Small is beautiful, and feasible?

Research into the feasibility of a decentralised domestic water provision in the Vietnamese Mekong Delta

by

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Abstract

Land subsidence, mostly caused by groundwater extraction, poses threats to vulnerable deltas. The Vietnamese Mekong Delta is an example of such a delta that faces problems due to groundwater over extraction. However, tackling the problem of groundwater over extraction is not an easy task, since people rely heavily on this fresh water source, of which domestic water use is an important aspect.

This research proposes a decentralised domestic water provision, based on the use of alternative water sources rainwater, stormwater and wastewater, as a solution to diminish groundwater use while keeping domestic water users secure. The feasibility of this proposed solution within the Vietnamese Mekong Delta is researched by defining the motivation and abilities of actors within this area, derived from the social, governmental, economic and technical- geographical conditions that need to be present for the implementation of a decentralised domestic water provision.

An extensive literature study, in-depth interviews in the Netherlands and Vietnam and surveys among households in the Vietnamese Mekong Delta provided the data to assess the presence of these conditions.

It was found that currently, the implementation of a decentralised domestic water provision in the Vietnamese Mekong Delta is not feasible. Important stakeholders lack the motivation to implement this strategy and are not fully capable with regard to governmental, economic and technical aspects. Especially with regard to economic abilities there seem to be problems. Besides, a lack in coordination between governmental departments and involvement from stakeholders pose problems for the implementation of a decentralised domestic water provision. Furthermore, some geographical conditions hamper the uptake of this solution.

Therefore, this research recommends to enhance the knowledge on groundwater extraction in the Vietnamese Mekong Delta, to stimulate the motivation among actors and design solutions that help the uptake of a decentralised domestic water provision. Furthermore, finances and coordination between governmental departments should be better aligned to enhance the success of development plans in the future. Researchers should keep researching the Vietnamese Mekong Delta to map groundwater problems and assist in the formulation of adaptation plans to water pollution and climate change in order to ensure a sustainable development of the Vietnamese Mekong Delta.

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Abbreviations and Acronyms

CANTHOWASSCO	Can Tho Water Supply and Sewerage Company
CDWP	Centralised Domestic Water Provision
CERWASS	Centre of Clean Water and Sanitation
DARD	Department of Agriculture and Rural Development
DDWP	Decentralised Domestic Water Provision
DONRE	Department of Natural Resources and Environment
MARD	Ministry of Agriculture and Rural Development
MDP	Mekong Delta Plan
MONRE	Ministry of Natural Resources and Environment
RWH	Rainwater Harvesting
RWST	Rainwater Storage Tank
SWC	Stormwater Catchment
VMD	Vietnamese Mekong Delta
WWT	Wastewater Treatment

Chapter 1: Introduction

1.1 Problem Definition: groundwater overexploitation in a context of water insecurity

Land subsidence, the lowering of the land surface due to changes underground, can pose threats to human society, especially in low-lying regions as deltas, which commonly inhabit large populations. While causes for land subsidence can either be natural or anthropogenic, one of the most common human-induced causes for land subsidence is the extraction of groundwater (Bakr, 2015). The extraction of groundwater causes changes to aquifer systems, which can be of an elastic (reversable) character, or, when the groundwater is over extracted and critical limits are exceeded, this extraction can lead to aquifer compaction. This aquifer compaction leads to the subsidence to land and/or ground failures such as earthquakes (Galloway & Burbey, 2011; Galloway, Erkens, Kuniansky, & Rowland, 2016). This (human-induced) land subsidence poses several threats to sinking deltas, such as floods, infrastructure loss and saltwater intrusion. The latter poses threats to human fresh water sources, used for economic- or domestic purposes, and further accelerates land subsidence as well: salt ions can react chemically with sediments in the ground, making the area more prone to oxidation and compaction, resulting in the subsidence of land (Schmidt, 2015).

It is thus evident that the problem of subsiding deltas need to be tackled. However, diminishing the use of groundwater resources is not an easy task, due to the human as well as ecological dependency on this water source. Around 20% of the global fresh water need is met by groundwater, used for domestic, industrial as well as agricultural purposes (Jakeman, Hunt, Barreteau, Andrew, & Rinaudo, 2016). Furthermore, the demand on fresh water resources has increased tremendously in the past decades and is expected to continue to rise in the future. Some see this as one of the biggest challenges for the sustainable development of communities, since water scarcity or water stress, which is defined by the ratio of the demand of fresh water in comparison to the availability of fresh water, is already evident in some places (Grafton, 2017). It seems that the linkage between groundwater overexploitation and land subsidence is thus a wicked problem: the problem cross-cuts boundaries between other global challenges. This can especially be said for the continent of Asia, where the water stress is the highest (Grafton, 2017), while also more than half of the world its most vulnerable deltas are situated here (Schmidt, 2015).

One of such vulnerable deltas is the Vietnamese Mekong Delta (VMD), located in the South-West of Vietnam, which is subsiding as a consequence of groundwater overexploitation. The delta covers an area of 39,000 km^2 and inhabits approximately 17.6 million people (Ha, Dieperink, Dang Tri, Otter, & Hoekstra, 2018). After Vietnam its transition to a market economy in 1986, a massive cultivation, urbanisation and industrialisation took place in the delta. With surface water often being polluted or saline, the demands on fresh groundwater increased tremendously. In 1991, groundwater levels were similar to natural levels, but in the past 25 years the increasing demand on this water sources caused aquifer compaction and the delta to sink (Minderhoud et al., 2017). Surface water sources in the delta have been impacted by foreign policies, since big rivers, such as the Mekong, originate in other countries. These countries, for example China, change the water availability in the VMD due to water measures as policies and dam constructions, this has impacted the aqua- and agricultural conditions in the VMD and affected the sediment budget and flood frequency. It is calculated that the VMD on itself is not under water stress yet, due to the huge availability of surface water, however, the trans-political water management issues may pose the delta to severe water stress in the future (Ngo, Le, Tuyen, & Luong, 2018). Furthermore, the pressure on fresh water sources is heightened within the delta as well. Surface water quality of the canals and rivers decreases due to microbial, organic, ammonia and nitrate contamination while

groundwater faces pollution by heavy metals and arsenic. Besides, the drinking water sources surface water, groundwater and rainwater all face pollution by pesticides (Chau, Sebesvari, Amelung, & Renaud, 2015). Due to the demands of these water sources this can pose real problems in the future. Especially combined with the problems caused by groundwater over extraction, which is an important water source for drinking water sources. It is therefore evident that new measures are needed that control the groundwater use, in order to limit land subsidence and secure water availability. This research focuses on such measures.

1.2 Previous research and knowledge gap: linking land subsidence to water provision

The Mekong Delta Plan (MDP), a strategy plan to tackle problems relating to the sinking and urbanising delta, states the importance of shifting from groundwater to surface water use (Kingdom of the Netherlands & Socialist Republic of Vietnam, 2013). Furthermore, numerous studies have linked the groundwater use to land subsidence, tried to map the size of this problems (Erban, Gorelick, & Howard, 2014; P. Minderhoud et al., 2017; P. S. J. Minderhoud et al., 2018a, 2018b) and/or proposed strategies to diminish (consequences of) groundwater extraction, i.e. the building of dikes and the adaptation of alternative strategies (Duc Tran et al., 2018; Ha et al., 2018; Witjes, 2018). Furthermore, in the use of groundwater for domestic purposes, water demand, water supply and/or health issues due to groundwater quality are widely studied (Herbst et al., 2009; Kotsila & Subramanian Saravanan, 2017; Li, Li, & Wichelns, 2016; J. Spencer, 2007; J. H. Spencer, 2008b, 2008c, 2008a; Wilbers, Sebesvari, & Renaud, 2014).

However, groundwater governance usually gets less attention compared to surface water governance (Hoogesteger & Wester, 2015; Ross & Martinez-Santos, 2010). This is mainly due to the ecological characteristics of groundwater: it is less visible and the hydrological boundaries are diffuse, therefore it is harder to track than surface water, and the social-economic characteristics of groundwater: there often is an economic investment and it has an individualistic character, water is mostly extracted through private wells, this makes it harder to regulate (Hoogesteger & Wester, 2015; Ross & Martinez-Santos, 2010). Effective (ground) water governance is an important challenge to create long-term sustainability and the improvement of water governance means the improvement of water security (Villholth & Conti, 2018). However, when looking at the current state of water security regarding the domestic water provision in the VMD, we can see that this faces problems as well, mainly with accessibility and management of the provided piped water (Wilbers et al., 2014). A study by Wilbers et al. (2014) stated that the piped water supply in the rural areas of the VMD is insufficient and should be complemented by alternative measures, of which a decentralised domestic water provision (DDWP) could be an option (Wilbers et al., 2014).

This DDWP is the opponent of the commonly used centralised domestic water provision (CDWP). In a CDWP, water is transported from remoter areas to urbanized areas through large-scale pipe networks that are connected to water treatment facilities (Sharma, Burn, Gardner, & Gregory, 2010), whereas in a DDWP, wastewater and stormwater is provided, and possibly treated, at the local scale (Domènech, 2011; Neumann, Nguyen, Moglia, Cook, & Lipkin, 2011; A. Sharma et al., 2010). This DDWP is mainly constructed on-site or has a clustered form (for example for multiple houses in a neighbourhood) (Sharma, Tjandraatmadja, Cook, & Gardner, 2013). The use of this decentralised form gains more recognition due to the expected environmental benefits, of which the diminishment of groundwater use (Pandiyaraja, Shrinithivihahshini, & Chithra Devi, 2013) or other problems related to sinking deltas, such as land subsidence, are recognized (Schuetze & Chelleri, 2013). Therefore, this strategy may pose a solution to the use of groundwater over extraction and the accompanying problem of land subsidence. However, a study assessing the

feasibility of DDWP in the VMD, in order to diminish the groundwater use and enhance the water provision in the area, is missing. This research tries to fill this gap.

1.3 Research aim and research questions

The aim of this research is 'to explore the feasibility of a decentralised water provision in the Vietnamese Mekong Delta, in order to improve the water security and diminish the pressure on groundwater sources, and to provide a list of government recommendations based on the feasibility that helps to tackle the problem of land subsidence'. In order to reach this aim, the following research question is guiding for this research:

'To what extent is it feasible to implement a decentralised domestic water provision in the Vietnamese Mekong Delta in order to diminish groundwater extraction?'

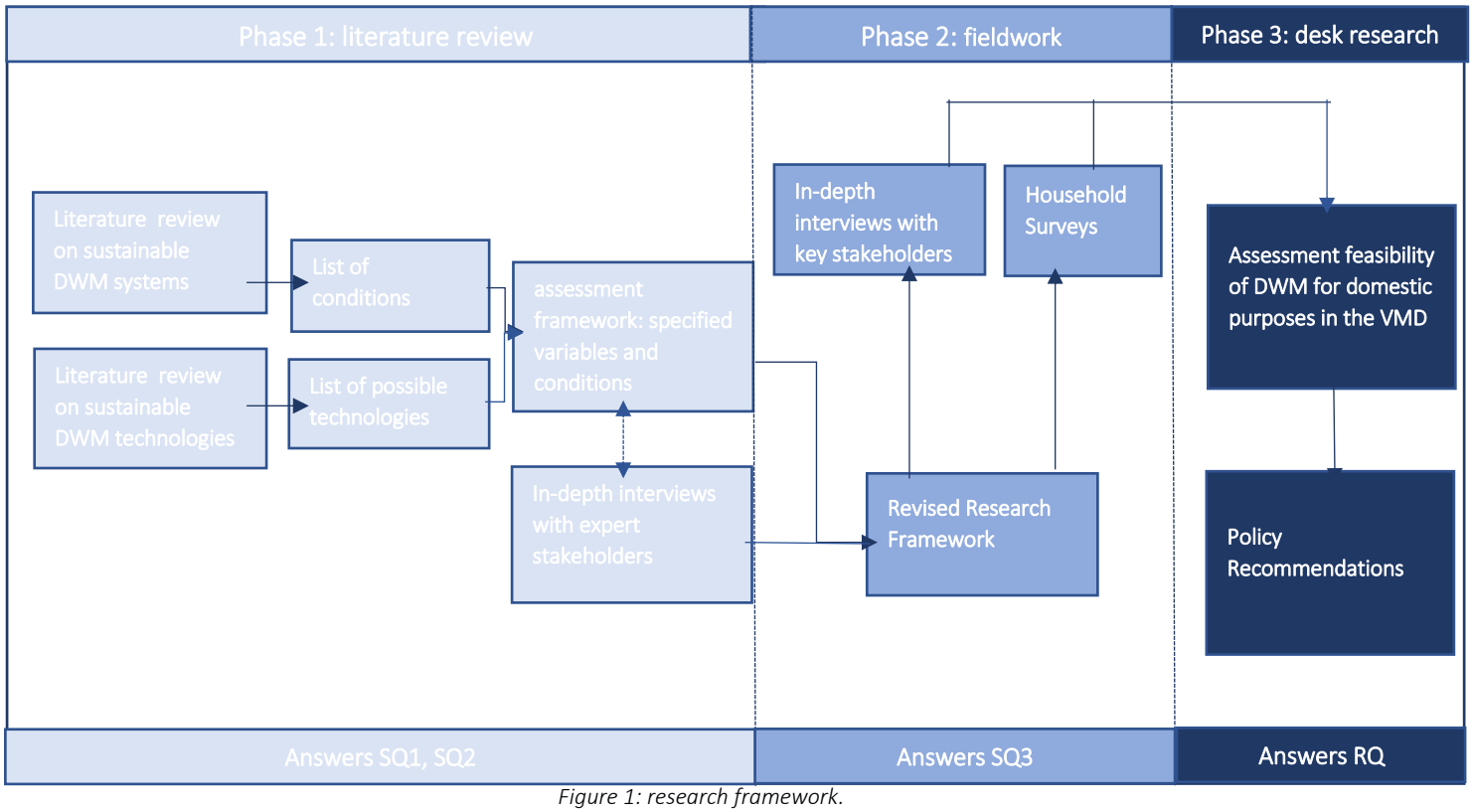

Figure 1: research framework.

Figure 1 shows the research framework that guides this research and is used to answer the research question. The research is divided into three phases. Phase one takes place in the Netherlands and starts with an extensive literature review on a DDWP and on DDWP technologies. This in-depth literature review results in a list of conditions needed for a DDWP, which forms the bases for the creation of an assessment framework to research the feasibility of a DDWP in the VMD. Furthermore, semi-structured interviews with experts in the Netherlands were held, to broaden the understanding of DDWPs and validate and enhance the assessment framework. More information on these interviews can be found in chapter 3. This revised research framework is guiding for phase two, that takes place in Vietnam. Here, interviews with governance agencies and surveys among households provided a set of data that is used to test the feasibility of a DDWP in the VMD. The latter is done in phase three, that again takes place in the Netherlands. Here, the data is analysed, the answer to the main research question is given and policy recommendations are formulated.

The following sub-questions are formulated that further help to structure the research, figure 1 shows the research phase in which they are answered:

1. What alternative water sources for a decentralised domestic water provision can be used, as can be derived from literature?
2. Which conditions for these water sources and a decentralised domestic water provision need to be present, as can be derived from literature and expert interviews, in order to successfully implement this strategy?
3. To what extent are the conditions for these conditions present in the Vietnamese Mekong Delta?

1.4 Outline of the thesis

This thesis is outlined as follows. The previous chapter provided the problem definition, research questions and research framework that are guiding for this research. The next chapter (chapter 2) consists of a theoretical background where the concept of a DDWP is further elaborated, the alternative water sources are explained and the conditions needed for both these aspects are outlined. Chapter 3 contains the assessment framework, an elaboration on the research area and the methodological approaches chosen to collect the data. The following chapters then contain the results based on the social conditions (chapter 4), the governmental conditions (chapter 5), the economic conditions (chapter 6) and the technical- and geographical conditions (chapter 7) needed for the implementation of a DDWP. Chapter 8 wraps up the research and consists of the conclusion, limitations of the research and policy recommendation for the uptake of a DDWP.

Chapter 2: towards a conceptualisation of decentralised domestic water provision

2.1 Introduction

In this chapter, the theory behind a DDWP is further elaborated on. Furthermore, it will provide certain requirements that are, according to scholars in the field of DDWP, needed in order to successfully implement a DDWP. This information and the conceptual framework made according to this research was validated and complemented by interviews with Dutch Experts on decentralised domestic water provision systems or the VMD. During this chapter, these Dutch experts are referred to as DE1-DE5. More information on these interviews can be found in chapter 3.2.

2.2 Decentralised domestic water provision: context and possibilities

In modern societies, a CDWP has been of critical importance. Due to health concerns, capital accumulation and political control over the use of local water sources this provision strategy became necessary and had an improved water quality as main benefit (Domènech, 2011; Sharma et al., 2010). However, as explained in chapter 1.2, the opponent of this system, a DDWP, has gained more attention. The reason for this increasing interest is the global trend of rapid urbanization, that puts pressure on the CDWP, and the belief that a DDWP can provide certain environmental benefits (Burn, Maheepala, & Sharma, 2012). Tackling problems as groundwater over extraction and land subsidence were already mentioned earlier in this research. However, more environmental benefits can be subscribed to a DDWP.

Firstly, a DDWP can increase the climate resilience of a city or country. Among some scholars, there is the belief that the current CDWP cannot respond to pressures posed by ageing infrastructure, rapid urbanization, environmental change, population growth and climate variability (Quezada, Walton, & Sharma, 2016). It is expected that a DDWP is more flexible and therefore contains a greater responsiveness to local conditions (Carlitz, 2017) and a greater spread of risk during extreme events as drought (Capodaglio, 2017). Secondly, a DDWP can strengthen local communities. Due to the management on local scale, residents become more involved in the management of water resources. This diminishes alienation to water management, increases public participation and enhances environmental awareness among citizens. Furthermore, a DDWP offers a fit-for-purpose solution: since different water uses require different water quality levels, the treatment of the water source can be done according to its purpose. This also makes the reuse of water easier and thus diminishes the pressure on natural water sources (Domènech, 2011; Moglia, Cook, Sharma, & Burn, 2011; A. Sharma et al., 2010).

When trying to implement a DDWP, a wide range of possibilities is possible that are defined by the local conditions of an area. Even though the implementation from the system mostly has the incentive of a governance agency, such as the government or a non-governmental organization, the management of a DDWP can either be communal, governmental or private (Bédécarrats, Lafuente-Sampietro, Leménager, & Sowa, 2016). Furthermore, in a DDWP different alternative water sources (as an opposite to the water resource that one would like to reduce pressure on) can be used. However, generally, the use of rainwater, stormwater and wastewater, including greywater recycling, is most common (Burn et al., 2012).

2.3 The use of rainwater

In the use of rainwater, one speaks about rainwater harvesting (RWH). RWH is a method of inducing, collecting, storing and conserving local surface runoff for subsequent use (Rahman, 2017). The main advantage of RWH is the direct provision to households, giving them full control of their water sources (Naddeo, Scannapieco, & Belgiorno, 2013). The rainwater collection area can be expanded when needed and the time of use of the water source is controlled (Zhu, Gould, Li, & Chengxiang, 2015). Furthermore, it is a relatively clean water source and seen as sustainable, since the water source closes the hydrological cycle and recharges natural water sources (Czarny, Präbst, Spinnler, Biek, & Sattelmayer, 2017; Zhu et al., 2015). A RWH system is an integrated system, that consists of three components: the rainwater collection subsystem, the rainwater storage subsystem and the rainwater supply subsystem (see figure 2). The rainwater collection subsystem is the water source and includes rainwater collection surfaces and interception, collection and conveyance ditches. There are three types of rainwater collection subsystems: natural surfaces, less permeable surfaces or existing structures and purpose built catchments. Roofs are an example of the second category and are widely used to capture rainwater. Other examples of collection fields may be courtyards, (paved) roads, purpose built catchments etc. The water storage subsystem has as purpose to store the rainwater, ideally in the wet season so the water can be used during the dry season. The water supply subsystem consists for the supply of water for domestic purposes, irrigation or other production uses (Zhu et al., 2015). Generally, RWH technologies capture rainwater for domestic use (Andrukonis, Foster, Henriques, & Wildfire, 2010), which will be the main focus of this research as well. However, the reuse of rainwater for other purposes is not excluded.

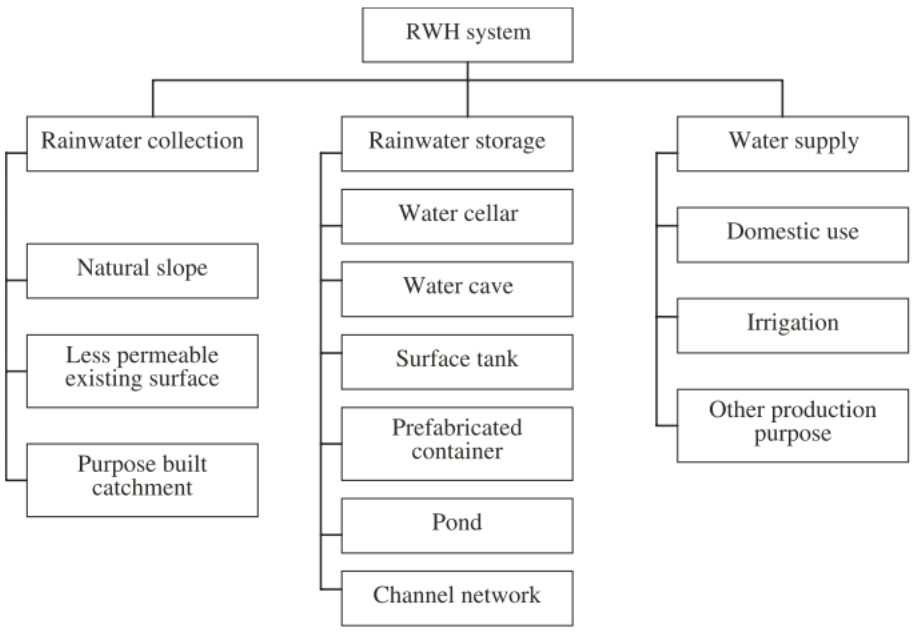

Figure 2: schematic overview of a rainwater harvesting system. Source: (Zhu et al., 2015)

The technology for RWH is overall relatively cheap and accessible (Zhu et al., 2015). The main cost for RWH lies in the water storage subsystem, which is mostly done in storage tanks. Especially in domestic use, if the roof is used as catchment area, it may even be the only cost for RWH (Zhu et al., 2015).

