiveness of my chosen methods for conducting interviews with farmers and experts. This

assessment will help to ensure the validity and reliability of the data collected, and it will also enable me to identify any areas that need improvement or adjustment.

1. The current level of the agricultural reuse of TWW in Nicosia is not well understood, and there is a lack of clear policies and regulations in place to guide its use. This sub-question was only partially answered by the study. The lack of quantitative data has prevented me from answering this sub-question fully.

2. Education level, perceived water quality, knowledge on treatment technology, and perceived health risks were found to impact social acceptance among farmers significantly. The study thoroughly answered this sub-question however, the low number of respondents reduced the reliability of the results. Also, the results could not be cross checked or validated by any means due to the limited data provided by the experts and governing bodies.

3. Most farmers were willing to pay for TWW, but only if the price was equal to or less than the cost of withdrawing water from other sources. Perceived water quality did not significantly impact farmers' willingness to pay, but economic values and the availability of other water resources did. The study thoroughly answered this sub-question. However, farmers wanted to be heard, and the friendly approach during interviews could have caused the farmers to see the research as a chance to complain about their problems in general. This could potentially cause farmers to indicate a lower WTP. The choice of using contingent valuation method appers to be the right choice as many respectable and current research preferred to use this method. Also providing farmers with hypothetical scenarios was useful to determine the factors affecting farmers' WTP.

4. There is a lack of clear policies and regulations in place to guide the use of TWW in agriculture in Northern Cyprus. As there were no policies or regulations in place the first part of this questions was answered thoroughly. However, how the lack of legislations affects reuse in general could not be fully clarified, as the results mainly relied on the information gathered through roughly structured open ended questions.

Overall, the sub-questions were largely successful in answering the main research question. However, further research is needed to fully understand the current level of TWW reuse in Nicosia and the specific challenges faced by farmers. Through the use of both qualitative and quantitative data, the study was able to identify a range of factors that impact social acceptance and WTP for TWW among farmers. Additionally, the use of the contingent valuation method provided a structured framework for assessing WTP, and allowed for the examination of how this willingness changes under different hypothetical

scenarios. The selection of three hypothetical scenarios for assessing the WTP was a productive choice, as it enabled a more comprehensive analysis of farmers' attitudes towards TWW reuse. By presenting farmers with different scenarios that varied in terms of the availability of water resources, the quality of the wastewater, and the price being charged, the study was able to identify how these factors influenced their WTP. This provided valuable insights into the challenges and opportunities presented by TWW reuse in Nicosia, and will be useful for policymakers and other stakeholders seeking to implement TWW reuse programs in the region.

However, the study did have several limitations. One potential drawback is the small sample size, which may lead to bias in the results. Given that only 10 farmers were interviewed, it may not be possible to generalize the findings to the larger farming community in Nicosia. Another potential weakness of the study is the lack of clear policies and regulations on wastewater reuse in Northern Cyprus. The lack of a legal framework for TWW reuse may have impacted the willingness of farmers to adopt the technology, and may have influenced their responses in the survey. Overall, while the study did provide valuable insights into the challenges faced by the agricultural reuse of TWW in Nicosia, additional research with a larger sample size and a more robust framework would be needed to fully understand the issue and identify potential solutions.

CHAPTER 6. CONCLUSION

This research aims to identify and evaluate the challenges hindering the effective reuse of TWW in the Haspolat region of Nicosia. This was achieved through studying and evaluating variables affecting farmers' social acceptance and WTP for applying TWW in crop irrigation. The social acceptance is evaluated by identifying variables that affect farmers decision making, through the use of a questionnaire. WTP of farmers was evaluated by using contingent valuation method on three case scenarios. By doing so, the thesis tried to fill a knowledge gap between the technical and social aspects of a TWW reuse project, allowing agricultural managers and water planners to address concerns held by farmers. The research has not analysed the other possible challenges that hinder the effective use. However, additional ideas of interviewed experts and farmers regarding the challenges to the effective reuse of TWW have also been presented. This chapter summarizes the answers to the research questions, provides suggestions for governmental organisations and identifies future research directions.

The data collected in this study suggests that the current level of wastewater reuse in Nicosia is not well understood. While most farmers were aware of the potential benefits of TWW reuse, including the conservation of groundwater resources and the ability to irrigate crops during dry periods, there was a lack of clear policies and regulations in place to guide its use. This lack of legal guidance may have hindered the adoption of TWW reuse among farmers, and may have contributed to the challenges faced in implementing TWW reuse programs in the region. Further research, including a larger study with a more robust framework, would be needed to fully understand the current level of TWW reuse in Nicosia and identify potential solutions to the challenges faced by farmers.