Generally, rainwater storage tanks (RWST) can be divided into three categories: surface-, subsurface- and underground storage tanks (Kahinda, Taigbenu, & Boroto, 2007; Zhu et al., 2015). For any sort of tank it is important that the tank is watertight, durable, watertight and will not contaminate the water. Since the water storage structure is the highest expense in the RWH, there is the need for careful selection design (Zhu et al., 2015). Below, a more in-depth discussion on the RWST categories, and certain conditions that need to be present for their implementation, are discussed.

Surface and subsurface RWST can be made of a wide range of materials, such as plastic, ferro-cement, wood or stainless steel. The main advantage off surface tanks in relation to subsurface tanks is the possibility to easily extract water through a tap. However, they usually are more expensive (Zhu et al., 2015). For both RWST, certain conditions apply. For surface tanks, it is important that the tanks contain a sufficient closing to prevent contamination from mosquitos and algae (Aladenola, 2010; Zhu et al., 2015). For both tanks it is necessary that the rainwater collection system (for surface tanks mostly roofs) need to be sufficient for enough water runoff and should not contain materials that cause contamination of the water (Aladenola, 2010; DE5; Kahinda et al., 2007; Zhu et al., 2015). For subsurface tanks, it is important that there is the room for extra measures for the installation of the tank. Due to the external pressure of groundwater and soil on the tank, the tank floats if the internal pressure from the water inside the tank is taken away. Therefore, there must be careful consideration in the placement of the tank, preferably not in an area with a too high water table. Furthermore, the ground around the subsurface tank must always be heightened in order to prevent pressure from surface water and there must be the effort to keep the tank filled with water to diminish these problems. Their main advantages are that they are cheaper and need less space than surface RWST. However, most of the time, an extraction method, such as a pump, is needed to extract the water from the subsurface tank (Zhu et al., 2015). The main advantage of underground RWST, is that the water is kept cool and that they are usually covered. This reduces the risk to contamination (Zhu et al., 2015). However, the implementation costs can be higher due to excavation and the water is not safe to use as drinking water when the RWST is filled with runoff from the ground surface (Kahinda et al., 2007; Zhu et al., 2015). Underground storage tanks cannot be implemented when the water table is high and different types of underground storage tanks only function with certain soil types (Zhu et al., 2015). When choosing the right type of RWST, certain general conditions are of importance as well. These include the amount of rainwater that is required for storage, the type and size of the catchment area, the rainfall amount and availability, the soil type and its permeability, the availability and costs of the construction materials, the affordability of the population and the local skills available in the area (Kahinda et al., 2007; Zhu et al., 2015). These conditions will be taken into account later in this research.

RWH is thus a relative cheap form of a DDWP. However, there are some limitations apparent in RWH systems. Firstly, there is a high dependency on the rainfall. Second, there is uncertainty in precipitations and thirdly, the quality of the rainwater can differ (Naddeo et al., 2013). Furthermore, in some cases the rainwater has to be purified before it can be used as drinking water source [DE5].

2.4 The use of stormwater

Stormwater is a similar water source compared to rainwater. However, the harvesting of stormwater (referred to as stormwater catchment (SWC)) differs on two principles: firstly, it is the (rain) water from a storm, so more excessive, and secondly, the water is not collected directly or through roofs, but through (street) gullies, private and public drainage systems, inlets from paved and unpaved infrastructure, connection through sewage systems etc. (Göbel, Dierkes, & Coldewey, 2007). The catchment areas can differ in type and size, however, due to the contact with the ground, it is usually contaminated with organic (ranging from twigs to animal faeces) and inorganic materials (that were laying on the top soil) (Oladoja & Hasan, 2008). Historically, there was a focus on reducing stormwater

due to flood risk. Currently, more benefits are seen: storing stormwater can contribute to an ecosystem its health and the water is useable for non-potable purposes. Since it can be stored near the point of generation and use (Jenkins, Greenway, & Polson, 2012) it is fitting for a DDWP.

However, for SWC areas to be effective, there needs to be a sufficient amount of stormwater runoff, which is determined by the amount of impervious surfaces in the area. If there is, a stormwater harvesting system consists of six components: a collection-, treatment-, storage-, environmental- and distribution component (Mitchell et al., 2006). Since the treatment of stormwater is consistent with the treatment technologies in chapter 2.5, this subchapter will only focus on the collection (which is in some cases the same as storage) component. Stormwater can be collected through traditional gullies and pipes, which are mostly connected to the sewer and then transported to the catchment area, or in more nature based solutions as raingardens, ponds or wetlands (American Organization of Civil Engineers, 2007; Mitchell et al., 2006). Since there is already the knowledge that the rural districts of Can Tho do not have an elaborate sewage system, this research focuses on the latter. For the implementation of these systems, enough space is needed.

2.5 The use of wastewater

In city districts with a non-urban character, important provisions often lack behind. When there are already important facilities in place, such as water and sanitation, wastewater treatment (WWT) facilities are often still non-existent. Therefore, wastewater is often untreated disposed to the open ground and surface water, which increases human contact with contaminants, the spread of diseases and contamination of groundwater resources. For example, contaminated surface water brings faeces to the surface in case of floods and mosquitos and other pests breed in ponds and blocked drains. This is especially the case when piped water is supplied before an adequate drainage infrastructure is installed. Furthermore, untreated wastewater can be reused by farmers for irrigation and the consumption of these crops can cause serious health risks to the consumer (Parkinson & Tayler, 2003). As a response to these problems, the use of decentralised WWT for these areas has gained attention over the years (Parkinson & Tayler, 2003). In decentralised WWT, relatively small volumes of wastewater are treated and disposed near or at the source, usually serving single or multiple (cluster) households (Capodaglio, 2017).

Wastewater can include agricultural, industrial or domestic wastewater. Domestic wastewater consists of multiple colours. Black wastewater is a mixture of urine and faeces, yellow wastewater consists of separately collected urine, while brown wastewater only includes faeces. The last category within domestic wastewater is greywater, which is the wastewater produced in a domestic setting without excreta (Domènech, 2011). Separation of these wastewater streams can help in efficiently using the water source. Mostly, the wastewater streams are already made separately, thus only the catchment needs to be separately as well. For example, when yellow and black wastewater is stored in a container like a sceptic tank while greywater is kept separately, the latter can be reused for other purposes such as irrigation with little or no treatment due to the lesser amount of contaminants present in this stream (Parkinson & Tayler, 2003).

Before the use of wastewater, treatment of this water source is needed. A wide range of technologies is available for this treatment, ranging from low-tech cheaper options to high-tech more expensive options. Due to the scope of this research not all of these technologies will be further elaborated on, instead an explanation will be given on some main treatment categories: aerobic or anaerobic treatment, natural treatment systems, unnatural treatment systems or a combination of the latter.

Biological treatment, through aerobic or anaerobic processes, is a promising, cost-effective treatment option that has no secondary pollution. In aerobic treatment free or dissolved oxygen by micro-

organisms (aerobes) is used to converse organic waste into biomass and CO2. In contrast, anaerobic treatment degrades organic wastes into methane, CO2 and H20 without the use of oxygen (Chan, Chong, Law, & Hassell, 2009). Furthermore, a distinction can be made between natural and unnatural systems. In natural systems, organic components are used to treat the wastewater. An example is the use of soil to filter wastewater, such as in constructed wetlands. Unnatural, man-made, systems has a lot of variety in options, such as membrane technology or point-of-use filters (Nhapi, 2004; Patterson et al., 2010; van Afferden, Cardona, Lee, Subah, & Müller, 2015). It is also possible to combine different systems in order to increase efficiency and cost-effectiveness, a fit-for-purpose approach is of importance here: what is the water use and which water quality standards are needed for this use? Water used for irrigation, for example, has less quality standards than water for drinking water purposes. However, within agricultural purposes there are further distinctions between crops for food consumption or non-consumption crops etc. [DE2].

2.6 Conditions for a decentralised domestic water provision

A transition to a DDWP can find some difficulties, such as sunk costs, perceived risks and resistance from stakeholders with a stake in a CDWP (Domènech, 2011). Therefore it is important to develop a cohesive framework to assess the feasibility of a DDWP and formulate policy strategies or recommendations (Moglia et al., 2012; A. Sharma et al., 2010). In order to develop such a framework, a focus on social-, governmental-, economic-, technological- and geographical conditions that define the feasibility of a DDWP, is needed.

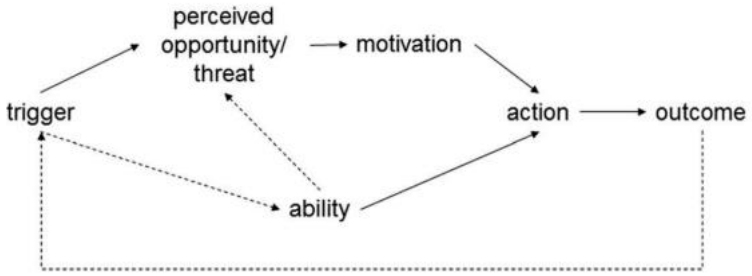

Figure 3: conceptual framework of the MOTA framework. Source: (Phi, Hermans, Douven, Van Halsema, & Khan, 2015)

The focus on these specifics categories is underlined by the MOTA-framework (see figure 3) (DE4; Phi, Hermans, Douven, Van Halsema, & Khan, 2015). In this model, the proposed action, in this case the implementation of a DDWP, is the outcome of the motivation and the ability of the involved actors (Phi et al., 2015). In other words: for the implementation of a DDWP to be feasible, there should be a sufficient motivation and ability. This can be enhanced through a trigger, such as an environmental disaster. In the precondition motivation, it is assumed that an actor is more likely to take action, when the actor is motivated to do so (Phi et al., 2015). In the later proposed assessment framework, this motivation is linked to the social conditions for a DDWP. More information can be found in chapter 2.6.1.

The precondition ability can be defined as the capacity of an actor to take certain actions, which derives of its access to certain resources. Within the MOTA framework, the ability is defined as the institutional-, financial- and technical abilities of actors (Phi et al., 2015). This coincides with the focus on governmental-, economic and technological- conditions in the later proposed assessment framework in this research. However, due to the emphasis on local conditions in a DDWP (see chapter 2.2), the category geographical conditions is added. A further explanation of the governmental-, economic-, technical- and geographical conditions is provided in subchapters 2.6.2-2.6.4.

2.6.1 Social conditions for a decentralised domestic water provision

When implementing sustainable measures in a community, such as a DDWP, embedded habits and socio-cultural aspects among water users in the community are of importance in defining the success or failure of the proposed measure (Fam, Mitchell, & Abeysuriya, 2014). However, choices made in a community are not always made realistically, more often they are defined by emotions, perceptions (Mankad, 2012) and motivations [DE4]. Therefore, the acceptance of actors is one of the most decisive factors in the feasibility of a DDWP adoption (DE4; Kamal, Goyer, Koottatep, & Amin, 2008; Mankad, 2012; Mankad & Tapsuwan, 2011). In the case of a DDWP these aspects are made up of the perceptions of threats and risk (DE2; Mankad, 2012). The latter two definitions may need some further elaboration.

The psychological definition of risk is defined as the expected probability and value of a future threatening event. In DDWP literature, risk is defined as 'the negative outcomes that may come when choosing to adopt a decentralised domestic water provision system' (p. 133, Mankad, 2012). Threat is similar to risk and can be defined as 'a negative event which directly influences an individual, their family, friends or their way of life' (p. 136, Mankad, 2012). However, the two concepts differ on an important aspect: whereas risk is often a consequence of an action made, a threat is harder to control. Nonetheless, it can define the risk you are willing to take (Mankad, 2012). I.e., the threat in the VMD is the land subsidence in the area while the risk could be to adopt a DDWP to diminish the use of groundwater and try to stop this threat.

In the case of adopting a DDWP three aspects are of importance in this risk and threat perception. For the latter, knowledge of the water issues affecting the region (i.e. the threat) is of importance (Mankad, 2012). People who think that they live in an area prone to threats, are more likely motivated to adopt measures to prevent this threat (Phi et al., 2015). In the case of risk perception, two additional aspects are of importance. First, familiarity with alternative water sources or measures can decrease the perception of risk and thus increase the public acceptance, i.e. if you do not know something you are less likely to use it. Secondly, the perception of water quality is of utter importance since people do not want to compromise their health when adopting a new water system (Mankad, 2012).

2.6.2 governance conditions for a decentralised domestic water provision

Urban planning to enhance the resilience to climate change and population growth, especially on the aspect of sustainable water management, is an increasing challenge for this century (Wong & Brown, 2009). Furthermore, deficiencies within governmental departments seem hampering for the uptake of decentralised (waste) water management in developing countries (Kamal et al., 2008). Hence, government- and governance conditions are of vital importance for the uptake of a DDWP. Especially since, as is stated in chapter 2.2, governance agencies commonly give the incentive to adapt to a DDWP. The governance conditions can be divided into institutional conditions and stakeholder engagement (Witjes, 2018).

The institutional conditions are derived from the formal institutional abilities, such as laws and regulations (Phi et al., 2015) and interaction among institutional departments (Moglia et al., 2011). First of all, there should be an institutional framework that allows for the implementation of a DDWP, i.e. the presence of laws and policies that do not hamper the adoption of a DDWP. A lack in policies and legislation can negatively affect the uptake of water management measures (Mankad & Tapsuwan, 2011). Secondly, there should be cooperation between different departments that work on the domestic water provision with limited power struggles between departments (Kamal et al., 2008; Moglia et al., 2011). Thirdly, a DDWP has more chances to succeed if there is a collaboration present, that can successfully implement these measures, for example a collaboration between knowledge institutes, water companies and the government [DE5]. Furthermore, the engagement of stakeholders can enhance the feasibility of a DDWP adoption. In the decision making of stakeholders, the information they possess directly influences the decision (Mankad, 2012). Therefore, the government should

communicate about the drivers behind their policies (Witjes, 2018) and engage stakeholders in the planning and development of a DDWP or the policies relating to this aspect (Chelleri, Schuetze, & Salvati, 2015).

2.6.3 Economic conditions for a decentralised domestic water provision

Financial constraints are seen as a considerable constraint to the implementation of a DDWP (Mankad, 2012). Furthermore, limitations in finance seem a limitation for the implementation of sustainable water measures in the VMD (Witjes, 2018). However, research has showed that a DDWP can actually be more economically viable than a CDWP. Especially when low-cost technologies are used, such as partially natural systems (DE3; Nhapi, 2004).

However, some economic aspects are still of importance. First, there should be enough financial capital in the area to implement, operate and maintain a DDWP (DE5; Witjes, 2018). One is only able to implement an action when there is enough money available (Phi et al., 2015). Secondly, when there is enough financial capital, there should also be a willingness to pay among the implementers and users of a DDWP to make the measure viable (Mankad & Tapsuwan, 2011). A project into the possibility of a DDWP in India was cancelled, because an analysis among the community indicated that people did not have a high enough willingness to pay for technologies that improved their water quality. It was indicated that if people had more money, they would rather spend this on a new television or cell phone, since they were used to the water quality not being high [DE1]. Furthermore, in defining the implementation of sustainable measures and their costs, externalities should be taken in to account. In externalities, not only costs, but also social and environmental benefits are taken into account when making a financial decision (Mankad & Tapsuwan, 2011).

2.6.4 Technical and geographical conditions for a decentralised domestic water provision

Technical conditions refer to skills and equipment that are needed to implement the action (Phi et al., 2015). A DDWP and the used water sources within this DDWP comes with a wide range of different possibilities and technologies. It is important that the DDWP has a sustainable character to release the pressure on natural resources, makes a reuse of water possible (Gikas & Tchobanoglous, 2009) and does not impose the natural resources to further pollution. Especially in the use of (black) wastewater nitrates and metals present in the water source can further pollute groundwater resources (Nhapi, 2004; Pandiyaraja et al., 2013). Furthermore, within these wide possibilities of technologies it is important that, especially for the use in developing countries, the operation and maintenance of the technologies is simple in order to ensure that the local community can effectively use their DDWP (Brunner et al., 2018). However, these considerations should be taken into account when actually designing and implementing a DDWP. In researching the feasibility some more general remarks can be made. Nonetheless of knowing which technologies are going to be used, it is of importance that there should be technological equipment available for the VMD (DE5; Phi et al., 2015; Witjes, 2018). This chance can be increased when choosing simple technologies, but at least for the most simple forms getting equipment should be viable. Furthermore, there should be a sufficient amount of people with the right knowledge and skills available for the implementation of a DDWP (Phi et al., 2015; Witjes, 2018).

Furthermore, the geographical conditions of the area are of importance in implementing a DDWP, especially due to its flexibility per local area this should not be overlooked (Brunner et al., 2018). The conditions needed for the alternative water resources use and their technologies were explained in chapter 2.3-2.5 and can be summarized as ‘the geographical conditions of the area are sufficient for the implementation of decentralised system’. Under this condition necessities as space, collection systems (such as sufficient rooftops for rainwater harvesting) and rainwater availability can be included.

2.8 Conclusion

This chapter elaborated on the theory behind a DDWP, the used alternative water sources within this system and its requirements. In order to assess the feasibility of a DDWP in the VMD these findings have to be translated into an assessment framework with specific conditions. The following chapter will provide this framework, the methodological choices used for assessing the presence of the conditions in this framework and further elaborate on the case study area.

Chapter 3: Methodology

3.1 Introduction

This chapter provides an elaboration on the used methodologies and research methods that were used to carry out this research. It will provide the assessment framework, as based on the information given in chapter 2, that is used to assess the feasibility of a DDWP in the VMD and the research methods used to gather the data to apply this framework. Furthermore, the research area is described.

3.2 The creation of an assessment framework

A feasibility study is mostly defined as an 'evaluation or analysis of the potential impact of a proposed project or program' (p. 264., Urkiaga et al., 2005). It is conducted to assist policy makers in deciding whether or not to implement a policy, project or programme (Urkiaga et al., 2005). This research coincides with the proposed aim of a feasibility by Urkiaga et al. (2005). However, in its definition it differs on an important aspect: this research does not research the impact of the proposed programme, a DDWP, but analyses whether a DDWP is suitable for the VMD. In order to assess this, the feasibility study is complemented with a case study (the application of the chosen option in a feasibility study (Urkiaga et al., 2005)) that assesses the feasibility of a DDWP in the VMD. More information on the case study area can be found in chapter 3.3.

In order to assess the feasibility of a DDWP, an assessment framework is created (see table 1, 2, 3 and 4). This assessment framework consists of certain conditions that need to present in order for an area to be suitable for a DDWP. The framework is partially based on the MOTA framework, where it is assumed that a presence of motivation (social conditions) and abilities (governance-, economic-, technical- and geographical conditions) defines the successful implementation of a policy plan. Thus, it is assumed that the more conditions are present, the more likely it is to successfully implement a DDWP. However, as the discrepancy of the amount of categories between the motivational aspect and the ability aspect suggests, the two variables do not have the same weight. For the motivation, only one condition category is assessed, while for the ability four condition categories are analysed. This means, that the motivational side is quicker to be succeed or fail than the ability side. The reason for this is, that even when you are capable (or not capable) to implement a certain plan, it will probably still not be implemented if there is no motivation to do so (and the other way around) (Phi et al., 2015).

It is important to note, that even though the assessment framework is partially based on the MOTA framework, it differs on two important aspects. Firstly, the MOTA framework is a general framework for policy plan implementation, while the proposed framework in this research is based on an extensive literature review focused on a DDWP. It is thus specialized on one specific topic. Furthermore, while the MOTA framework assesses the motivation and abilities through a quantitative analysis (Phi et al., 2015), the proposed framework in this framework is based on a qualitative analysis. The presence of conditions in the framework will be given a score that indicates their presence: -/- (condition not present), +/- (condition partially present) or +/+ (condition present). For each condition the score will be given per actor group (see chapter 3.4 and 3.5), with an exception of the government conditions that will only contain an overall score. The reason for this is, that due to information sensibility within the top-down governance structure in Vietnam, literature study is the main focus for this condition while the other research methods have a complementary function. Furthermore, the households were not directly asked about governmental conditions. Table 1, 2, 3 and 4 define the used research method per condition to define this score. A further elaboration on the these methods can be found in chapter 3.4 and 3.5.

	Social conditions			
Motivation	*Variable*	*Condition*	*Source*	*Data collection method*
	Threat perception	There is sufficient knowledge about groundwater extraction and land subsidence.	(Mankad, 2012; Phi et al., 2015)	Household Surveys & Interviews
	Risk Perception	There is familiarity with the use of rainwater, stormwater and wastewater (treatment).	(Mankad, 2012)	Household Surveys & Interviews & Literature
		There is a not too high perceived risk in term of perceived water quality.	(Mankad, 2012)	Household Surveys & Interviews & Literature

Table 1: social conditions that need to present to implement a decentralised domestic water provision.

	Governance conditions			
Ability	*Variable*	*Condition*	*Source*	*Data collection method*
	Institutional Capacity	The institutional framework allows for the implementation of a decentralised domestic water provision system.	(Mankad & Tapsuwan, 2011; Phi et al., 2015)	Literature
		There should be sufficient cooperation between departments.	(Kamal et al., 2008; Moglia et al., 2011)	Interviews & Literature
		There are parties present that can function as a collaboration to work on the implementation of a decentralised domestic water provision.	[DE5]	Interviews & Literature
		There is communication about drivers behind policies	(Mankad & Tapsuwan, 2011; Witjes, 2018)	Interviews

	Stakeholder engagement	from the government to stakeholders.		
		Stakeholders are involved in planning and development of policies.	(Schuetze & Chelleri, 2013)	Interviews & Literature

Table 2: governance conditions that need to present to implement a decentralised domestic water provision.

	Economic Conditions			
Ability	*Variable*	*Condition*	*Source*	*Data collection method*
	Financial Capital	There is enough financial capacity available for the implementation, operation and maintenance of a decentralised water provision system.	(DE5; Phi et al., 2015; Witjes, 2018)	Household survey & Interviews & Literature
	Willingness to pay	There is a willingness to pay among the implementers and users of the decentralised domestic water provision system.	(DE1; Mankad & Tapsuwan, 2011)	Household survey & Interviews
	Externalities	Externalities are taken into account in policy- and or financial-decision making.	(Mankad & Tapsuwan, 2011)	Interviews & Literature

Table 3: economic conditions that need to present to implement a decentralised domestic water provision.

	Technical- and geographical conditions			
Ability	*Variable*	*Condition*	*Source*	*Data collection method*
	Equipment availability	The technologies and equipment for the implementation of decentralised water provision are available for the area.	(DE5; Phi et al., 2015; Witjes, 2018)	Household Surveys & Interviews
	Knowledge availability	There is a sufficient amount of people with the knowledge and skills to implement decentralised domestic water provision systems in the area.	(Phi et al., 2015; Witjes, 2018)	Household Surveys & Interviews & Literature

	Geographical conditions	The geographical conditions of the area are sufficient for decentralised domestic water provision technologies.	(Brunner et al., 2018)	Household Surveys & Interviews & Literature

Table 4: technical- and geographical conditions that need to present to implement a decentralised domestic water provision.

3.3 Case study: defining and elaborating on the research area

The VMD (see figure 4) is one of the five most vulnerable deltas in the world. In order to ensure the competitiveness of the delta, the efficiency and effectiveness of investments for flood protection, salinity control, water quality and water supply are is of great importance. The area is densely populated and contributes to more than half of the rice production in Vietnam, therefore the VMD is also called the 'rice bowl' of Vietnam. Even though the area is highly populated, the urbanisation rate (in 2012) only accounts for 25% and the economy is still mostly based on agriculture and aquaculture. The GDP of the VMD is lacking behind the development of the national GDP (Kingdom of the Netherlands & Socialist Republic of Vietnam, 2013).

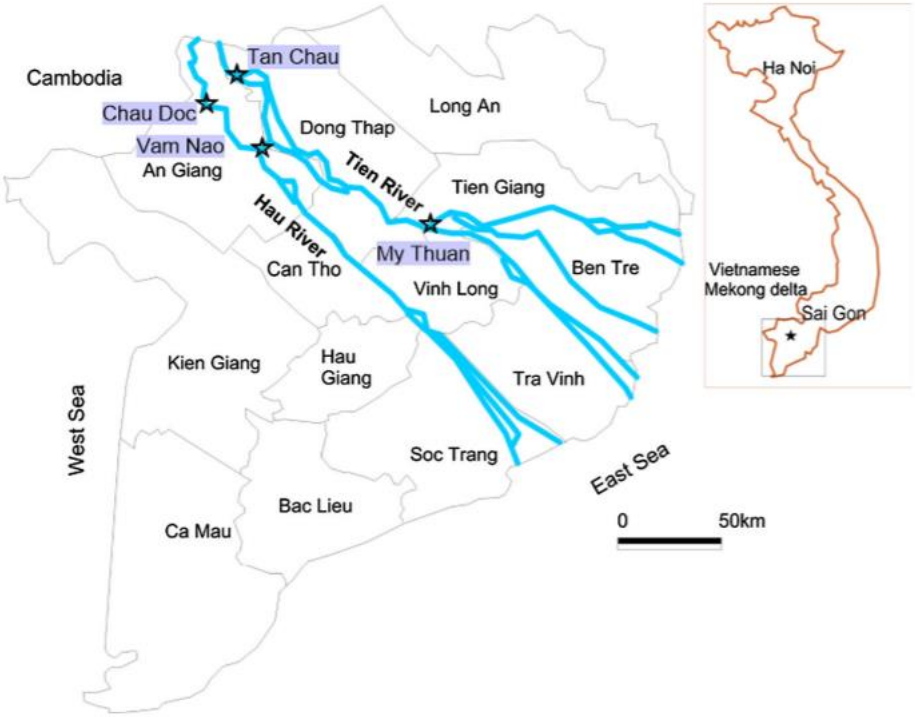

Figure 4: The Vietnamese Mekong Delta. Source: (Trieu & Phong, 2015).

In the VMD, around 2 million m^3 of groundwater is extracted from the 500 meter of the multi aquifer subsurface on a daily basis. This adds to the land subsidence, which currently has an average of 1.6 cm/yr^{-1}. This is worrisome, since the majority of the delta lies less than 2m above the sea level (Minderhoud, Erkens, Pham, Vuong, & Stouthamer, 2015). Recent studies tried to map the subsidence rates in the VMD per region, and found that the highest subsidence rates were the biggest in the industrial zones and cities, calling them *'subsidence hotspots'* (p. 9, Minderhoud et al., 2017). Of these cities, the city of Can Tho, is seen as the centre of the delta (Kingdom of the Netherlands & Socialist Republic of Vietnam, 2013). Therefore, this city will be the focus of this research.

3.3.1 Can Tho City: general characteristics.

Can Tho City is the largest city within the VMD and is located on the South Bank of the Hau River, a branch of the Mekong River. It lies in a tropical monsoon climate with a rainy season from May-November and a dry season from December-April. The city had a population of around 1.6 million people in 2016 and the increasing growth of the city will likely change the land use and planning within and around the city. Currently, the city is made up of 9 districts (5 urban and 4 rural) (see table 5 and figure 5) (Moglia et al., 2012; H. Ngo, Pathirana, Zevenbergen, & Ranasinghe, 2018).

	District	Area (ha)	Population
Urban	Ninh Kieu	2,927	244,065
	Binh Tuy	7,068	111,306
	Cai Rang	6,894	86,328
	O Mon	12,552	130,274
	Thot Not	17,130	159,461
Rural	Phong Dien	12,364	99,667
	Vinh Tanh	41,039	112,888
	Co Do and Tho Lai	40,188	245,566

Table 5: the 5 urban districts and 4 rural districts[1] of Can Tho City. Source: (Moglia et al., 2012).

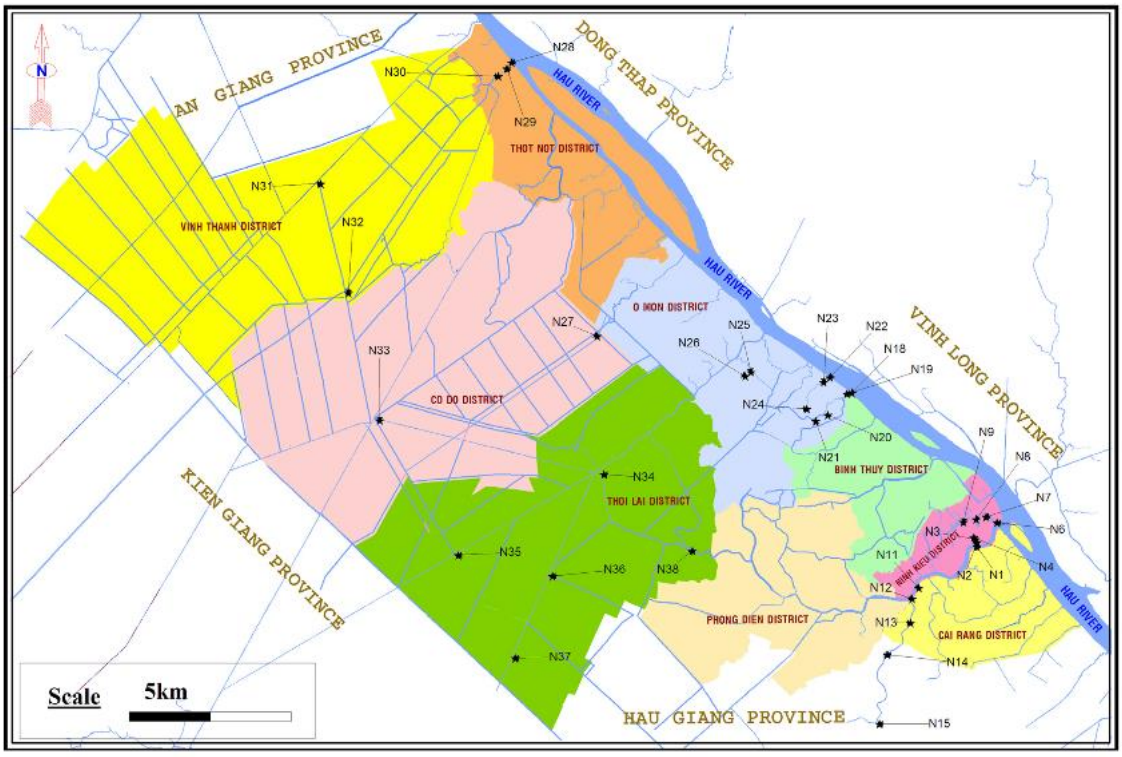

Figure 5: Map of Can Tho City with the 9 districts. Source: (Trinh, Duong, Van Der Steen, & Lens, 2013).

However, investments in water infrastructure have not kept up with the rapid economic growth of the city. Especially outside the urban areas, water and sanitation systems are lacking behind. Furthermore, there is a degradation in river water quality, due to the discharge of wastewater from households, industry and agriculture in the river. Not surprisingly, groundwater is an important water source for Can Tho City and used for domestic use, water supply, industry, aquaculture and agriculture. Especially the

[1] In table x, the data of Co Do districts and Thoi Lai district are combined, however, these are two different rural districts and will be researched separately in this research.

rural districts (Vinh Tanh, Co Do, Thoi Lai and Phong Dien) depend heavily on this water source (Moglia et al., 2012).

3.3.2 Water supply and groundwater use in Can Tho City

The water use in Can Tho City can be divided into two categories: private water use and the water provided by the water companies and local government (supplied piped water). The supplied water system in Can Tho City is based on the concept of maximizing cost recovery by the state and subcontracting water infrastructure to water companies (Spencer, 2007). Two main institutions are responsible for the water supply, which in turn collaborate with other stakeholders. The urbanized area of the city is connected to the pipeline scheme of which the Can Tho Water Supply and Sewerage Company (CANTHOWASSCO) is responsible. This system is based on surface water. However, it faces problems regarding leakage, fluctuating pressure, connecting to other areas and water quality. The rural areas of Can Tho City are managed through the community groundwater schemes for which the Centre of Clean Water and Sanitation (CERWASS) of the Department of Agriculture and Rural Development (DARD) is responsible. The latter system faces connection problems, with most households in this area detached from the water system. Officials claim that a lack of funding or a lack of willingness at the household level causes this problem, while closer observation indicates much deeper problems in the governance structure (Kotsila & Subramanian Saravanan, 2017). This problem can only become worse with climate change (Neumann et al., 2011).

On the demand side it is clear that households use multiple sources of water for domestic use, especially in the rural areas of Can Tho City. These sources include RWH, piped water supply, well water (groundwater), river water and bottled water (Kotsila & Subramanian Saravanan, 2017). As can be seen in figure 6a, around only 40% of the rural area has access to the piped water supply. In addition, as can be seen in figure 6b, well water is a commonly used additional water source for these areas. The different sources of water serve multiple uses, often related to water quality (Spencer, 2008b). Due to an awareness on the pollution of water sources by the local population and the expected increase on this pollution, it is expected that household water demand for more clean sources, such as piped water supply, will increase (Spencer, 2007). Furthermore, health related aspects get a great deal of attention, which interrelates with the demand side. The water provided by CANTHOWASSCO and CERWASS is not safe to directly consume and is boiled before use (Kotsila & Subramanian Saravanan, 2017). Other water sources are first treated as well (Spencer, 2007). The pollution of surface- and groundwater sources is therefore a major risk, particularly for potential illness and issues of hygiene (Herbst et al., 2009).

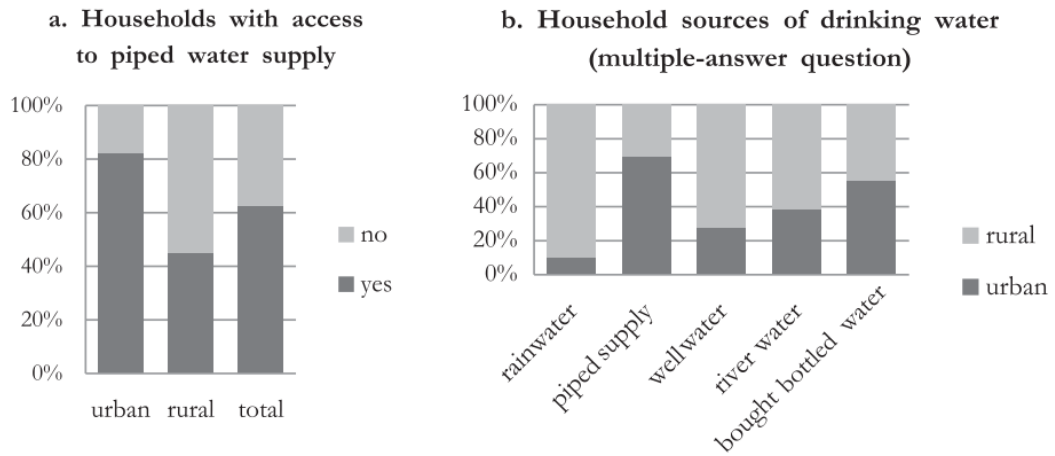

Figure 6: Household access to piped water and use of drinking sources in Can Tho, located in the Vietnamese Mekong Delta. Source: (Kotsila & Subramanian Saravanan, 2017).

Since it is evident that the rural districts of Can Tho City rely much heavier on groundwater resources, these districts will be the main focus area within this research. However, due to financial and time constraints, the district of Co Do is left out of the research, therefore the research will mainly focus on the districts Vinh Thanh, Phong Dien and Thoi Lai.

3.4 Data collection

Multiple methods of data collection are used in this research: an in-depth review of scientific and grey literature, semi-structured interviews and household surveys. The subchapters below will further elaborate on the methods of data collection and data analysis.

3.4.1 Data collection in the Netherlands: literature review and interviews

Phase one of the research consisted of an in-depth review of mostly scientific literature, this literature was found through Scopus and complemented through the use of Google Scholar. Main key words that were used to search within these databases in order to enhance the authors knowledge on DDWP were 'decentralised water management', 'decentralised water provision' and 'decentralised water supply'. Subsequently, articles cited by the previously read articles and suggested articles were read, creating a 'snowball-effect' in literature. Furthermore, in order to get a grasp on the study area and the water provision within this area, articles within the Rise and Fall Research Programme were read and searches within the same databases were done. Now, key words as 'water supply Can Tho', 'water security Vietnamese Mekong Delta', 'Groundwater use Vietnamese Mekong Delta' and 'Land Subsidence Vietnamese Mekong Delta' were used. Logically, more articles were read to broaden the understanding behind the processes as groundwater extraction, aquifer compaction and land subsidence. The articles found in Scopus were first sorted on 'relevance', then on 'date (newest)' and lastly on 'cited by (highest)' in order to ensure a broad enough data set. In order to remain the feasibility of the literature review the data search for the options above were limited to the first 100 findings in Scopus.

As explained in chapter 2.1, semi-structured interviews were held with Dutch experts (referred to as DE) to complement and validate the draft of the assessment framework. These Dutch experts were found through Google searches on research on DDWP in The Netherlands and through suggestions of researchers at Utrecht University. Table 6 provides an overview of the interviews held in the Netherlands. In appendix A the interview guide can be found. However, the interview guide was only guiding, since the research expertise and the willingness to share of the research were the central focus of the interviews held in the Netherlands. All the interviews were held face-to-face.

No. 1	Institution	Position	Date
DE1	Wageningen University and Research	Programme Manager at Wageningen Food and Bio based Research.	28-01-2019
DE2	KWR & Utrecht University	Scientific Researcher in the Resilient Water Management and Governance team KWR and PHD-candidate at Utrecht University.	22-02-2019
DE3	KWR	Researcher in chemical water quality	11-02-2019
DE4	IHE Delft	Associate Professor in Integrated River Basin Management	13-02-2019

DE5	Water Innovation Consulting	CEO	20-02-2019

Table 6: overview of interviews with Dutch Experts.

3.4.2 Data collection in the Vietnamese Mekong Delta: interviews and household surveys

Phase two of the research consisted of data collection in the VMD. This data was retrieved through four data collection methods: interviews with experts in Vietnam, governance agencies, household surveys and a further review of grey as well as scientific literature. Subchapters 3.4.3 and 3.4.4 will further elaborate on these data collection methods.

3.4.1. Interviews with governance agencies in the Vietnamese Mekong Delta

Phase two of the research consisted of collecting data in the VMD. An important aspect of this data collection are interviews held with governance agencies. These governance agencies can be divided into two categories: experts from knowledge institutes, like universities and research institutes, and officials from governmental departments and water supply companies. The latter are referred to as [GO] further in this research. Researchers at universities or research institutes are considered Vietnamese Experts (in this research referred to as [VE]).

Vietnamese Experts

Interviews with Vietnamese experts were (mostly) conducted face-to-face in Vietnam. The interviews had a semi-structured character and respondents were asked about their knowledge regarding the conditions (as defined in chapter 3.2) needed for a DDWP. The interviews consisted of 16 questions and took approximately 30-60 minutes, depending on the speed of the interview or the time the respondent had available for the interview. Some respondents were not available for an interview face-to-face and filled out the interview guide digitally. Appendix B provides the interview guide that was used to conduct the interviews with the Vietnamese experts. The respondents were found through Google and suggestions from the contact persons in Vietnam, associated with the Rise and Fall Research Programme. A total of 8 interviews were held, the list of respondents can be found in table 7. The interviews were mostly held in English. However, a translator was available during the interviews in case language barriers hampered the knowledge sharing. The interviews were arranged through e-mail in the Netherlands, before the fieldwork was conducted. When a respondent did not respond after two weeks the request was send for a second time. All the desired respondents agreed to an interview.

No.	Institution	Position	Date
VE1	Mekong Delta Development Research Institute	Researcher	19-03-2019
VE2	DRAGON Institute, Can Tho University	Senior lecturer & Vice Director of the Institute for Climate Change	Filled out digitally
VE3	College of Environment and Natural Resources, Can Tho University	Vice head of the Department of Engineering	20-03-2019
VE4	College of Environment and Natural Resources, Can Tho University	Lecturer at the Department of Engineering	Filled out digitally
VE5	College of Environment and Natural Resources, Can Tho University	Associate Professor	21-03-2019

VE7	Division of Water Resources Planning and Investigation for the South of Vietnam	Deputy General Director	09-04-2019
VE8	Southern Institute of Water Resources Research	Deputy Head	10-04-2019

Table 7: overview of interviews with Vietnamese knowledge experts.

Officials working at government department and water supply companies

The interviews held with officials in governmental departments and water supply companies also focused on the earlier defined conditions for a DDWP. The interview guide (see appendix C) consisted of 23 questions and the interviews took approximately 45-60 questions. In some cases, not all the questions were answered due to time constraints or a gap in knowledge among the respondents. For example, officials at the water supply stations sometimes found it difficult to answer policy related questions. All interviews were held face-to-face and most of them in Vietnamese, which was translated directly by the translator available during the interviews. The preferred list of interviews was made in The Netherlands in collaboration with contact persons from the Rise and Fall Research Programme in Vietnam. The interviewees were approached through these contact persons as well, since official permission from the Vietnamese government was needed to conduct the interviews. Almost all desired interviews were conducted. However, two interviews were cancelled due to time constraints or a reluctance to conduct the interview on the side of the governance agency. A total of 9 interviews was held. An overview of these interviews can be found in table 8.

No.	Institution	Position	Date
GO1	Division of Mineral and Water resources, DONRE	Government Official	13-03-2019
GO2	Can Tho Water Supply and Sewerage Company	Vice Director	15-03-2019
GO3	Phong Dien district Water Supply Station	Vice Director	25-03-2019
GO4	Phong Dien district DONRE	Vice Director	26-03-2019
GO5	Vinh Thanh district Water Supply Station	Director	28-03-2019
GO6	Vinh Thanh district DONRE	Government official responsible for water mandates	29-03-2019
GO7	Thoi Lai district Water Supply Station	Director	02-04-2019
GO8	Thoi Lai district DONRE	Manager of environment	03-04-2019
GO9	Vitens-Evides International B.V.	VEI Project Manager & Residence officer Asia/Water Supply expert	20-03-2019

Table 8: overview of interviews with officials in governmental departments and water supply stations.

3.4.3 Household surveys in the Vietnamese Mekong Delta

The household perspective was retrieved through surveys with households in Phong Dien, Thoi Lai and Vinh Tanh district, in each district different four communes were visited to spread the data collection over multiple areas, since water uses as piped water supplies often cover most part of a neighbourhood.

The surveys were held between the 25th of March and the 3rd of April, with a coverage of 15 surveys a day due to the travel time between the centre of Can Tho and the district and the different communes. Respondents were interviewed in their household and were found during the fieldwork itself, with the help of the head of the commune that accompanied the research in the districts. All surveys were held personally and in Vietnamese and consisted of (mostly) closed questions, to minimize discrepancies in language and due to time efficiency. After the field work, the surveys were translated from Vietnamese to English by the research team that helped collecting the data. There was an aim to do 90 surveys in total, with a total of 30 surveys per district to spread the data collection totally. In reality, due to unforeseen circumstances only 85 surveys were conducted, table 9 provides an overview of the number of surveys per district.

District	Amount of Surveys	Date
Phong Dien	24	25-03-2019 & 26-03-2019
Thoi Lai	31	02-04-2019 & 03-04-2019
Vinh Tanh	30	28-03-2019 & 29-03-2019

Table 9: overview of amount of surveys held per district in Can Tho City.

The surveys mainly collected data on the social, economic and environmental conditions, since for these conditions household perspectives and habits were of importance the measure the presence of the conditions. Appendix D provides an English version of the survey.

3.4.5 Complementary literature review on the Vietnamese Mekong Delta

Some data to assess the presence of conditions could not (solely) be retrieved from the approaches as described in chapter 3.4.4 and 3.4.5. This data was then collected through a complementary literature review on grey and scientific literature. The reasons for this is, that due to the top-down regime in Vietnam, some questions could not be answered directly. For example, the governance condition on cooperation between governmental departments could not be asked directly to the respondents. After deliberation with the contact persons in Vietnam, gaining information for such conditions was reframed, for example to 'do you think that the water provision should be under a single department or under multiple departments?'. This sometimes provided insights in the thoughts and opinions of the respondents, without asking them question that could be politically sensitive.