Farmers generally have favourable opinions about TWW usage for irrigational purposes, mainly due to their awareness of water scarcity. However, perceived water quality had no significant effect on their decision-making regarding TWW usage, partly because their perceived environmental and health risks about TWW does not affect humans directly (producing crop only for livestock consumption) and partly because of the availability of other water resources (groundwater). Education and knowledge of water quality and treatment technology significantly impacted social acceptance among farmers. Perceived health risks also significantly impacted farmers' decision-making and social acceptance. However, it was also observed in two interviews that when farmers were presented with water quality tests or information on the treatment technology, their perception of risks fell. Farmers’ practices were significantly influenced by economic values but perceived health and environmental concerns also had an impact. Farmers' values

are usually challenging to alter. However, given that wastewater reuse is beneficial in preserving groundwater resources, there is a chance to encourage them to prioritize pro-environmental attitudes and behaviours. Farmers should recognise the risks and benefits of agricultural reuse of TWW to use the resource effectively; hence information campaigns through mass media and governing bodies are recommended. Moreover, the literature reviewed showed that raising stakeholders' awareness and encouraging farmers' involvement is essential in policy development. It is recommended that the governing bodies incorporate farmers' opinions into their decision-making agenda.

Most farmers are willing to pay for TWW; however, their WTP is less than the amount they currently spend on gas and electricity to withdraw the water from the Kanli River basin or wells. According to the three case scenarios presented to the farmers, the farmers' WTP increases as the availability of water resources decreases and WTP increases as water quality increases, allowing the cultivation of more profitable crops. However, the possibility of cultivating more profitable crops did not affect 70% of farmers' WTP. If the piping project is realised, the water quantity in the river basin will likely decrease significantly, and in this scenario, the farmers' WTP is 1.55 TL/ton. Highly educated farmers (Bachelor's degree or higher) have indicated higher WTP for TWW. Although it has not been evaluated within this thesis, literature shows that the information on wastewater treatment technology can have a significant impact on WTP. Therefore, information campaigns on wastewater treatment technology are recommended as they might positively affect farmers' WTP.

There are no laws or regulations addressing the reuse of TWW in TRNC; according to the interviews, this is one of the main issues which hinder effective reuse in the Haspolat region of Nicosia. It was also remarkable that the results indicate a lack of official regulating bodies and penalties for improper usage; water usage is hugely unregulated in a country facing water scarcity issues. A more comprehensive study with a larger sample size, preferably based on a more quantitative study, is needed to conclude how the lack of regulations affects reuse in the region.

Based on the limitations of this study, future research should consider carrying out field observations, increasing the number of interviews and the duration of the research. A selection-based sampling method was used for farmers, which might have affected the results; a larger sample size with different sampling methods can be recommended for future researchers. Research on identifying factors hindering the effective reuse of wastewater requires a strong understanding of the Region, people and the technology at hand. Such research can be broad, so it would not be possible to study within a single paper and may require a longer time frame. Also, future research should investigate the role of regulating bodies and

authorities and how they can foster crucial information regarding wastewater systems as information and education are among the most significant factors affecting farmers' decision-making.

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Appendix A: Information Sheet

Research Project: Challenges to Wastewater Reuse in Agriculture: The Case Study of Nicosia, Cyprus (TRNC)

Project Information

- The objective of this research is to analyze the main factors influencing the acceptance of wastewater reuse in agriculture and farmers' willingness to pay. This research project will assess the knowledge, motivations, and resources of various actors to determine the factors affecting the reuse of wastewater in Nicosia. There are several possible reasons why wastewater reuse in agriculture is lower than intended such as trust in authorities, ease of access to wastewater canal, knowledge, perceived health and environmental risks, etc. However, there is no empirical knowledge for the case of Nicosia. Such knowledge can be useful to improve the practice of agricultural wastewater reuse in Nicosia and other water-scarce areas, where wastewater reuse is a non-conventional water resource.

- This research project has been reviewed and approved by the University of Twente BMS Ethics Committee, and there are no identifiable risks in participating.

- Should the participant wish to cease participating in the interview, they may do so at any time by informing the researcher.

- No personal information about the participant will be collected or processed. The participant may request access to and rectification or erasure of data or information they deem sensitive by contacting the researcher.