3.5 Data analysis

The collected data above was analysed in order to sufficiently process the data in the results. The data analysis can be divided between the interviews and the surveys, which were analysed differently. Most of the interviews were recorded and later transcribed. However, some respondents, mainly the officals in governmental departments and water supply companies, were reluctant to record the interview, during these interviews careful and comprehensive notes were taken that were worked out as soon as possible after the interview to minimize information loss. The interviews were then analysed through a qualitative analysis in the software programme *NVivo*. Within *NVivo* nodes and sub nodes were created, that coincide with the conditions and variables in the assessment framework. For respondents who gave alternative suggestions, the sub node 'proposed alternatives' was made. Appendix E provides an overview of the node structure in *NVivo.*

The data from the surveys was analysed through the software programme SPSS. All surveys were given an ID, consisting of abbreviations of the name of the districts and a number, starting by one and successive with the order of processing the data. In the end, the data set consisted of 85 surveys, divided into PD001-PD024, TL001-TL031 and VT001-030. This made possible to analyse the data of all districts together, but also analyse the data per district separately to see whether there are significant statistical differences between the districts.

3.6 Conclusion

This chapter provided the assessment framework that is used to assess the feasibility of a DDWP in the VMD, an elaboration on the research area and information on the data collection and data analysis methods. The methods as described in this chapter are used to formulate the results in the following chapters.

Chapter 4: The presence of social conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta

4.1 Introduction

This chapter elaborates on the presence of the social conditions that are needed for the feasibility a DDWP. For each condition, a score that indicates the presence of the condition is given per actor group (households and governance agencies). Table 10 provides an overview of the conditions with a score per actor, this will further be elaborated in the subchapters below.

	Social conditions			
	Variable	*Condition*	*Presence conditions among households*	*Presence conditions among governance agencies*
Motivation	Threat perception	There is sufficient knowledge about groundwater extraction and land subsidence.	-/-	+/-
	Risk Perception	There is familiarity with the use of rainwater, stormwater and wastewater (treatment).	+/-	+/-
		There is a not too high perceived risk in term of perceived water quality.	-/-	+/-

Table 10: the presence of social conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta.

4.2 Threat Perception

Household perspective

As stated in chapter 2.6.1, threat perception can be derived from knowledge on water issues that affect the region, that is present among the actors (Mankad, 2012). In the VMD this relates to groundwater over extraction and land subsidence problems. Figure 7a and 7b show the knowledge on land subsidence in the area, and the correlation between land subsidence and groundwater extraction among households. As can be derived from figure 7a, is that among most households there is no knowledge on land subsidence problems in the area. Furthermore, when households were asked if they experienced more practical problems, such as floods or damage to their house (see appendix D, question 30), the responses were negative as well [SURVEYS]. It can thus be concluded that among the households, threat perception on land subsidence is not present. In addition, as can be seen in figure 7b, the majority of household further do not know that groundwater extraction leads to land subsidence. There were no significant statistical differences between the rural districts. Therefore, the threat perception among households is not present (-/-), since knowledge on land subsidence,

groundwater extraction relating to land subsidence and problems coming from these aspects is not present.

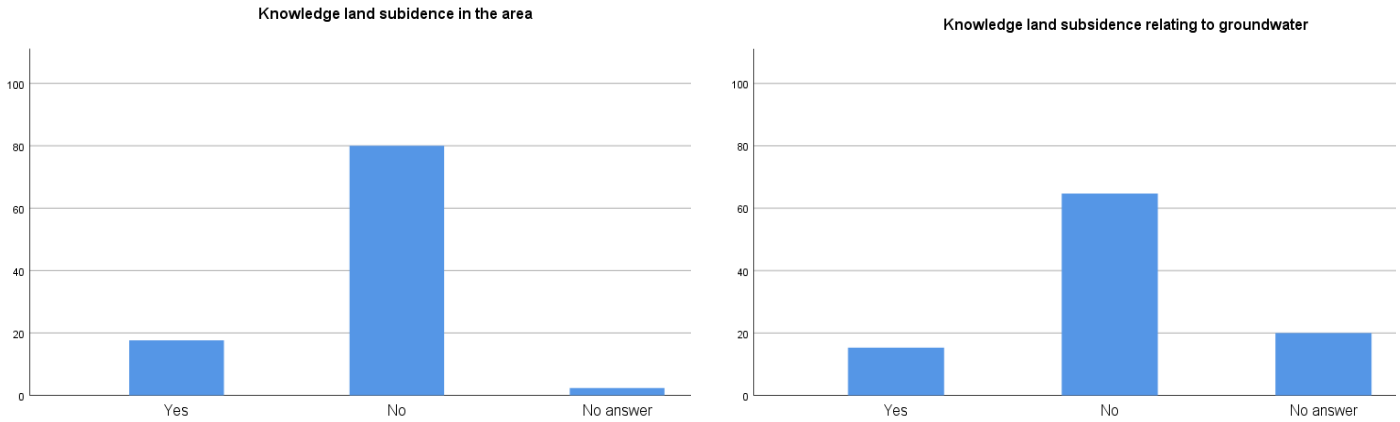

Figure 7a and 7b: knowledge of to land subsidence and land subsidence relating to groundwater in the rural districts of Can Tho City (in %).

Governance agencies

Among governance agencies, there seems to be a discrepancy among the water supply company on the one side, and the governmental institutions and Vietnamese experts on the other side. Most governmental agencies recognize the problem with groundwater extraction in the area, especially the Departments of Natural Resources and Environment (DONRE) who is responsible for mandating and/or managing the groundwater extraction by (water supply) companies. They recognize that groundwater should be used sustainably [GO1] or that switching to other water sources than groundwater needs to be encouraged [GO6]. Vietnamese experts agree with these statements, however, they put more value on groundwater extraction in the coastal areas. For Can Tho City, there is a less perceived risk due to the urban water supply based on surface water [VE2]. This coincides with responses from water company officials. All did not recognize groundwater extraction problems, due to their surface water dependency. According to one respondent there is no need to switch to alternative water resources at all, since the VMD is not under water stress and using groundwater to the amount that it is permitted by the government is easier than implementing alternative strategies. According to this respondent, countries like Singapore face threats regarding water security, but in the Vietnamese Mekong Delta there is no threat, so they can rely on surface water with groundwater as an additional source [GO2]. It thus seems that among governance officials, the threat perception is mixed, but highly influenced by the abundant availability of water in the area (see chapter 7 for more information). However, governance officials do know about groundwater problems in the Vietnamese Mekong Delta and especially government officials want to make more sustainable use of groundwater. Therefore, the presence of the condition is scored as partially present (+/-).

4.3 Risk Perception

To assess the risk perception among actors in the VMD, two aspects are of importance: the familiarity with the use of a DDWP and the used alternative water sources and that the perceived water quality is not too low.

4.3.1 Familiarity

Household perspective

Familiarity on a DDWP and the use of alternative water sources in the area are important aspects that define the risk perception. Currently, there are five main water sources used in the VMD: rainwater, supplied piped water, well water (ground water), river water and bottled water (Kotsila & Subramanian Saravanan, 2017). Figure 8 shows the use of these water sources among households in Phong Dien, Thoi

Lai and Vinh Tanh district. A few conclusions can be derived from this figure. First, it is evident that there is a mixed use of water sources in the area, with a biggest dependency on the supplied piped water of the water companies and bottled water. Secondly, the private use of groundwater (through groundwater wells) is not that high. Thirdly, there is a familiarity with the use of rainwater (around 30% of the households use this water source), but it is not one of the main used water sources. However, this can be explained through the expansion of the piped water supply network. Households told that they used to use rainwater but that they did not collect it anymore, since it was not needed when they connected to the piped water supply [SURVEYS]. Thus, there is familiarity, but the use of this water source decreased, which may negatively influences the acceptance of rainwater as water source in the future. Since stormwater is mostly collected through government implemented systems, such as flood plains or gullies, the use of this water source was not assessed through the households. Wastewater is not a commonly used water source in the VMD, a majority of 90.6% of the households indicated that they currently not reuse their wastewater [SURVEYS]. It can thus be concluded that there is a slight familiarity with the use of the alternative water sources within DDWP, which is mainly due to the familiarity with the (earlier) use of rainwater harvesting.

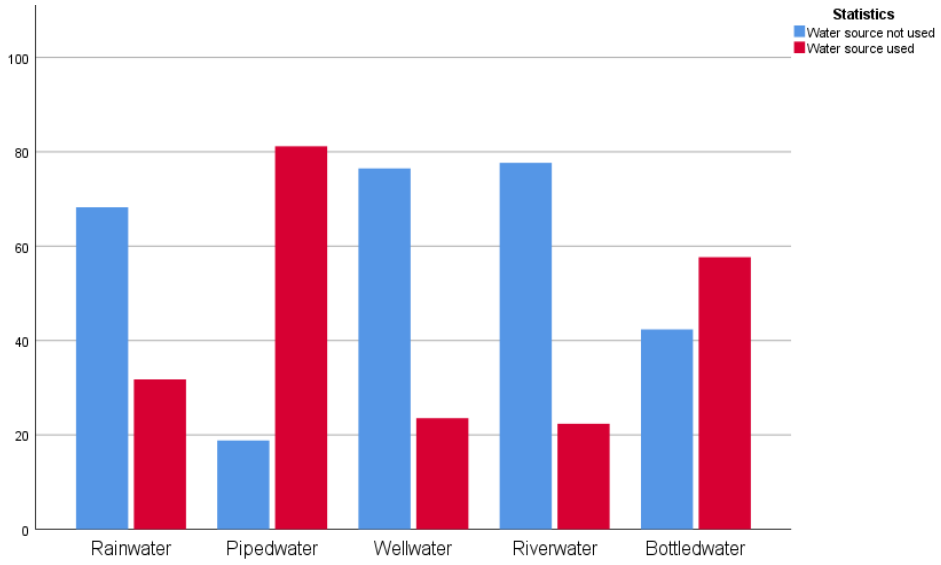

Figure 8: overview of water sources used (in %) in the rural districts of Can Tho City.

In addition, household were asked about their familiarity with the use of a DDWP (see figure 9). Most households were not familiar with the use of a DDWP, however, the percentages are not that far behind, especially when looking at the rural districts separately (see table 11). As table 11 shows, the results on the familiarity on a DDWP in the districts Phong Dien and Vinh Tanh are actually around half/half. The overall results that make up the non-familiarity with DDWP is thus mainly due to the results from Thoi Lai district.

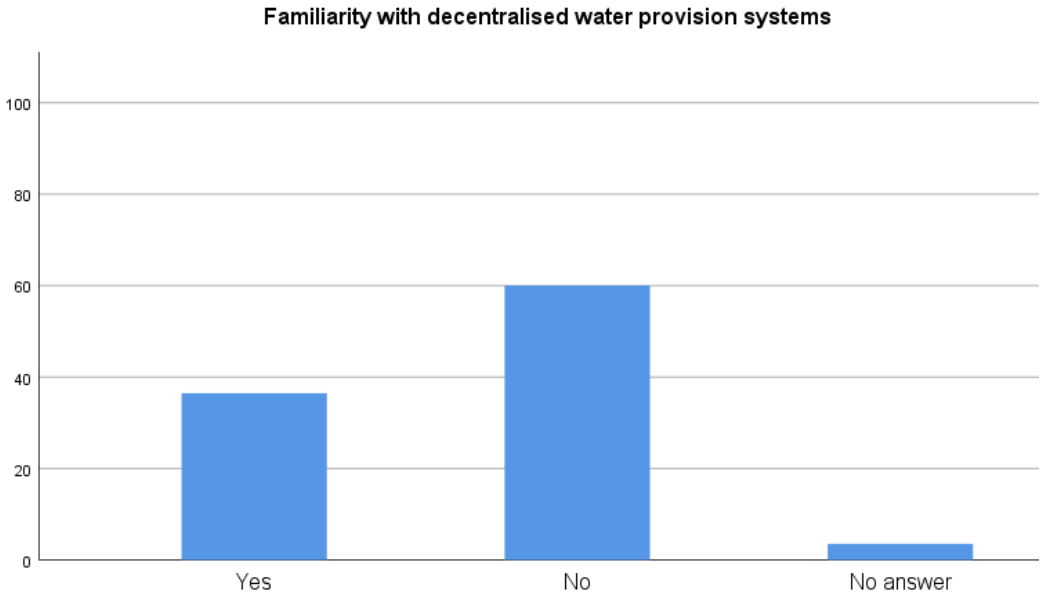

Figure 9: familiarity with decentralised water provision systems in the rural districts of Can Tho City (in %).

	Phong Dien	Thoi Lai	Vinh Tanh
Familiar (yes)	41.7	16.1	50
Not Familiar (no)	45.8	83.9	50
No answer	12.5	0	0

Table 11: familiarity with decentralised water provision systems per rural district (in %).

Household answers on how they became familiar with a DDWP were quite similar among the districts of Phong Dien and Vinh Tanh as well. Most households compared it to their (or their ancestors) situation before they were connected to the CDWP. This coincides with the use of rainwater as explained above. Furthermore, some households heard about the concept within the community, through television, social media and even one respondent (Phong Dien district) claimed to have heard about it through the government [SURVEYS]. It is thus evident that familiarity spreads through the strength of the community, people talk about it, or through promotion on social media or governmental channels. However, there is no data that explains why did this happened in Phong Dien and Vinh Tanh, but did not happen in Thoi Lai.

Overall, the familiarity with the use of a DDWP and the alternative water sources among households can be assessed as slightly familiar (+/-). This is due to the familiarity with the use of rainwater and the recognition of DDWP in Phong Dien and Vinh Tanh district. However, the use of wastewater could be a problem in the future, since households do not have familiarity with this water source and the implementation of a DDWP in Thoi Lai may be more challenging due to the lack of familiarity with a DDWP in this district. Furthermore, the use of rainwater in the districts decreases, of which the implications are unsure.

Governance Agencies

Most governance agencies are familiar with the use of rainwater and stormwater. However, they are sometimes seen as the same concept [GO1; GO3]. Within DONRE, centralised projects to harvest rain- and stormwater in the wet season are proposed (Seijger, Hoang, van Halsema, Douven, & Wyatt, 2019). However, there is no recognition of the use of stormwater as a separate water source that is managed by the government through gullies or other measures. In the case of wastewater, governance agencies

know about it, but none have experience with the use of this water source. Can Tho City did open a pilot on WWT in Kanang district [GO3] and it is sometimes used in industrial settings [GO1], but the respondents did not have personal experience with the concept. Furthermore, projects related to this water source face a lot of delay due to the lack of experience that causes constraints [VE5]. A DDWP is slightly familiar among governance agencies, since the approach of CERWASS, that provides groundwater to communes through communal supply stations, can be seen as a form of DDWP [GA5; VE3]. Furthermore, RWH is recognized as a form of DDWP and known through household uses [GO1]. It can be expected that more governance agencies are familiar with the previously mentioned examples, but did not link it to the concept of DDWP. This argument is underlined by literature, that found that several thousand decentralised WWT plants, including sceptic tanks for households, are spread throughout Vietnam, including Can Tho City (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013).

It thus seems that regarding alternative water sources, governance agencies have most familiarity with RWH and that there is a slight familiarity with stormwater and WWT. For the latter, there is evidence from other research that centralised and decentralised WWT is already used in Vietnam, including Can Tho City. Furthermore, some governance agencies were familiar with a DDWP to some extent. Therefore, the presence of the condition is scored as partially present (+/-).

4.3.2 Perceptions on water quality

Household perspective

The perception on water quality is one of the most important indicators that make up risk perception among citizens on the aspect of a DDWP (Mankad, 2012). This perception consists of a few aspects. First, the perception on the current water quality and water accessibility is needed. Secondly, the water behaviour on potable water uses (drinking, cooking, bathing) is of importance, since due to health risks some water sources are not used for potable purposes. Therefore, this can be an indicator of the water quality perception per alternative water source (Ali Sajjadi, Alipour, Matlabi, & Biglari, 2016). Lastly, household opinions on the relation between water quality, water accessibility and a DDWP are defined.

Overall, households perceive the current quality of their main water sources as medium (see figure 10). However, when looking at their potable water uses (see figure 11), it seems that the majority of households do not use rainwater, piped water, river water or well water for drinking. Most households (around 60%), use bottled water for this purpose. Rainwater and piped water are the runners up with around 35%. Thus, the perceived medium quality water sources are mostly not seen as suitable for drinking purposes. Looking at the remaining potable water uses, cooking and bathing, it seems that almost all households use piped water for these purposes (see figure 12 and 13). This can indicate that the other water sources do not have a high enough perceived quality to be used as preferred water source for these water uses.

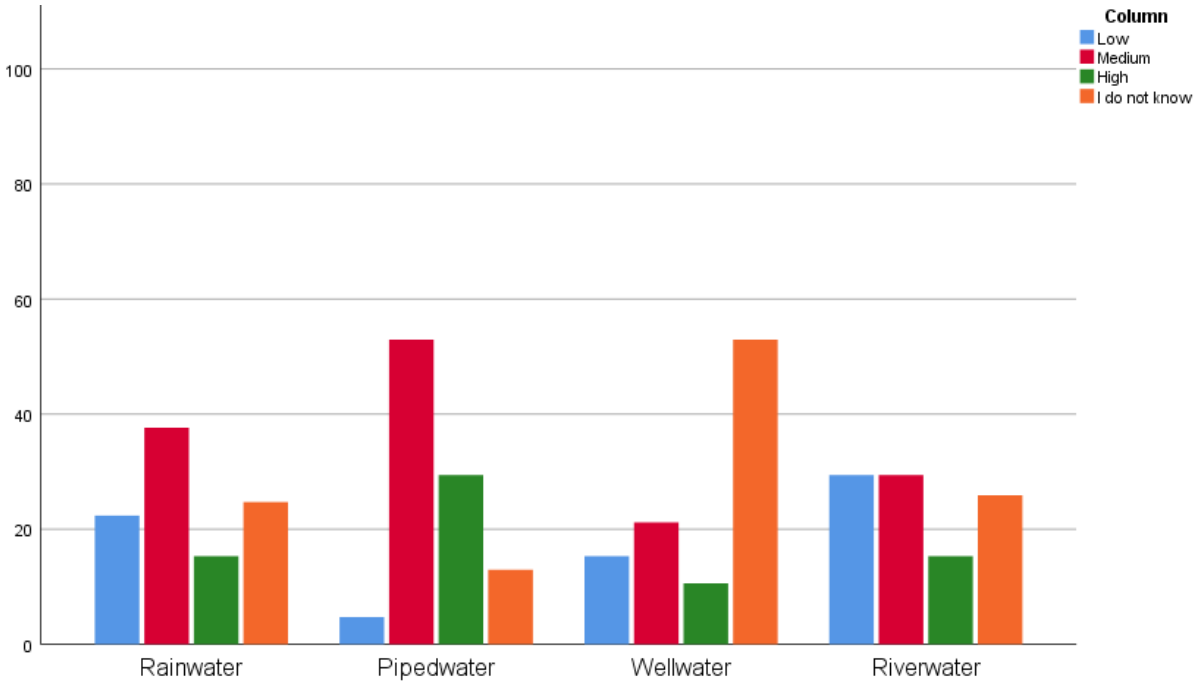

Figure 10: perceived quality of used water sources in the rural districts of Can Tho City (in %).

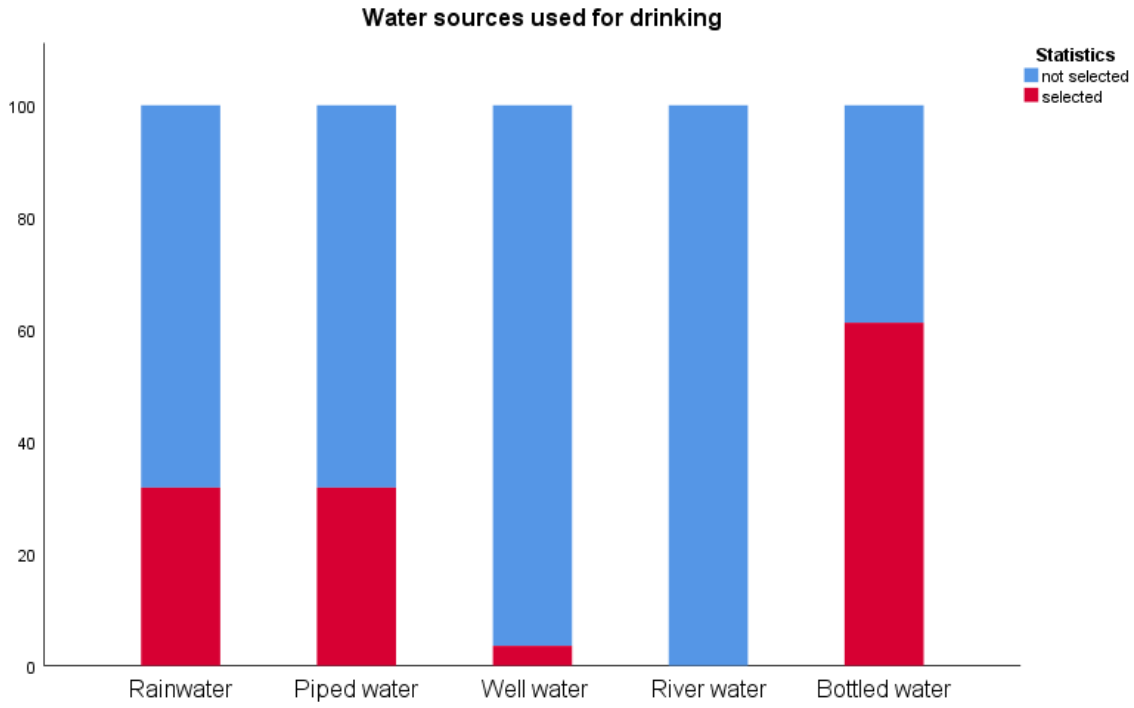

Figure 11: water sources used for drinking in the rural districts of Can Tho City (in %).

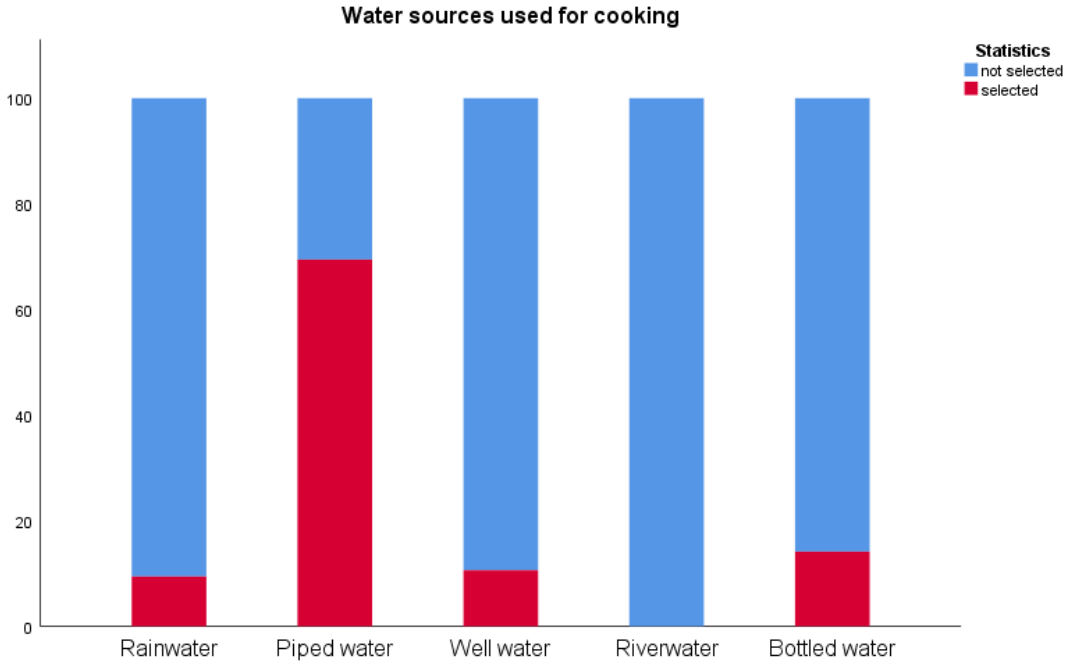

Figure 12: water sources used for cooking in the rural districts of Can Tho City (in %).

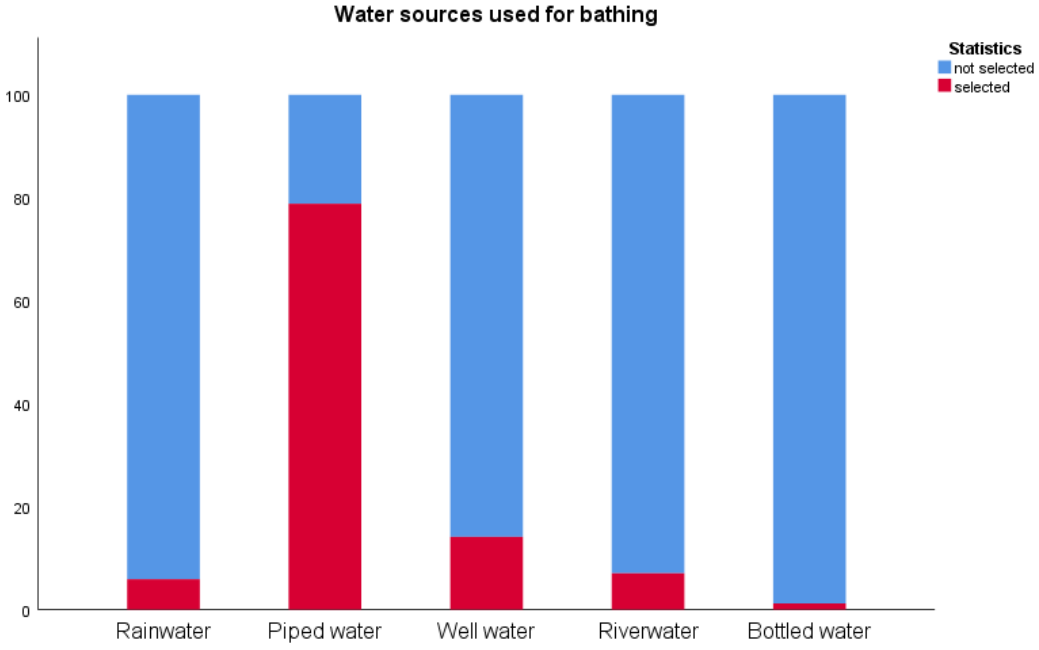

Figure 13: water sources used for drinking in the rural districts of Can Tho City (in %).

As stated earlier, the use of wastewater is currently (almost) non-existent among the households in the rural districts of Can Tho City. Since it could be an useable water source in a DDWP, the households were asked whether they would like the government to build a WWT plant to make the reuse of wastewater possible (see figure 14). Most households indicated that they did not wish for a WWT plant in their residential area. However, explanatory answers did not relate to water quality. Most households simply did not see the need for one, or did not think they had enough knowledge about the subject to answer the question [SURVEYS]. The last remaining question to establish the baseline was an indication

of their perceived household water accessibility, which most households perceived as high (see figure 15).

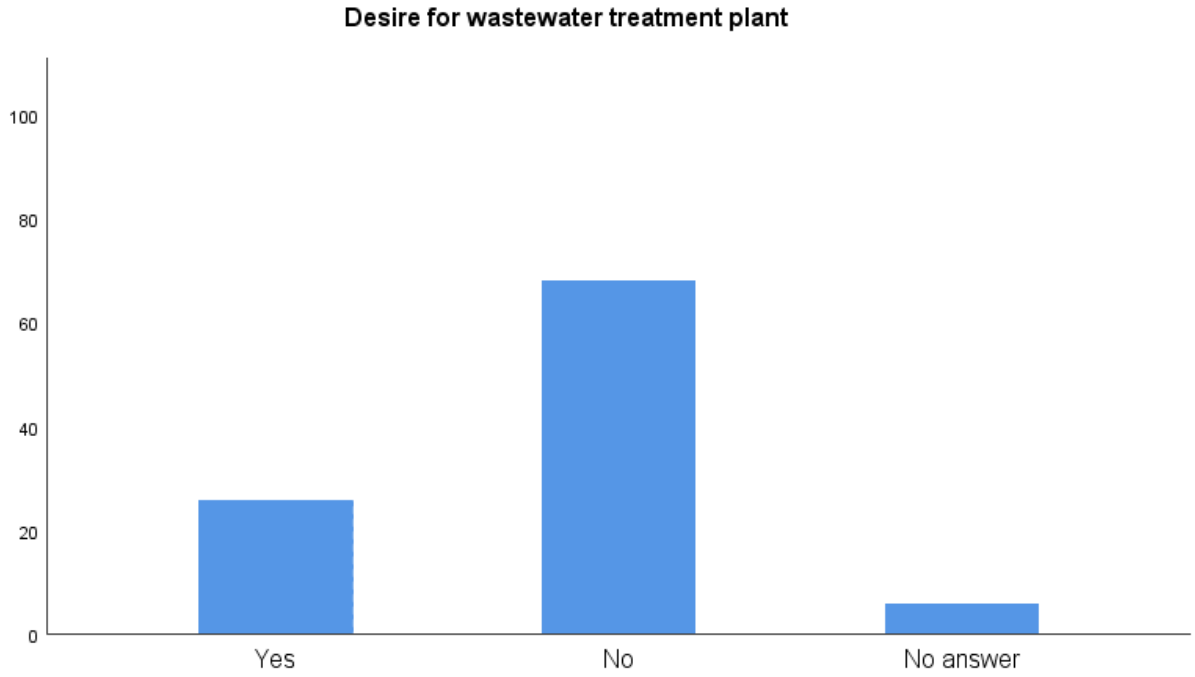

Figure 14: households their wishes on a wastewater treatment plant in the area (in %).

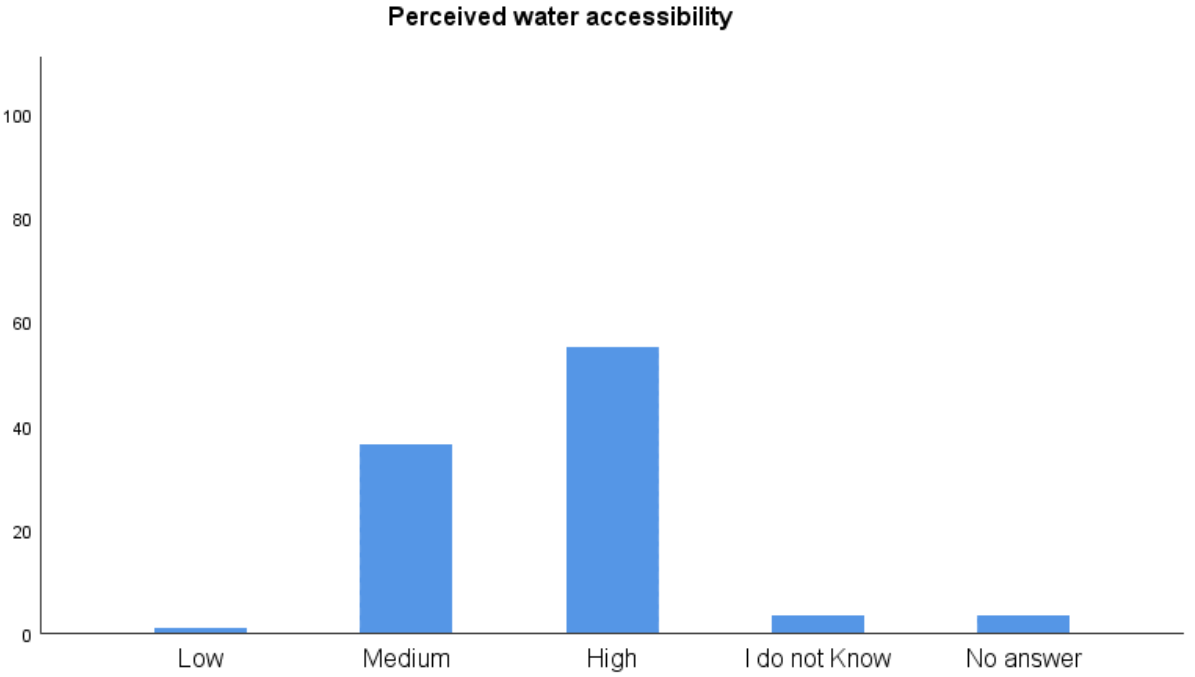

Figure 15: perceived quality of water accessibility in the rural districts of Can Tho City (in %).

Thus, in general it can be stated that the overall perceived water accessibility is high and the overall water quality is perceived as medium quality. For the implementation a DDWP with the proposed alternative water sources, the perceptions on rainwater and wastewater are of importance. Rainwater is perceived as medium quality, however, not preferred for potable water sources. This may cause implications for the expansion of this water source in the future. Wastewater is currently not reused and most households do not see the need for this as well. Again, this can lead to implementation problems. However, what is important to know, is if households think that a DDWP can enhance the water quality and water accessibility in their residential area. As is evident from figure 16, most households do not think that a DDWP can improve their water quality or accessibility. However, an improvement in accessibility is seen as significantly more likely than an improvement in water quality. In both cases, a lot of households just did not find an alternative water provision necessary, and thus gave a negative answer. However, an increased risk in water quality was detected as well: a lot of households indicated that they thought that the water quality could not be guaranteed or that the water sources would be unstable [SURVEYS]. Furthermore, 81.2% of the respondents (with no significant statistical difference between the districts) indicated that they found a CDWP more trustworthy than a DDWP, which indicates a high perceived risk among the household in the rural districts of Can Tho City, and mainly gave a guarantee of water quality as explanation [SURVEYS].

Households who thought a DDWP could provide for a better water quality and/or accessibility, found a trust in technologies or the belief that the smaller decentralised systems would come with better technologies to clean the water as a decisive factor. In the case of water availability, the use of more water resources was the main reason why households thought that a DDWP could provide for a better water accessibility. Furthermore, some found it appealing due to environmental beneficial reasons, of which one respondent (Vinh Tanh district), even mentioned a diminishment on the use of groundwater resources [SURVEYS]. Again, there were no significant statistical differences between the rural districts.

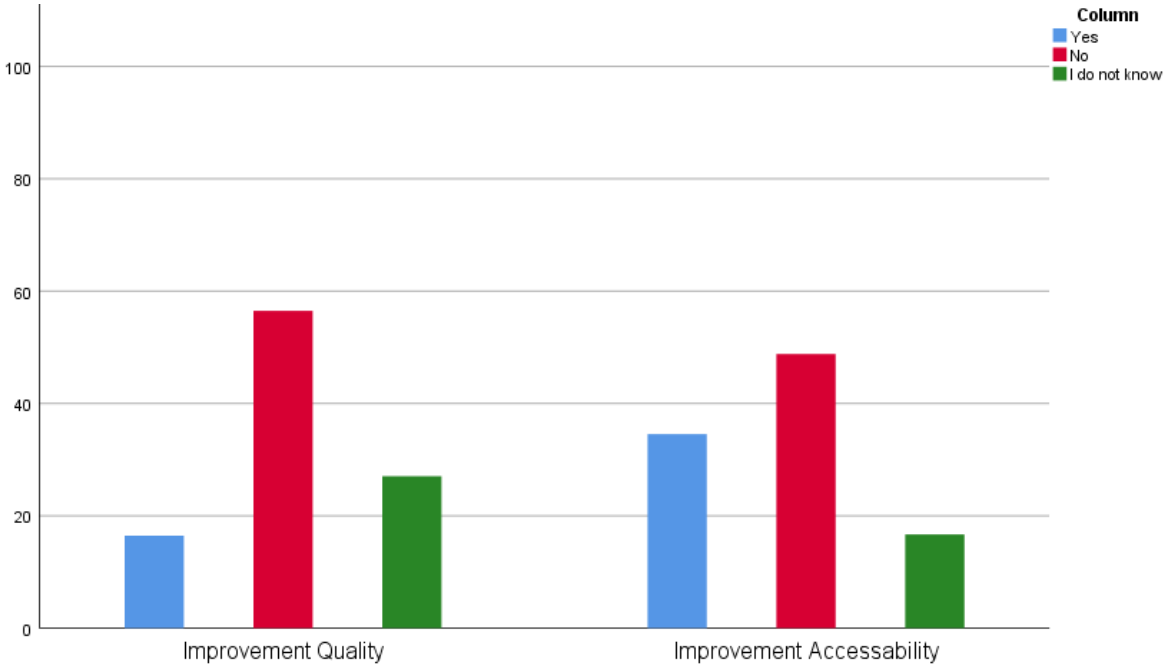

Figure 16: Perceptions on water quality and water accessibility in the rural districts of Can Tho (in %).

It can thus be concluded that relating to water quality, the perceived risk is high. Rainwater is perceived as medium quality, but barely used for potable water uses. Furthermore, wastewater is not reused

among households and most households do not see the need to start using it in the future. Furthermore, the current accessibility to water is perceived as high and most households do not see a DDWP as a solution to improve water quality and quantity, except for some who relate to environmental benefits or an expansion of water sources. In addition, 82.2% of the respondents puts more trust in a CDWP, with water quality as main reason, which is a large number to convince. Therefore, the condition 'There is a not too high perceived risk in term of perceived water quality' is scored as not present (-/-).

Governance Agencies

"When you do not connect to the centralised water system, you have to depend on alternative water sources, however, they are decreasing in quality. Thus connecting ensures a sustainable development." [GO6]

The quote above sums up the perspective of most governance agencies regarding water quality of DDWP. Even though there were no direct questions regarding this aspect, governance officials mentioned their concerns. This main concern regarded the water quality of alternative water sources, which is decreasing due to pollution. Water used for centralised water provision is decreasing in quality as well, however, this pollution is monitored by the government and is therefore perceived as a slighter risk [GO8]. In addition, previous experiences with a DDWP are negative due to water quality issues [VE3]. It thus seems that the perceived risk regarding water quality is especially importance for some governance agencies. However, research shows that in Vietnam, decentralised water solutions are recognized among more policy planners as a solution for sustainable sanitation (which is part of domestic water uses), especially for low density peri-urban or rural areas (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013). Furthermore, governance agencies were not questioned about this issue directly, which causes some perspectives to be missing. Therefore, the condition is scored as partially present (+/-).

4.4 Conclusion

To conclude it can be stated that threat- and risk perception, which make up the motivation of the involved actors, are not (almost) not present. Among households threat perception was non-existent, which is due to the lack of knowledge on groundwater over extraction and land subsidence in the VMD. The perception of risk was slightly higher when looking at the familiarity with alternative water sources and a DDWP. However, this is mainly due to the (previously) use of rainwater. Wastewater is currently not used and most households do not see the need to so. Furthermore, in Thoi Lai the majority of households are not familiar with a DDWP. However, taking water quality perceptions in mind, risk perception was non-existent as well. Households barely use alternative water sources for potable water uses, perceived their water accessibility as high and do not find a DDWP a solution for an improvement in water accessibility or water quality. Among governance agencies, the threat and risk perception is slightly higher. However, in the case of threat perception, there is a discrepancy between government officials, research experts and officials working at water companies. Among the latter, the threat perception was similar to the household level. Furthermore, the availability of surface water in the VMD affected their perception of threat. Governance agencies did have a slight familiarity with the use of alternative water resources, mainly rainwater. Stormwater is often seen as part of RWH and the use of wastewater is developing in the VMD, but none of the respondents has direct experience with the use of this alternative water source. The water provision through CERWASS provides a slight familiarity with the use of a DDWP, however, there was no further direct experience. Furthermore, there is the perception that alternative water sources, such as rainwater, are decreasing in quality and thus are less safe to use. The following chapter looks at the availability of governmental conditions for a DDWP in the VMD.

Chapter 5: The presence of governance conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta

5.1 Introduction

This chapter elaborates on the presence of the governmental that are needed for the feasibility a DDWP. For each condition a score will be given that indicates the presence of the condition in the VMD. Table 12 provides an overview of the conditions with their given score, this will further be elaborated in the subchapters below.

	Governmental Conditions		
	Variable	*Condition*	*Presence of conditions*
Ability	Institutional Capacity	The institutional framework allows for the implementation of a decentralised domestic water provision.	+/+
		There should be sufficient cooperation between departments.	-/-
		There are parties present that can function as a collaboration to work on the implementation of a decentralised domestic water provision.	+/+
	Stakeholder engagement	There is communication about drivers behind policies from the government to stakeholders.	+/-
		Stakeholders are involved in planning and development of policies.	-/-

Table 12: the presence of governance conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta.

5.2 Institutional capacity

To assess the institutional capacity among in the Vietnamese Mekong Delta, three aspects are of importance: an institutional framework that allows for the implementation of a DDWP, a sufficient cooperation between governmental departments and the presence of parties that can form a collaboration for the implementation of a decentralised domestic water provision.

5.2.1 Institutional framework

Over time, Vietnam has set up an institutional framework to help ensure the sustainable use, protection and development of water resources (Loan, 2014). In order to assess whether this institutional framework allows for the implementation of a DDWP, it is important to know how this framework works and which laws and regulations affect this implementation. According to the 1992 Constitution and the Law on Promulgation of Legal Documents (2008) the legal document system in Vietnam, that makes up the institutional framework, fits into a hierarchy from a high to a low legal force. The highest legal documents (beside the constitution) are laws and resolutions, which are passed by the National Assembly, the highest constitutional body. Under the National Assembly executive organizations implement these laws and resolutions within the country, ranging from the national to local level. On the national level, the national government and its ministries are important for issuing decrees: detailed guidelines on the implementation of certain laws and resolutions issued by the National Assembly. The local level consists of multiple institutions, of which for this research the local ministry department, the people's committee and the head of the communes are the most important institutions. The enumeration order is hierarchical determined, the local departments of the ministries have the highest power and the head of the communes the lowest. For example, the Ministry of Agriculture and Development (MARD) issues a decree, which outlines how a law issued by the National Assembly should be regulated within the country. The local enforcement of this decree is then regulated under DARD and is overseen on district level with the help of the head of the communes (Loan, 2014).

Relating to water governance, the Law on Water Resources No. 8/1998/QH10 (issued by the National Assembly in 1998) has created the foundation for water resource regulation within the country. According to this law, three water sources are defined: surface water, groundwater and domestic water. The latter can consists of every water source, as long as it can be economically treated to meet the quality requirements of Vietnam its standards for clean water for domestic use. Furthermore, the law stipulates that water is uniformly managed by the state, however, it is under ownership of the whole population. Furthermore, all organizations and individuals have the right to exploit and use water resources to meet their daily life and production demands (Loan, 2014). Taken this law into consideration, a DDWP fits into the legal framework. The use of rainwater, stormwater and wastewater for domestic use is permitted, as long as it is treated and reaches the quality standards. Furthermore, there are no restrictions in exploiting these water sources, since every individual or organization in the country has the right to do so.

In regard to implementing solutions to tackle land subsidence and improve the water provision in the VMD, Resolution 120/NQ-CP (2017) is of importance as well. This resolution was issued by the National Assembly to ensure a sustainable development of the VMD and some important aspects, such as tackling problems as land subsidence and improving the water provision, are mentioned as challenges that need to be dealt with sustainably (Socialist Republic of Vietnam, 2017). According to this resolution, water resource management has to be strengthened and water resources have to be efficiently used, climate change has to be prioritized and inhabitants of the VMD should *'use water efficiently and sustainably to ensure sufficient fresh water for people, and for people in the brackish and salt water areas (..) All projects, works must be carefully considered and analysed based on three aspects: economic, social and environmental with adequate objective, scientific feedbacks'* (p.6, Socialist Republic

of Vietnam, 2017). The implementation of a DDWP fits within this resolution and the previously mentioned goals. If implemented sufficiently, a DDWP can improve the efficiency of water resource use (diminish groundwater) and provide more households with fresh water. Furthermore, the implementation research takes the economic-, social and environmental dimensions into account and is scientifically based, which correspond with the previously stated rules for project implementation.

As previously mentioned, the national government issues decrees that translate laws and resolutions into practical guidelines. For the implementation of a DDWP and tackling the problem of land subsidence two decrees are especially of importance. Firstly Decree No. 179/1999/ND-CP that focuses on state management, exploitation, utilization and protection of water resources, especially relating to wastewater discharge. According to this decree, organizations and individuals that exploit groundwater must comply with regulations that protect aquifers and groundwater exploitation is only permitted when a permit is granted by the (local) government, with the exception of domestic use with limited quantities. Furthermore, it is forbidden to discharge untreated, or wastewater that is not treated according to the quality standards outlined in environmental protection law, into water resources (Loan, 2014). Secondly, the recently issued Decree No. 167/2018/ND-CP is of importance to tackle the problem of land subsidence since it further restricts groundwater use (Ministry of Natural Resources and Environment of the Socialist Republic of Vietnam, 2019). It is evident that these decrees put an emphasis on the protection of groundwater resources, which is not hampering but actually enhancing the implementation success of a DDWP in the VMD, since it has as aim to limit the use of this water source. Furthermore, when wastewater is used within a DDWP, this water is treated before use. Furthermore, treating wastewater to use for domestic purposes is a form of water reuse and actually diminishes wastewater discharge, and thus compatible with rules outlined in Decree No. 179/1999/ND-CP. The management of the wastewater is incorporated in the national environmental protection law, however, this does not exclude managing wastewater decentralised (Water Environment Partnership Asia & Institute for Global Environmental Strategies, 2014).

It can thus be concluded that the institutional framework in Vietnam allows for the implementation of a DDWP. The implementation of a DDWP complies with the Law on Water Resources No. 8/1998/QH10 that is the foundation of Vietnamese water governance. It further complies with Resolution 120/NQ-CP on the sustainable development of the VMD and is a solution to the intention to manage and limit groundwater use as outlined in Decree 179/1999/ND-CP and Decree 167/2018/ND-CP. Therefore, the condition 'the institutional framework allows for the implementation of a decentralised domestic water provision' is scored as present (+/+).

5.2.2 Cooperation between departments

Multiple ministries and their local departments work on the water provision within the VMD, of which MARD and the Ministry of Natural Resources and Environment (MONRE) are most important (see table 13). Furthermore, the management is divided under four state management levels: the centre (national), the province, the district and the commune (Waibel et al., 2012). However, for a successful implementation of a DDWP, it is important that all these departments efficiently cooperate with each other.

Ministry	Functions within water provision
Ministry of Agriculture and Rural Development	In charge of hydraulic engineering and water service delivery.
Ministry of Construction	Responsible for the construction of urban water supply, sanitation and drainage.
Ministry of Natural Resources and Environment	Manages water resources, water use, pollution and hydrology.
Ministry of Health	Controls drinking water quality.
Ministry of Science and Technology	Manages the technology relating water supply.
Ministry of Planning and Investment	Allocates the state budget and approves investment projects.
Ministry of Finance	Distributes the state funds to sectors and project and sets annual goals.

Table 13: ministries responsible for the water supply and their functions within this aspect. Sources: (Waibel et al., 2012; Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013).

As can be derived from table 13, the water provision cross cuts between quite a lot ministries. Taking into regard that this is then further managed on three different levels, it can be expected that some coordination problems may occur. This is indeed a common problem with the implementation of projects within the VMD. Water resources are often top-down managed and coordination between Mekong Delta provinces and Hanoi is lacking. Furthermore, with the implementation of development plans within the VMD in general, there is a fragmentation between ministries, provinces and between ministries and provinces present. In the period of 2010-2020, different planning processes took place within the ministries, who did not communicate sufficiently with each other. As a result, unfeasible targets for the delta were set and 19000 plans were formulated and sent from the national to local level. Achieving all targets and plans would have required an area four times larger than the whole Mekong Delta (Seijger et al., 2019). Not surprisingly, some respondents wished for the departments to collaborate more within policy making, such as a collaboration between the Ministry of Finance and MARD. Furthermore, a respondent would like a decentralisation of policies to the local level, since they have more knowledge on the specific area and can easier respond to occurring problems [GO8]. However, this local affiliation can create some problems as well. As stated in chapter 5.2.1 it is not permitted to discharge untreated wastewater, or wastewater that is not treated to the national standard, into water resources. However, on commune level this is often overlooked: the poorer households are not punished because the local government (or head of the commune) does not want to further decrease their standard of living, while the more affluent households are often not punished because their donations are needed for the development of the area (Waibel et al., 2012).

The lack in coordination between provinces of the VMD and ministries is a known phenomenon within the Vietnamese Government. The MDP states that more collaboration is needed and the Prime Minister issued Decision 593, that tries to improve interprovincial collaboration in order to ensure economic growth. Furthermore, provincial authorities recognized the problems and tried to collaborate more efficiently together. However, solving this problem is not easy and a lot of problems are still present, such as power differences between provinces. Rich provinces upstream, such as Can Tho, have more power than the poorer provinces downstream (Waibel et al., 2012).

It seems that the problems regarding collaboration and communication between the national and local level and between the different provinces of the VMD are known and that governmental actors try to solve these problems. However, since they are still apparent and pose problems to the implementation of development plans, and thus may pose problems to the implementation of a DDWP as well, the condition 'there should be sufficient cooperation between departments' is scored as not present (-/-).

5.2.3 Partnerships

Currently, Vietnam remains heavily on international donors to implement water development plans (Seijger et al., 2019). The MDP is written in a collaboration with the Netherlands, a partnership that the Vietnamese Government would like to continue in the future (Socialist Republic of Vietnam, 2017). Furthermore, a group of nine development partners, including the World Bank, Asian Development Bank, the International Union for Conservation of Nature and Deutsche Gesellschaft für Internationale Zussamenarbeit GmbH, formally endorsed the MDP and thus committed to a partnership (Seijger et al., 2019). More examples of collaboration between Vietnam and other partners can be found, such as collaborations between research institutes and universities (such as the Rise and Fall Research Programme) and public-private partnerships, such as the collaboration between Vitens-Evides International, local water companies and the VMD [GO9]. More examples can be found and there is the belief that development plans are easier implemented when international partners are available [GO1]. Vietnam should be careful to not fully depend on international partnerships (Seijger et al., 2019), however, due to the partnerships and collaborations that are already present, and with more opportunities possible, the condition 'there are parties present that can function as a collaboration to work on the implementation of a decentralised domestic water provision' is currently present (+/+).

5.3 Stakeholder engagement

Besides institutional capacity, stakeholder engagement is an important aspect of the government conditions needed for a DDWP. This stakeholder engagement consists of two conditions: there should be communication about drivers behind policies from the government to stakeholders and stakeholders are involved in the planning and development of policies.

5.3.1 Communication about drivers behind policies

Decrees like Decree No. 167/2018/ND-CP are issued to tackle groundwater extraction problems and land subsidence. As stated in chapter 4, the risk and threat perception among households and water companies is low, of which one reason is that they do not know about problems relating to groundwater extraction and land subsidence. It is not surprising to governance officials that households do not know about these problems [GO1; GO4; GO8; VE2; VE3]. Communication from the government about the drivers behind policies, such as knowledge on groundwater extraction, can enhance the knowledge on problems that affect the region. There are efforts to do so. On June 5th there is Environmental Awareness Day, that also pays attention to groundwater extraction [GO1]. Furthermore, there is communication from the local government to stakeholders through speakers in neighbourhoods, the local newspaper, radio and television [GO1; GO4]. However, as previously mentioned, the results of this communication are still low. Households mostly know about problems that directly affect them, such as alum in the aquifers that makes their groundwater well les useable [GO5]. This can partially be explained through the top-down governmental structure in Vietnam, *'the households do not understand why, since this discussion belongs to the government. The content of the paperwork and discussion is quite hard, household just want to have water, so it is hard for us to communicate so they can understand fully'* [GO8]. There is thus an effort to communicate drivers behind policies to households, however, there is not a significant increase in knowledge among stakeholders yet, therefore, the condition 'there should be communication about drivers behind policies from the government to stakeholders' is scored as partially present (+/-).

5.3.2 Involvement in planning and development

Resolution 120 NQ-CP that aims for an economic and sustainable development of the VMD encourages the involvement of all stakeholders to achieve this development (Socialist Republic of Vietnam, 2017). This is not surprisingly, since the MDP states that *'Also, measures will affect the operational field of many stakeholders at the level of authorities as well as at the level of private organisations, industries and e.g. individual farmers or cooperations.'* (p, 19. Kingdom of the Netherlands & Socialist Republic of Vietnam, 2013). Within these stakeholders, three specific groups are defined: experts and specialists from

different sectors, decision makers from local, provincial and national government and representatives of organizations, for example agricultural organizations (Kingdom of the Netherlands & Socialist Republic of Vietnam, 2013).

Within the case of the development of the water provision, stakeholders from the water companies are especially of importance. However, among some respondents there is the notion that the government is solely responsible for policy making [GO4; GO8]. Furthermore, a respondent indicated that policies are something that is hard for him to comprehend, however, it would be good if water companies and the government together would work on policies and local water departments become more involved, because they recognize issues quickly and have a lot of knowledge on the area. Currently they are not involved in finances and mandates which makes policies a complicated concept to understand. Collaboration with other stakeholders, like Vitens-Evides International, are made increase the chances of improving the water provision in an area [GO3]. For the second group, decision makers from local, provincial and national government, chapter 5.2.2. already indicated that there is a gap between the upper and lower governmental levels. However, the governments on district level mostly manage what is mandated by the upper government levels (city wide and above) [GO6]. More decentralisation to the district level and more stakeholder engagement is preferable [GO8]. Representatives from organizations were not directly interviewed for this research, however, recent research on the implementation success of the MDP showed that agricultural organizations and representatives were hardly involved in the planning processes on the Vietnamese Mekong Delta (Seijger et al., 2019).

It seems that the three stakeholder categories as outlined in the MDP, are currently not involved in the development and implementation of policies and that among some stakeholders there is the belief that policies are solely a governmental top-down aspect. Among some stakeholders there is the willingness to participate in the planning and development of policies, which can positively influence the decision making, since they have a lot of knowledge on the area. However, the governance structure is still top-down and they are hardly involved, therefore, the condition is scored as not present (-/-).

5.4 Conclusion

Within the governmental conditions, the institutional capacity and stakeholder engagement are two important variables for the implementation of a DDWP in the VMD. On the aspect of institutional capacity, it seems that the institutional framework allows for the implementation of a DDWP and there are enough partnership available to stimulate an implementation plan. The biggest problem seems to be the cooperation between governmental departments, which is lacking. There are efforts from the government to solve this problem, however, the cooperation between the national and local level and among provinces of the VMD is not sufficient. On the aspect of stakeholder engagement, some governmental department try to communicate about drivers behind policies to stakeholders, but it is a complex subject and has not reached its full potential. Furthermore, stakeholders are not involved in the planning and development of policies, even though some local departments want to be more involved. The governance structure is top-down arranged. The next chapter assesses the presence of economic conditions for the implementation of a DDWP in the VMD.

Chapter 6: The presence of economic conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta

6.1 Introduction

This chapter elaborates on the presence of the economic conditions that are needed for the feasibility a DDWP. For each condition, a score that indicates the presence of the condition is given per actor group (households and governance agencies). Table 14 provides an overview of the conditions with a score per actor, this will further be elaborated in the subchapters below.

Ability	Economic Conditions			
	Variable	*Condition*	*Presence conditions among households*	*Presence conditions among governance agencies*
	Financial Capital	There is enough financial capacity available for the implementation, operation and maintenance of a decentralised water provision system.	-/-	+/-
	Willingness to pay	There is a willingness to pay among the implementers and users of the decentralised domestic water provision system.	-/-	-/-
	Externalities	Externalities are taken into account in policy- and or financial- decision making.	n/a	+/-

Table 14: the presence of economic conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta.

6.1 Financial capital

Household perspective

Even though the availability of financial capital was not directly asked to households (due to information sensibility) some households stated themselves in the interviews that they would rather have a CDWP, simply because they did not have the funds to address the possibility of a DDWP. Furthermore, of the households that were not connected to the CDWP, the high costs of implementation were sometimes the reason. This is not surprisingly, since the VMD is one of the poorest regions of Vietnam (Kingdom of

the Netherlands & Socialist Republic of Vietnam, 2013). Therefore, the presence of this condition among households is scored as not present (-/-).

Governance agencies

It seems that the availability of financial capital to invest in decentralised measures can pose a threat to the implementation of a DDWP. Most respondents did not have specific knowledge on the financial capital of the local government, but did indicate that costs could be a specific problem and that financial assistance of the private sector may be needed. In the city centre of Can Tho a stormwater catchment pond is installed, with as main aim to prevent flooding. However, this was really expensive and it can be expected that when this water then has to be filtered to be used for domestic purposes, the costs will increase even more. According to one respondent this financial limitation is one of the reasons that *'an additional decentralised water provision is a reasonable idea, but not a feasible idea'* [GO1]. Furthermore, other decentralised measures that are designed to improve water provision in Vietnamese cities, using rainwater harvesting were never installed due to financial limitations [VE8]. However, it is recognized that chances can increase with the help of foreign aid [GO1; GO9], subsidies provided by the government [GO2], investments from the private sector and that some decentralised measures can offer a low-cost solution [VE2].

Especially for the implementation of domestic WWT, financial capacity could pose real implementation problems. Currently, the collection of wastewater in Vietnam is covered by provincial or city budget. However, this budgets are not sufficient to cover all the costs (only around 10-20%) and exclude the operation and maintenance of the treatment centre. The rest of the costs mostly have to be generated from the income of the water companies, i.e. the revenue created from the community payments for their water services (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013). As already stated, the VMD is one of the poorest regions in Vietnam (Kingdom of the Netherlands & The Socialist Republic of Vietnam, 2013), it can thus be expected that recovering the costs of decentralised WWT measures is not a feasible solution. Not surprisingly, this is already an evident problem among Vietnam and most local government do not have enough money to complement the rest of the costs (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013).

It thus seems that there are some tremendous problems that need to be overcome to install a DDWP in Can Tho City, especially relating to decentralised WWT. However, since the exact financial capital is uncertain among governance agencies and there could be potential to increase the financial capacity through government subsidies, foreign aid, investments from private sector and a (partial) recovery through household bills the condition is rated as partially present (+/-).

6.2 Willingness to pay

Household perspective

As stated in chapter 6.1, some costs for the operation and maintenance of a DDWP, especially in the case of wastewater, would be collected through the water bill from households. As can be seen in figure 17, households are not reluctant to pay a bit more if the water accessibility is improved. However, as is stated in chapter 4, the water accessibility is not perceived as low among the households and households do not think that a DDWP will improve the water accessibility. This may pose problems in the future for the implementation of a DDWP, since besides environmental benefits, an improved water accessibility is the main driver for implementing this possible solution. Not surprisingly, most households stated that they are not willing to pay more for the implementation of a DDWP (see figure 18).

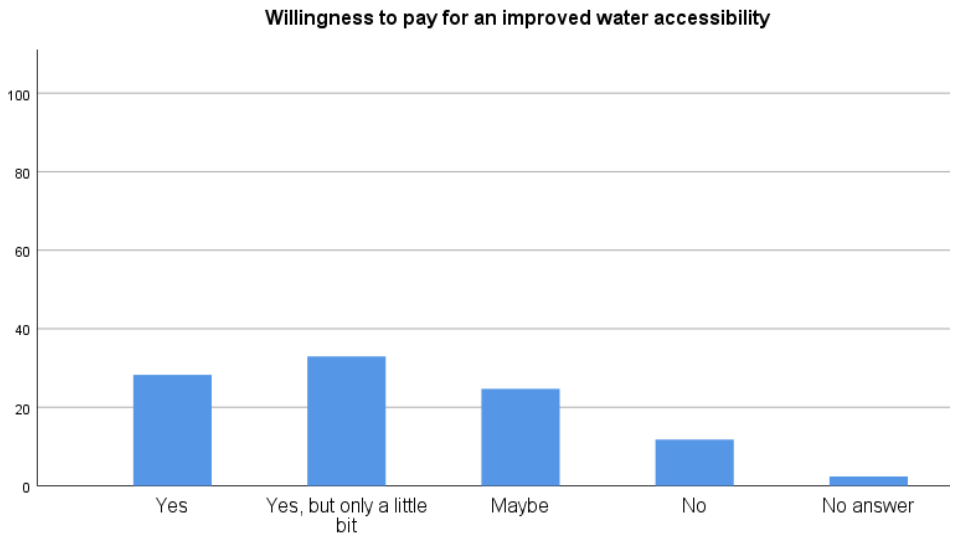

Figure 17: willingness to pay for an improved water accessibility among households (in %).

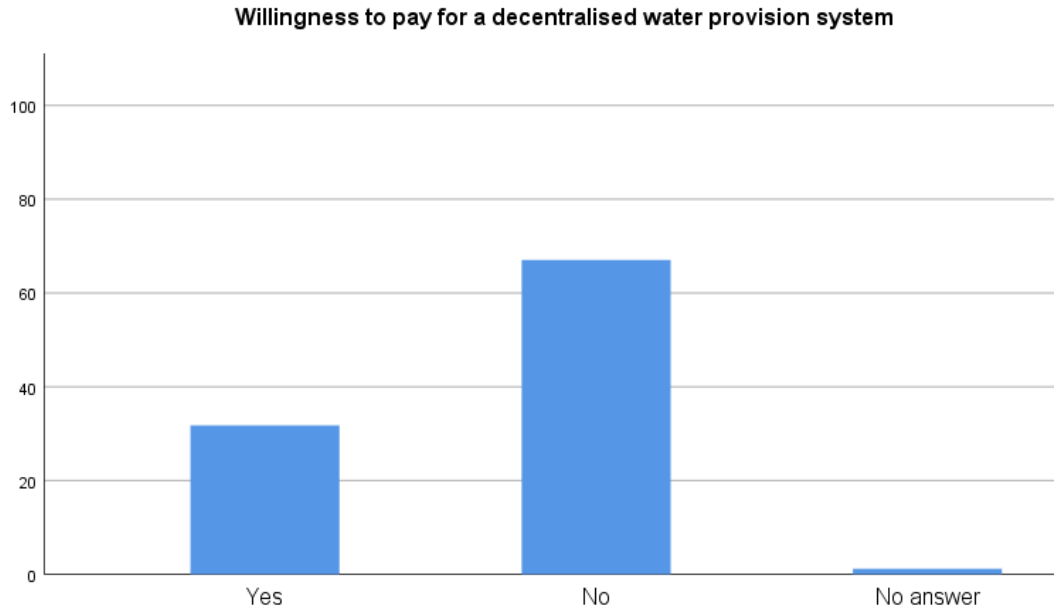

Figure 18: willingness to pay for a decentralised water provision system among households (in %).

Furthermore, households were asked when if a DDWP would be implemented, who they thought would be responsible for the implementation costs and the operation and maintenance costs. These costs were taken separately since, as explained in chapter 2, there could be a mixed form in a DDWP. For example, the government can take the responsibility in placing the system, while the community is expected to manage it. As figure 19 shows, most households expect the government to pay for the implementation as well as the operation and maintenance. However, there is a significant amount of households that holds the community or the community as well as the government responsible. There is no significant statistical difference between the three districts.

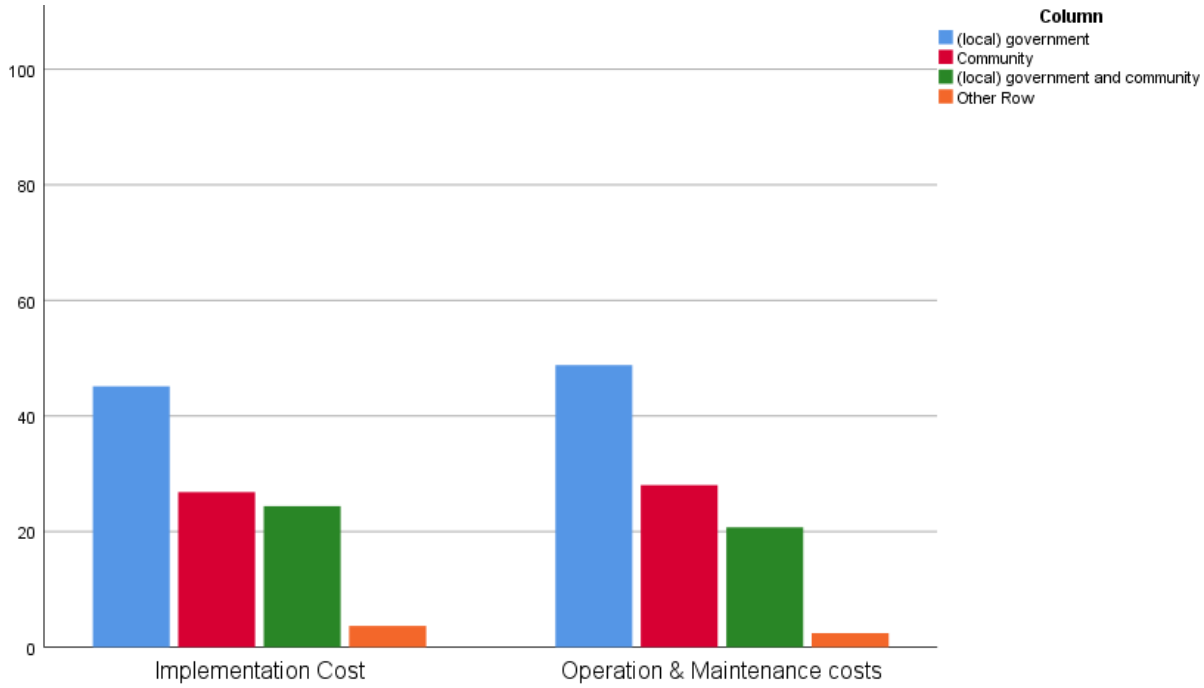

Figure 19: responsibility for the costs of a DDWP according to households (in %).

It thus seems that the willingness to pay among households is not present (-/-). Households are willing to pay a bit more for an improved water accessibility, however, they mostly perceive their water accessibility as high and most of them do not think that a DDWP is a solution to improve their water accessibility (see chapter 4.3.2). Furthermore, they are not willing to pay more for a DDWP and most households hold the government responsible for implementation as well as operation and maintenance costs.

Governance agencies

Among the governance agencies that would be responsible for the implementation of a DDWP (the local government and/or the water companies) there seems to be no agreement on the payment responsibility. The central division of CANTHOWASSCO indicates that they find DONRE fully responsible for the implementation as well as the operation and maintenance costs. In contrast, the local water supply stations of CANTHOWASSCO hold the central division of their company responsible. According to DONRE, households will mostly be responsible, however they should be supported by the local government through subsidies [INTERVIEWS]. There thus seems no willingness to pay among any of the possible governance agencies to cover these costs, therefore this condition scored as non-present (-/-) among governance agencies as well.

6.4 Externalities

Governance agencies

In the MDP, externalities are taken into account when talking about economic costs, especially related to environmental benefits and flood risk reduction (Seijger et al., 2019). This argument is partially underlined by data derived from the interviews. According to one respondent, externalities became more important since 1996. First, there was more a focus on social costs, but currently environmental benefits are taken into account as well. On the aspect of domestic water provision, especially social externalities that are taken into account are apparent. With the start of the improvement of the domestic water provision within Vietnam, the government and CERWASS provided free RWST to rural households that live too far away to connect to the CDWP and to households with members that fought in the Vietnam War. Furthermore, the first 3 m^3 of water provided to rural households in Can Tho City

is free, to improve the water accessibility. However, this has as downside that some households only use the freely provided water and complement their water use further with alternative water sources [GO1].

However, there are no specific examples of externalities relating to environmental benefits within the domestic water provision, even though an increasing focus on reducing environmental harm is apparent [INTERVIEWS]. Furthermore, in contrast to the previously mentioned interview, a respondent from the water supply company indicated that they would always choose for the cheapest technologies available, since more expensive measures do not guarantee a better water provision. This same respondent did not take it into account when improving the water provision in rural districts as well, since the rapid urbanization would transform these areas in the future. Thus there seems no incentive to economically invest in them now, this money could better be used elsewhere [GO2].

There thus seems a discrepancy between the view of the local government and the water supply company, that can influence decisions where externalities are of importance. Furthermore, there seems an incentive to further take environmental benefits into account, but relating to the domestic water provision this is not as apparent in concrete examples as is the case with the social externalities. However, this may could partially be explained through the time scale in which these aspects became of importance: improving the social conditions in Vietnam already started after 1996, while environmental benefits are currently becoming more important today. In conclusion, it can be said that externalities are taken into account, but that there could be more direct examples of environmental benefits within the domestic water provision. Furthermore, the view of the water supply company CANTHOWASSCO is not as progressive as that of the local government. Therefore, the condition regarding externalities among governance agencies is scored as partially present (+/-).

6.5 Conclusion

It seems that the economic conditions for the implementation of a DDWP in the VMD are lacking. Among households there is no financial capital available. Among governance agencies, the financial availability is not certain, however, current projects face problems with financing. Aligning funds through subsidies, foreign aid and the private sector may pose a solution to create financial capital. However, there seems to be no willingness to pay among any of the actor groups that would be involved in the implementation of a DDWP (households, governmental department, water supply company). They each hold someone else responsible for the payment of the implementation and operation and maintenance of a DDWP. Externalities are taken into account, however, especially social externalities and mostly within the governmental departments. Among the water company externalities seem less of importance. The next chapter will look at the presence of technical- and geographical conditions for the implementation of a DDWP in the VMD.

Chapter 7: The presence of technological- and geographical conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta

7.1 Introduction

This chapter elaborates on the presence of the technological- and geographical conditions that are needed for the feasibility a DDWP. For each condition, a score that indicates the presence of the condition is given per actor group (households and governance agencies). Table 15 provides an overview of the conditions with a score per actor, this will further be elaborated in the subchapters below.

	Technical- and geographical conditions			
	Variable	*Condition*	*Presence conditions among households*	*Presence conditions among governance agencies*
Ability	Equipment availability	The technologies and equipment for the implementation of decentralised water provision are available for the area.	+/-	+/-
	Knowledge availability	There is a sufficient amount of people with the knowledge and skills to implement decentralised domestic water provision systems in the area.	+/-	+/-
	Geographical conditions	The geographical conditions of the area are sufficient for decentralised domestic water provision technologies.	+/+	+/-

Table 15: the presence of technical- and geographical conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta.

7.1 Equipment availability

Household perspective

The technological availability can be hard to measure, since a DDWP comes with a lot of different technologies. However, focusing on the main technologies needed, it can certainly provide some important insights. On the household level, it seems that for the use of rainwater, technologies are widely available. The survey data showed that only 28.2% of the respondents has a rainwater storage tank. However, as some respondents indicated, they used to possess a rainwater storage tank, but did not use it anymore or got rid of it after they connected to the CDWP [SURVEYS]. However, it is evident that the households are familiar with the use of rainwater and RWST are a common phenomenon in the delta (Özdemir et al., 2011). In contrast with rainwater, wastewater is not a widely known water source. Furthermore, the households who do reuse their wastewater (for example to water trees and plants), do this without treating the water source first [SURVEYS]. Therefore, this condition among households is partially present (+/-), since the equipment for RWH is widely available and used within the delta, but the technology for WWT among households is not present.

Governance agencies

The use of rainwater is recognized by governance agencies and as the household perspective shows, this equipment is widely available [VE2; VE1; VE8]. However, SWC and WWT prove to more difficult in terms of equipment availability. In the case of SWC, which is mostly applied within Can Tho to prevent flooding, monitor equipment to indicate the amount of stormwater is present. However, this is more available for the urban areas of the VMD and less for the rural areas. Here, they mostly rely on (natural) wetland storage [VE5]. As is evident from previous chapters as well, wastewater is proven to more difficult. Current projects that are implemented are delayed, partially due to technological constraints [VE]. However, within Vietnam low-cost technologies as waste stabilisation ponds or constructed wetlands are becoming more familiar (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013). And as stated previously, these are present within the delta and sometimes used for SWC as well. Furthermore, providing sceptic tanks to households may be a solution to improve WWT on the household scale. Some households already use these sceptic tanks [VE5]. They are also a common feature in the rest of the country (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013).

It thus seems that the equipment availability is partially present (+/-). Especially for RWH, the equipment is widely available. However, equipment for SWC and WWT is less common. Advanced technologies for SWC are more available for the urban areas of the VMD than the rural, but the latter have more natural solutions as wetlands available. WWT technologies are in development on a centralised scale, however, more simple WWT equipment, such as sceptic tanks for sanitation, are present within the delta and some households.

7.2 Knowledge availability

Household perspective

From a household perspective, there is no decisive perception on the availability of knowledge and skills for the development and implementation of a DDWP in the VMD (see figure 20). Most household think there are not enough knowledge and skills present. However, the difference between households who do think this is available or the ones that do not know, is not significantly high. Some households further indicated that it would be dependent on where the VMD these people would live, but that they could be present [SURVEYS]. Therefore, the condition is partially met from a household perspective (+/-). There were no significant statistical differences between the districts.

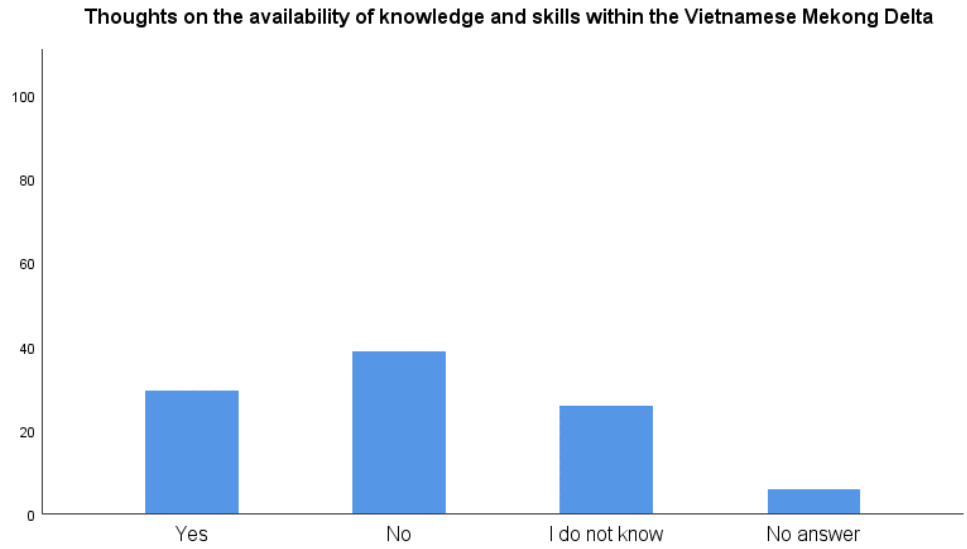

Figure 20: thoughts on the availability of knowledge and skills within the Vietnamese Mekong Delta (in %).

Governance agencies

Experts in the field of groundwater governance or water provision mostly did not have direct expertise on a DDWP. However, knowledge on groundwater, certain technologies, WWT and water governance is present [VE1; VE2; VE3; VE4; VE5; VE6; VE7; VE8]. Furthermore, previously mentioned projects on WWT, mostly for industrial zones, the creation of stormwater storage ponds in Can Tho City and the familiarity with rainwater harvesting indicate that knowledge on these aspects is available. One respondent, even designed a solution for flooding in cities where houses are built with an optimized stormwater runoff, which then can be harvested in rainwater storage tanks and used for domestic purposes [VE8]. This is designed for the household scale and thus indicates that knowledge on designing decentralised solutions is present. However, there are limitations as well. Especially for decentralised WWT projects, there is often a lack of standards and guidelines for the design, construction and operation and maintenance of these systems. Furthermore, relevant stakeholders often lack information and knowledge on decentralised options, most knowledge available relates to centralised solutions (Water Environment Partnership Asia & Institute for Global Environmental Challenges, 2013). From a governance agency perspective it can thus be concluded that the condition is partially present (+/-) as well.

7.3 Geographical conditions

Household perspective

On the household scale the most important geographical condition is that the residential area is suitable for the implementation of a DDWP. As stated in chapter 2.3.1 households can harvest rainwater when they have a RWST and when the rainwater collection system (mostly roofs) is sufficient. As explained in chapter 4, households are familiar with the use of rainwater and of the respondents 28.2% had a RWST in their possession. Furthermore, more households used to have one in the past, but disregarded it after their connection to the CDWP [SURVEYS]. Within the RWST owners, a slight majority (58.33%) did not find their RWST sufficient to store the capacity of rainwater needed. However, only 4.17% of these respondents indicated that they did not have the space to upgrade their RWST, which indicates that the geographical conditions to place a higher capacity RWST are available in their residential area. Furthermore, a majority of households had a shed or gable rooftop (see figure 21 for visual representation of rooftop types), which are suitable for the collection of rainwater (see figure 22).

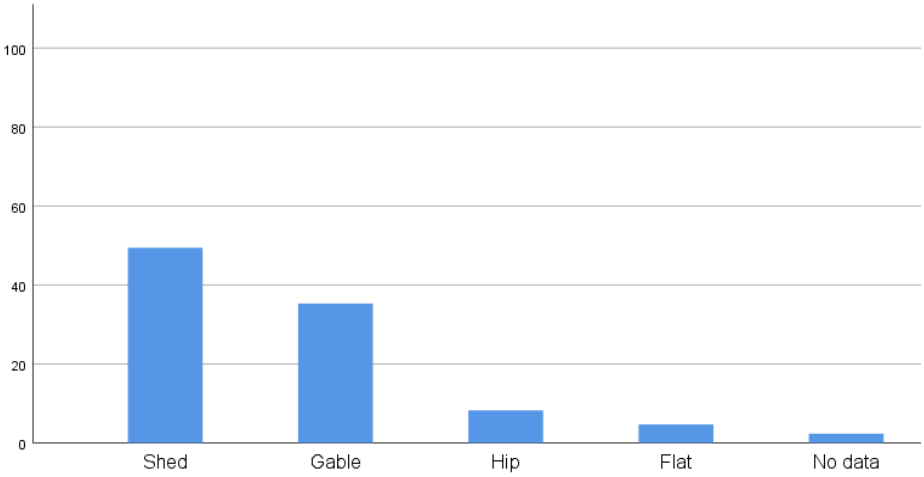

Figure 21: roof types in the rural districts of Can Tho (in %).

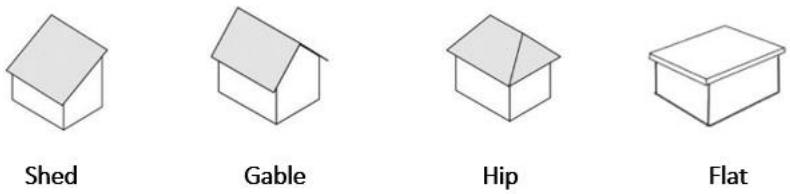

Figure 22: examples of roof types.

The use of stormwater and wastewater needs enough space, but this is not limited to the personal residential area of the households and can therefore be disregarded in this perspective. Thus, it can be concluded that from a household perspective, the geographical conditions are present (+/+).

Governance agencies

The success of the geographical conditions for a DDWP is mainly dependent on the geographic suitability for the (decentralised form of) alternative water sources rainwater, stormwater and wastewater. In general, all strategies may be suitable when taking the geographical conditions of the VMD in mind [VE2]. However, all alternative water sources face some limitations as well. In the case of RWH, storing the rainwater forms a major limitation. Approximately 90% of the rainfall falls in the wet season from May-October, storing this rain for the dry season is theoretically possible, but practically not feasible (mainly due to financial constraints) (GO1; Özdemir et al., 2011). SWC is mostly suitable for the rural areas, where there is the space to build a SWC pond. However, for the more urbanized areas there is a lack of space which makes the solution harder to implement [GO1]. It is currently mostly applied in low land an depression areas, which are most suitable for this alternative water strategy [VE2]. WWT is still under development and currently most applied on a centralised scale in industrial zones, however, it could also be suitable for peri-urban areas due to the availability of space here [VE2].

Thus, all alternative water resource strategies are theoretically feasible in term of geographical conditions, but face some limitations. However, for the addition of a DDWP based on these water sources in general, two major limitations occur. Firstly, in upstream provinces in the VMD, especially Can Tho, surface water is abundant [VE2]. This influences the threat and risk perception as outlined in chapter 4. Upstream provinces have concerns on water quality and in Can Tho they are developing solutions to tackle this problem for the water provision in the future, such as big reservoirs and a more responsive monitoring system. However, using alternative water resources to tackle groundwater

extraction is less taken into consideration, since the abundancy of surface water diminishes the need to do so [GO2; VE5]. It could therefore be a more suitable solution for coastal provinces or provinces that face salinity and do not have a lot of surface water, like An Giang province [VE5; GO6]. The second problem that occurs within the research area of Can Tho City is urbanization of peri-urban and rural areas. Rural areas are becoming peri-urban areas and are treated as such, with water provision development plans based on the centralised approach as is applied in the urban area [VE2]. This faces the risk and threat perception on water accessibility and groundwater use in the rural areas as well, '*You should not invest in it (the rural areas), since in the future people will move to the urban areas, so you should not focus too much on the rural areas now. People still living there in the future can get subsidies from the government.*' [GO2]. There are limited funds available and the urbanization of the rural and peri-urban area thus decreases the risk and threat perception: you can better improve the centralised strategy for urbanized areas and connect these areas, than invest in an area while this may be dispensable when the urbanization trend keeps increasing.

In general, the geographical conditions in the VMD are suitable for a DDWP. However, it depends on where in the VMD this would be implemented, since the local characteristics of the provinces differ. For the research area and other upstream provinces, the geographical conditions of abundant surface water and the rapid urbanization rate influences the risk and threat perception that is needed for implementation. Therefore, the condition is scored as partially present (+/-).

7.4 Conclusion

It can be concluded that on a technological aspect, the equipment for RWH is widely available. The equipment for SWC and WWT is more challenging, however, there are (centralised) projects focused on these water sources and especially in rural areas natural solutions, such as wetlands, are available that can store stormwater. Knowledge and skills regarding alternative water sources is available in the VMD, however, it seems that experts often lack the knowledge on the decentralised form of the technology and clear guidelines for implementation are lacking. On the geographical scale, theoretically all the conditions for the implementation of a DDWP are present. However, practically three limitations occur: firstly, there is the dependency on rainfall in the wet season and the problem to store this in the dry season. Secondly, the wide availability of surface water affects the threat and risk perception of stakeholders, since water seems abundant. Thirdly, the fast urbanization of Can Tho City transform rural areas into peri-urban areas, which makes it less appealing for stakeholder to make special development plans for these areas. The next chapter will outline the conclusion and limitations of this research and provides policy recommendations for the implementation of a DDWP in the VMD.

Chapter 8: Conclusion, limitations and recommendations

8.1 Introduction

This chapter provides the conclusion of this research and assesses whether an implementation of a DDWP is feasible in the VMD. Furthermore, the limitations of the research are provided and policy recommendations regarding a DDWP in the VMD are given.

8.2 The presence of conditions for a decentralised domestic water provision in the Vietnamese Mekong Delta

This research assessed the feasibility of a DDWP in the VMD, in order to reduce the pressure on groundwater resources and pose a solution to land subsidence in the area. The following research question was guiding for this research:

'To what extent is it feasible to implement a decentralised domestic water provision in the Vietnamese Mekong Delta in order to diminish groundwater extraction?'

In order to answer this question, conditions that need to be present for the implementation of a DDWP were defined. Furthermore, the presence of these conditions within the VMD were defined through data collection consisting of an extensive review of grey- and scientific literature and the conduction of interviews and household surveys. Table 16 provides an overview of the presence of these conditions in the VMD. In the subchapters below, these results will be guiding to assess the availability of the motivation and ability to implement a DDWP in the VMD and answer the research question.

Social Conditions				
Motivation	*Variable*	*Condition*	*Presence conditions among households*	*Presence conditions among governance agencies*
	Threat perception	There is sufficient knowledge about groundwater extraction and land subsidence	-/-	+/-
	Risk Perception	There is familiarity with the use of rainwater, stormwater and wastewater (treatment).	+/-	+/-
		There is a not too high perceived risk in term of perceived water quality.	-/-	+/-
Ability	Governmental Conditions			
	Variable	*Condition*	*Presence of Conditions*	
	Institutional Capacity	The institutional framework allows for the implementation of a decentralised domestic water provision.	+/+	
		There should be sufficient cooperation between departments.	-/-	
		There are parties present that can function as a collaboration to work on the implementation of a decentralised domestic water provision.	+/+	

	Stakeholder Engagement	There is communication about drivers behind policies from the government to stakeholders.	+/-	
		Stakeholders are involved in planning and development of policies.	-/-	
	Economic Conditions			
	Variable	*Condition*	*Presence conditions among households*	*Presence conditions among governance agencies*
	Financial Capital	There is enough financial capacity available for the implementation, operation and maintenance of a decentralised water provision system.	-/-	+/-
	Willingness to Pay	There is a willingness to pay among the implementers and users of the decentralised domestic water provision system.	-/-	-/-
	Externalities	Externalities are taken into account in policy- and or financial- decision making.	n/a	+/-
	Technical- and geographical conditions			
	Variable	*Condition*	*Presence conditions among households*	*Presence conditions among governance agencies*
	Equipment Availability	The technologies and equipment for the implementation of decentralised water provision are available for the area.	+/-	+/-
	Knowledge Availability	There is a sufficient amount of people with the knowledge and skills to implement decentralised domestic water provision systems in the area.	+/-	+/-
	Geographical Conditions	The geographical conditions of the area are sufficient for decentralised domestic water provision technologies.	+/+	+/-

Table 16: the presence of conditions needed for a DDWP in the VMD.

8.2.1 Availability of a motivation for the implementation of a decentralised domestic water provision

The motivation among actors, that needs to be present for the successful implementation of policy plans, in this case a DDWP, was assessed through the social conditions 'threat perception' and 'risk perception'. As can be derived from table 16, none of the conditions is fully present among actors in the VMD. The presence of threat perception is slightly higher among governance officials than households, however, this is due to the knowledge on problems in the area among government officials and Vietnamese experts. Among the water supply company, the threat perception was non-existent, as is the case with households in the VMD. On the aspect of risk perception, there seems to be a slight familiarity with the proposed alternative water sources and the use of a DDWP. However, this was

mainly due to the familiarity with RWH which is a common practice within the VMD. Furthermore, especially among households, actors have concerns about the guarantee of a sufficient water quality within a DDWP.

8.2.2 The availability of abilities for the implementation of a decentralised domestic water provision

Whether actors in the VMD have the ability to implement a DDWP in the VMD, was assessed through the presence of governmental-, economic- and technical- and geographical conditions. Within the governmental conditions, the institutional capacity of the VMD is more promising for the implementation of a DDWP than the availability of stakeholder engagement. On the aspect of institutional capacity, the institutional framework allows for the implementation of a DDWP in the VMD. Furthermore, there is the availability of partnerships that can help in stimulating this implementation. However, the cooperation between different governmental departments seems hampering for the uptake of a DDWP, since there is a lack of coordination between the national government and the local government and problems between the provincial governments. Furthermore, stakeholder engagement seems lacking within the VMD. There is an effort to communicate drivers behind policies to stakeholders, however, the results are lacking. Furthermore, there is no stakeholder engagement in the development of policies.

The economic ability within the VMD seems most challenging. Households do not have the financial capital to implement a DDWP, while the presence of financial capital among governance agencies is uncertain. Furthermore, it seems that none of the actors is willing to pay for the implementation of a DDWP in the VMD and that externalities are not fully taken into account yet. The focus on externalities within economic decision making is the highest within government officials, however, environmental externalities are lacking behind social externalities. Nonetheless, this could be different in the future, since the focus on environmental development is relatively new in Vietnam compared to the focus on social development. Lastly, there needs to be a technological ability present in the VMD and the geographical conditions have to be suitable for the implementation of a DDWP. As can be seen in table 16, the technological aspect (equipment availability and knowledge availability) are not fully present in the VMD. Technology and knowledge regarding RWH is widely available, while WWT seems to be the most challenging alternative water source. This is mainly due to its developing character in Vietnam. Furthermore, when there is the knowledge available for the implementation of alternative water resource strategies, this is mainly focused on a CDWP instead of a DDWP. Geographical conditions are present, but the difference in rainfall, abundancy of surface water and rapid urbanization of some cities and provinces could be challenging for the uptake of rural investment projects.

8.3 Overall conclusion

For the implementation of a DDWP in the VMD to be feasible, actors within the VMD need to have a sufficient motivation and ability to do so. Currently, these aspects are not sufficiently present among actors in Can Tho City. Especially in relation to the motivational aspect, the threat and risk perception in the VMD seems hampering for the uptake of decentralised solutions due to a lack of knowledge on groundwater issues, non-familiarity with most aspects of a DDWP and a high perceived risk in water quality of alternative water sources and decentralised solutions. Within their ability to implement a DDWP, none of the variables for the governmental-, economic- and technical and geographical abilities are fully present. Especially the economic ability seems most challenging, due to an uncertainty in financial capability and an unwillingness to pay among important actors. Furthermore, on the governmental side there seem to be problems with coordination between departments and stakeholder engagement. Even though the government has as aim to improve these aspects within the VMD. Within technical capabilities, there is knowledge available, but lacking on decentralised solutions. Besides, the

rapid urbanization and surface water abundancy in the VMD seems to be hampering the uptake of a DDWP.

Furthermore, the implementation of a DDWP was proposed to reduce the groundwater extraction in the area. However, as this research showed, within the research area, there is a main focus on surface water and the use of groundwater is not that high. Therefore, it seems that currently the implementation of a DDWP in the VMD is not feasible in terms of implementation capacity and in terms of tackling groundwater problems. However, the VMD is a diverse area where local conditions differ greatly, especially between upstream and downstream areas. Therefore, even though this research area shows a non-feasibility for the uptake of decentralised solutions within the VMD, the results may differ in another research area. This and other limitations to this research are further addressed in the next subchapter.

8.4 Limitations of the research

In order to get a comprehensive view on the feasibility of a DDWP in the VMD, some limitations of this research need to be addressed. Firstly, this research provided a solution to tackle groundwater problems by proposing a DDWP based on rainwater, stormwater and wastewater. However, surface water was not taken into account as alternative water source, while this is abundant within the VMD and the main alternative strategy (as alternative to groundwater) among actors within the research area. Alternative strategies proposed by respondents, which are not taken up in the research, were based on the use of this water source. However, surface water is decreasing in quality and for this water source to be sufficient in terms of quantity and quality for the future, adaptation plans are needed.

Secondly, local characteristics within the delta differ widely within provinces and regions. Due to the effect of urbanization on land subsidence and the groundwater use in the rural districts of Can Tho City, this research are was the main focus of this research. However, the results may differ in a downstream province where surface water is less abundant, saltwater intrusion is more challenging and the groundwater dependency is higher. This research gives a good indication for provinces with the same characteristics as Can Tho province, however, further studies could be conducted to assess the feasibility of a DDWP in other areas within the VMD.

Thirdly, the exact research areas where the interviews and surveys were conducted, were determined beforehand by the Vietnamese government. This may have led to uncertainties in the data. The local water supply stations talked to all belonged to CANTHOWASSCO, which provides water to the urbanized areas of the rural districts and focuses on the use of surface water. The research team did not succeed to talk to CERWASS, the water company that focuses on groundwater and it is uncertain from which water supply company the interviewed households receive their water from. However, its seems most likely that the interviewed households are all connected to the surface water company. For further research, it could be interesting if CERWASS and the households connected to this company were interviewed as well to get a clear image of the groundwater use within the districts.

Lastly, there may be a bias in the data due to language barriers. For the literature review only English literature was studied. Furthermore, most interviews and all the surveys were conducted in Vietnamese and later translated to English, which may caused information loss. However, this research tried to diminish this aspect by recommendations for articles from the contact persons within the Rise and Fall Research Programme within Vietnam and through direct translation during the interviews. The latter provided the researcher the opportunity to directly clarify with the translator and respondent when answers were unclear.

8.5 Recommendations

Relating to the results found in this research, this study can provide some recommendations for policy makers and further research.

Firstly, it is recommended that the Vietnamese Government educates on groundwater extraction and land subsidence within the VMD to raise awareness among actors. Knowledge on these problems among households and other stakeholders can improve the uptake for a DDWP or other proposed projects that would like to tackle this problem.

Secondly, this study recommends the Vietnamese Government to further strengthen the coordination between governmental departments to ensure a sustainable development of the VMD. Currently, a lot of departments are working on water related issues within the VMD and make plans separately. Working together on these issues and create development plans that are aligned with each other can positively stimulate the development of the VMD and makes it easier to implement plans. Furthermore, it is recommended that more stakeholders are involved in formulating these policy plans, especially local government departments (of the target area), since they have most knowledge on the issues affecting the area.

Thirdly, it is advised that experts are not only educated on centralised solutions, but on decentralised solutions as well. Currently, there is knowledge on certain water provision technologies, however, the implementation of a DDWP is negatively influenced due to the focus on centralised approaches. Broadening this knowledge among expert enhances the expertise within the VMD and ensures a greater responsiveness to local conditions, since the most suitable approach for an area is chosen. Starting with updating and expanding the current guidelines and manuals on decentralised technologies can be a good starting point for this.

Fourth, this study advices other researchers to map the groundwater uses in the rural areas of rural districts as well. It is uncertain how quick the urbanization process of rural districts within the VMD will take and to efficiently tackle the problem of groundwater over extraction and land subsidence, it is important to map the groundwater use in more areas.

Fifth, further research should look into the pollution of surface water and assist in the formulation of adaptation plans to ensure a fresh water supply in the VMD. If surface water is the preferred alternative water source (opposite to groundwater) then it is important that this water supply is secured for the future. Furthermore, it is recommended to keep researching the VMD since it a vulnerable delta with high (economic) value, insights in water uses and water issues affecting the region can help in developing the VMD sustainably and ensure that ‘the rice bowl of Vietnam’ keeps existing.

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Appendices

Appendix A: Interview Guide Dutch knowledge experts

Dear respondent,

First of all, I would like to thank you for taking the time to answer this interview on decentralized water provision. For my Master Sustainable Development at Utrecht University, I am writing my thesis on the feasibility of decentralised water management in the Vietnamese Mekong Delta. In order to research this feasibility I create an assessment framework based on social-, governmental-, economic-, technical- and environmental conditions. This assessment framework is mainly based on an extensive literature review. However, within the research community in The Netherlands a lot of knowledge on decentralised water management and/or the Vietnamese Mekong Delta, therefore the aim of this research is to see whether this knowledge can be exchanged in order to improve my research framework. The interview consists of 16 question and will take approximately 45-60 minutes. However, the questions are more a guideline, if you would like to anything regarding your research expertise, please feel free to ask. Furthermore, if anything is unclear during the interview, please do not hesitate to ask.

---

1. Could you tell me something about yourself and your research expertise?

2. Do you have specific experience of decentralised water management systems or technologies related to decentralised water management?

3. Do you have specific experience on The Vietnamese Mekong Delta (if only expert on decentralised water management: do you maybe have experience with a country with similar characteristics as Vietnam?)

4. Do you have any remarks about processes that enhance or hamper the success or failure of decentralised water management systems in general?

The assessment will be made according to an integrated assessment framework, based on social-, economic-, governmental-, technological- and environmental conditions.

5. Do you have any experience with social factors that determine the success or failure of decentralised water management systems?

6. Do you have any experience with economic factors that determine the success or failure of DWM systems?

7. Do you have any experience with governmental factors that determine the success or failure of DWM systems?

8. Do you have any experience with technological factors that determine the success or failure of DWM systems?

9. Do you have any experience with environmental factors that determine the success or failure of DWM systems?

10. In your experience, what conditions are of real importance for the development and implementation of decentralised water management technologies?

11. How do you perceive the knowledge transfer among decentralised water management specialists?

12. These were all the question I wanted to ask you. Is there anything you would like to add yourself, regarding your research expertise?

Appendix B: interview guide Vietnamese knowledge experts

Dear respondent,

First of all, I would like to thank you for taking the time to answer this interview on decentralized water provision. The results from this interview add to the research from my master thesis, which has as aim to 'research the feasibility of a decentralised water provision in the rural districts of Can Tho in order to diminish groundwater use and improve the water provision in the area'. In order to research this, the opinion of research experts, such as you, is of vital importance. The answers to this interview will be handled with great care, taking your privacy into account. The results will be used for solely academic purposes. For your information, a decentralised water provision in this research is defined as 'the provision or treatment of water resources, near its point of use', this is thus a provision on the household level, where multiple households can be included. It is important to note, that this does not mean that the centralised water provision will stop existing, it can be an addition to the current existing water provision. If anything is unclear during the interview, please do not hesitate to ask. The interview consists of 16 questions and will take approximately 45-60 minutes.

a. Introduction

1. Could you tell me something about yourself and the research you are working on?

2. What are you thought on the current issues relating groundwater extracting in Can Tho City?

3. What are your thoughts on the current water provision in the rural districts of Can Tho?

With a decentralised water provision, the use of alternative water resources is of importance. For this research, the following alternative water resources are defined:

Rainwater Harvesting: *the collection and storage of rainwater at the household level, this water is intercepted before it reaches the surface.*

Stormwater Catchment: *the collection and storage of water generated by storm of heavy rainfall, after it has reached the surface.*

Wastewater treatment: *the treatment of contaminated water near the point of use, this can either go through advanced technologies or through simple biofilters.*

b. Social conditions

4. Have you already heard, or have experience with, of a decentralised water provision? Please specify.

5. Do you have experience with the expansion of rainwater harvesting, stormwater catchment and/or wastewater treatment in the Vietnamese Mekong Delta?

Currently, not all households in the rural districts of Can Tho are connected to the centralised water provision provided by CERWASS..

6. How do you foresee the development of the centralised water provision in the rural dsitricts of Can Tho?

7. Do you see any problems with the centralised water provision in the rural districts? Please specify.

8. (if yes), how do you think this problems can be solved in the future?
9. Do you find rainwater harvesting, stormwater catchment and/or wastewater treatment on a decentralised level can be an valuable addition to the current centralised water provision? Please specify per alternative water resource.

10. Do you think the households in the rural districts of Can Tho are familiar with problems regarding groundwater extraction?

11. Do you think that household understand why certain policies on groundwater extraction, such as Degree 167, are issued by the Vietnamese government?

c. <u>Governmental conditions</u>
12. Do you think that the institutional framework regarding water provision for the rural districts in Can Tho allows for the implementation of decentralised measures? Please elaborate.

d. <u>Economic, technical and environmental conditions</u>
If there would be the willingness to implement decentralised water provision measures in the rural districts of Can Tho …

13. Do you think there is enough financial capital available to complement the centralised water provision in the rural districts of Can Tho with additional measures, such as a decentralised water provision? Please elaborate.

14. Do you find all strategies (rainwater harvesting, stormwater catchment, wastewater treatment), equally feasible in term of finance, needed technology and the geographical conditions (such as space) of the area?

e. <u>Closure</u>
15. What do you think the water provision in the rural districts of Can Tho will look like in 20 years?

16. I want to thank you a lot for the participation, these were all the question I wanted to ask you. Do you have any special remarks you would like to add yourself regarding your research expertise?

Appendix C: interview guide governance agencies

Dear respondent,

First of all, I would like to thank you for taking the time to answer this interview. The results from this interview add to the research from my master thesis at Utrecht University, which is written within the Rise and Fall international Research Programme. My research has as aim to 'research the feasibility of a decentralised water provision in the rural districts of Can Tho in order to diminish groundwater use and improve the water provision in the area'. In order to research this, the opinion of policy experts, such as you, is of vital importance. The answers to this interview will be handled with great care, taking your privacy into account. The results will be used for solely academic purposes. For your information, a decentralised water provision in this research is defined as 'the provision or treatment of water resources, near its point of use', this is thus a provision on the household level, where multiple households can be included. It is important to note, that this does not mean that the centralised water provision will stop existing, it can be an addition to the current existing water provision. If anything is unclear during the interview, please do not hesitate to ask. The interview consists of 27 questions and will take approximately 60 – 75 minutes.

a. Introduction

1. Could you tell me something about yourself and the work you are doing within your department?

2. Do you face issues regarding groundwater extraction within your department? Please

3. Is your department working on water provision in the rural districts of Can Tho? If yes, how?

With a decentralised water provision, the use of alternative water resources is of importance. For this research, the following alternative water resources are defined:

Rainwater Harvesting: *the collection and storage of rainwater at the household level, this water is intercepted before it reaches the surface.*

Stormwater Catchment: *the collection and storage of water generated by storm of heavy rainfall, after it has reached the surface.*

Wastewater treatment: *the treatment of contaminated water near the point of use, this can either go through advanced technologies or through simple biofilters.*

b. Social conditions

4. Had you already heard, or have experience with, of a decentralised water provision? Please specify.

5. Do you have experience with water provision through rainwater harvesting, stormwater catchment and/or wastewater treatment?

Currently, not all households in the rural districts of Can Tho are connected to the centralised water provision provided by CERWASS..

6. How do you foresee the development of the centralised water provision in the rural districts of Can Tho?

7. Do you see any problems with the centralised water provision in the rural districts? Please specify.

8. (if yes), how do you think this problems can be solved in the future?

9. Do you find rainwater harvesting, stormwater catchment and wastewater treatment on a decentralised level can be an valuable addition to the current centralised water provision? Please specify.

10. Do you think the households in the rural districts of Can Tho are familiar with problems regarding groundwater extraction?

11. In Vietnam, the government makes effort to diminish the use of groundwater, such as a recently issued new degree. Do you think households understand why such measurements are issued?

12. Does the local government try to inform the households about the drivers behind such policies, for example through institutions or the media?

c. Governmental conditions

13. Earlier in the interview, you stated that your department was … (involved/not involved/doing something in particular) in the rural water provision of Can Tho. Who do you think is mainly responsible for policies regarding this aspect?

14. Do you think that one department or multiple departments should be responsible for the water provision in the rural districts of Can Tho?

d. Economic, technical and environmental conditions
If there would be the willingness to implement decentralised water provision measures in the rural districts of Can Tho …

15. Who do you think is then responsible for the cost for the implementation of these systems? And why?

16. Who do you think is responsible for the costs maintenance of the system?

Question 17 & 18 only when not already answered in question 15&16:

17. Do you think the – implementer and maintenance caretaker you just suggested – has enough financial capital for the implementation and maintenance of these systems?

18. Do you think the local government can help in assisting with finances, for example through subsidies?

19. How do you foresee the chances of the implementation of such systems, when there would be some international financial aid available?

20. Do you find all strategies (rainwater harvesting, stormwater catchment, wastewater treatment), equally feasible in term of finance, needed technology and the geographical

conditions (such as space) of the area?

21. How would you choose the best available strategy for the rural districts of Can Tho?

When you take the current financial availability in mind..

22. Would you choose for the cheapest available technology, a more expensive technology that with social benefits, a more expensive technology with environmental benefits or the most expensive technology with all three included? Please Specify, you can of course make a division between what you would like to do and what you are able to do.

e. Closure

23. I want to thank you a lot for the participation, these were all the question I wanted to ask you. Do you have any special remarks you would like to add yourself?

Appendix D: Household Survey (English Version)

Dear respondent,

Thank you for taking the time to answer this survey. This survey is part of a research into the domestic water provision in the rural districts of Can Tho City. The research aims to see whether a decentralized provision may improve the water provision and diminish groundwater use in the area. The survey and its outcomes are anonymous and while analysing the data, your privacy will be taken into account. The outcomes of the research will be used for scientific purposes.

Date of survey:

---

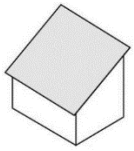
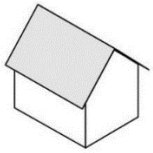
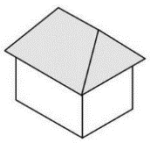
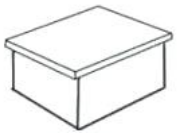
1. District:

☐ Phong Dien (1)
☐ Vinh Tanh (2)
☐ Thoi Lai (3)

2. Type of household:

☐ Homestead only (1)
☐ Homestead and agriculture (2)
☐ Homestead and aquaculture (3)
☐ Homestead, agriculture and aquaculture (4)

3. Roof type of the house:


☐ Shed (1) ☐ Gable (2) ☐ Hip (3) ☐ Flat (4) ☐ Other (5)

A. Personal information

4. What is your gender?

☐ Male (1)
☐ Female (2)

5. What is your age?

---

6. What is your highest education level?

☐ Have not gone to school (1)
☐ Elementary level (2)
☐ Secondary level (3)
☐ Senior level (4)
☐ Vocational level (5)
☐ College or University (6)

7. How many members live in your household?

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ Other: ____

B. Current Water Use

8. What water sources do you use?

☐ Rainwater
☐ Piped water
☐ Well water (ground water)
☐ River water
☐ Bottled water
☐ Other

9. If you are not connected to the piped water system, are you planning to connect in the future?

☐ Yes
☐ No
☐ Connected already

10. Why did you choose for the answer above?

---

11. For what water uses do you use rainwater?

☐ Drinking
☐ Cooking
☐ Cleaning
☐ Bathing
☐ Agriculture
☐ Aquaculture
☐ I do not use rainwater

12. For what water uses do you use piped water?

☐ Drinking
☐ Cooking
☐ Cleaning
☐ Bathing
☐ Agriculture
☐ Aquaculture
☐ I do not use piped water

13. For what water uses do you use well water/ground water?

☐ Drinking
☐ Cooking
☐ Cleaning
☐ Bathing
☐ Agriculture
☐ Aquaculture
☐ I do not use well water/ground water

14. For what water uses do you use river water?

☐ Drinking
☐ Cooking
☐ Cleaning
☐ Bathing
☐ Agriculture
☐ Aquaculture
☐ I do not use river water

15. For what water uses do you use bottled water?

☐ Drinking
☐ Cooking
☐ Cleaning
☐ Bathing
☐ Agriculture
☐ Aquaculture
☐ I do not use bottled water

16. Which water sources do you collect at home?

☐ Rainwater
☐ Piped water
☐ Well water (ground water)
☐ River water
☐ Not any

17. Which water sources are collected somewhere else?
- ☐ Rainwater
- ☐ Piped water
- ☐ Well water (ground water)
- ☐ River water
- ☐ Bottled water
- ☐ Not any

18. Do you own a private well for groundwater extraction?
- ☐ Yes
- ☐ No

19. If yes, do you share this well with your surround neighbours?
- ☐ Yes
- ☐ No

20. If yes, with how many neighbours do you share your well?

---

21. Do you have a tank for rainwater storage?
- ☐ Yes
- ☐ No
- ☐ I share one with other households

22. If yes, is the capacity of your rainwater storage tank sufficient?
- ☐ Yes
- ☐ No

23. If no, do you want to upscale it in the future?
- ☐ Yes
- ☐ No
- ☐ Yes, but I do not have the funds to upgrade my rainwater storage tank
- ☐ Yes, but I do not have the space to upgrade my rainwater storage tank

24. What do you currently do with your wastewater (all the water you used at home: water from your sink, bath, dishes, toilet etc.)
- ☐ I collect it, in for example a tank
- ☐ I throw it away on the ground
- ☐ I throw it away in the river
- ☐ Other:

25. Do you currently reuse water? This means that you may use your water source twice or more. For example, use water for cooking and later for irrigation.
- ☐ Yes
- ☐ No

26. If yes, how do you reuse your water?

---

27. Would you like the government to build a treatment plant, so you can reuse the wastewater you make at home?

☐ Yes
☐ No

28. Why did you choose for the answer above?

C. Social context

Knowledge – groundwater extraction and land subsidence

29. Are you aware that your living area has problems regarding land subsidence?

☐ Yes
☐ No

30. Do you have problems regarding land subsidence?

☐ Yes, I face problems regarding floods
☐ Yes, there is damage to my house
☐ Yes, I face problems with travelling on the roads
☐ Yes, it affects my agricultural land use
☐ Yes, it affects my aquaculture
☐ Yes, it affects both my agricultural land use and aquaculture
☐ No

31. Do you face any other problems regarding land subsidence?

---

32. Are you aware that the use of ground water accelerates problems with land subsidence?

☐ Yes
☐ No

Knowledge – decentralized water systems

A decentralised system is when there is a water provision on the point of use, this can be used by one or multiple households. For example, rainwater collection systems and wastewater treatment systems for local use can be implemented by the government in your area.

33. Are you already familiar with decentralized water systems?

☐ Yes
☐ No

34. If yes, how are you familiar with this concept?

Risk perception

35. How do you perceive the quality of rainwater?

☐ Low
☐ Medium
☐ High
☐ Have no idea

36. How do you perceive the quality of piped water?

☐ Low
☐ Medium
☐ High
☐ Have no idea

37. How do you perceive the quality of well water/ground water?

☐ Low
☐ Medium
☐ High
☐ Have no idea

38. How do you perceive the quality river water?

☐ Low
☐ Medium
☐ High
☐ Have no idea

39. How do you perceive your current water accessibility?

☐ Low
☐ Medium
☐ High
☐ Have no idea

40. Do you think a decentralised water provision can improve the water quality?

☐ Yes
☐ No
☐ Have no idea

41. Why did you choose for your answer?

---

42. Do you think a decentralised water provision can improve the accessibility of water?

☐ Yes
☐ No
☐ Have no idea

43. Why did you choose for your answer?

---

44. What do you perceive as more trustworthy?

☐ A water provision by the government via a centralized system
☐ A water provision by the government via a decentralized system

45. Do your trust that there are enough people with the knowledge and skill in the Vietnamese Mekong Delta to implement decentralized systems in your area?

☐ Yes
☐ No
☐ Have no idea

46. What would you find more trustworthy?

☐ If the operation and maintenance of the decentralized water provision systems is managed by the community itself
☐ If the operation and maintenance of the decentralized water provision system is managed by the local government
☐ If the operation and maintenance of the system is managed by the community as well as the local government
☐ I think that the operation and maintenance of the system should be managed through a third party and not the community or the local government

D. Economic Context

47. In an estimation, how much water do you think you currently use (in m3/day)?

---

48. What do you currently pay for your water provision (in Vietnamese Dong)?

---

49. Are you willing to pay more for an improved water accessibility?
- ☐ Yes
- ☐ Yes, but only a little bit
- ☐ Maybe
- ☐ No

50. Who do you think is responsible for the implementation costs of a decentralised system in your area?
- ☐ The (local) government
- ☐ The residents of the area
- ☐ The (local) government as well as the residents of the area
- ☐ Other:

51. Who do you think is responsible for the operation and maintenance costs of a decentralised system in your area?
- ☐ The (local) government
- ☐ The residents of the area
- ☐ The (local) government as well as the residents of the area
- ☐ Other:

52. Would you be willing to pay for the use of a decentralised water system?
- ☐ Yes
- ☐ No

53. If you could choose, would you rather connect to a centralised or decentralised water system?
- ☐ Centralised
- ☐ Decentralised

54. Why did you choose for you answer above?

Appendix E: node structure in *NVivo*