- During the research, the interview information will be recorded and stored on a GDPR-compliant University of Twente Google Drive server. The confidentiality of the participants will be maintained, and no personally identifiable information will be used or stored. Only the researcher and a documented list of individuals will have access to the data on this server. The thesis will be published on the University of Twente website.

- Any recordings will be deleted upon transcription. Written transcripts will be stored on the secured UT Google Drive server until the completion of the thesis.

- Please see the third page for contact details.

Appendix B: Consent Form

Challenges to the Wastewater Reuse in Agriculture: The Case Study of Nicosia treatment plant, Cyprus (TRNC)

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes for taking part in the study	**YES**	**NO**
I have read and understood the study information sheet, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to participate in this study and understand that I can refuse to answer questions and withdraw from the study at any time, without having to give a reason.	☐	☐
I understand that the interviews will be audio recorded, and the audio recordings will be stored until the information is transcribed as text. No personally identifiable information will be requested, and the participants will remain anonymous.	☐	☐
Use of the information in the study I understand that information I provide will be used for a final report on Improving the Social Acceptance of Wastewater Reuse in Agriculture: The Case Study of Nicosia, Cyprus. This interview information will be used to analyse the main factors influencing the acceptance of wastewater reuse in agriculture and based on the findings, make recommendations for a reuse-oriented wastewater policy at the regional level.	☐	☐
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team if I don't agree to do so.	☐	☐
Extra questions for information share policy: I agree that the information I give to the researcher can be quoted in the research outputs	☐	☐
I agree that my real name can be used for quotes	☐	☐
Consent to be Audio/Video Recorded I agree to be audio/video recorded. Yes/no	☐	☐
Future use and reuse of the information by others I agree that my information may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information.	☐	☐
I give the researchers permission to keep my contact information and to contact me for future research projects.	☐	☐

Signatures

_____	_____	_____
Name of participant	Signature	Date
Kaan Redif	_____	_____
Researcher name [printed]	Signature	Date

To the best of my ability, I have accurately read out the information sheet to the potential participant and ensured that the participant understands what they are freely consenting.

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by emailing ethicscommittee-bms@utwente.nl

Appendix C: Questionnaire S1

The following supplementary material is available online at: https://drive.google.com/drive/folders/1B50_z3q2fK7o2fJHVJO2pYNWVfwtdowu?usp=sharing

Appendix D: Water Quality Data S2

The following supplementary material is available online at: https://drive.google.com/drive/folders/1uanF5IBhCH96wbxPt2MAmm2xy8HXVOD-?usp=sharing

Appendix E: Expert Interview Guide

1. Although we have some familiarity with the responsibilities of your organization, in this interview, we would like to get a better sense of the details of your work. Can you briefly describe your role, expertise, and the rules and regulations your organization has to follow related to water or wastewater management?

2. Does your organization have any programs to improve the awareness or acceptance of farmers about wastewater reuse in agriculture?

If no, next question.

If yes: Which topics do these programs include? Such as how wastewater reuse can benefit the farmers, the region, or the country.

Do you think such programs are useful? Why?

3. Do you have any work related to the development of the new wastewater reuse policy? Can you explain your role?

4. In your opinion, what are the main hindrances to the effective reuse of wastewater? How could these hindrances be resolved?

5. Due to climate change and the excessive use of groundwater, which is the most important water source for the island, recharge and discharge balance deterioration of groundwater has occurred. The use of alternative water sources, such as wastewater for irrigation, offers a solution to this problem by potentially decreasing the amount of groundwater withdrawn. Do you think farmers in the Haspolat region are or will be affected by climate change?

If no, next question.

If yes: What are your plans to overcome the problems they face now or in the future?

6. Some studies show that a holistic methodology that enables all stakeholder's opinions to be heard and includes analysis of social factors in the initial stages of the projects is needed to achieve successful implementation. However, there is an opposition to this statement; such involvement usually makes the situation more complex, extending the project start date and causing money and time loss. What do you think about the current level of public involvement in the decision-making process for the delivery of wastewater reuse policy?

7. In your opinion, who is the actor with the most influence on the development of wastewater reuse in TRNC? Why?

8. In your opinion, what would be the situation of wastewater reuse in the future? Why? In your opinion, how should be the situation of wastewater reuse in the future? Why?

9. If I have further questions, can I contact you again?

10. Who else can I / should I interview, do you have their contact details?

11. Would you like to receive a copy of the thesis when it is completed?

Post Interview Comments and/or Observations: