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Urban water supply through private tanker water markets

An empirical market analysis of Amman, Jordan

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1 Introduction

1.1 The role of private tanker water markets for Amman's drinking water supply

The Hashemite Kingdom of Jordan faces a severe water crisis. The Ministry of Water and Irrigation (MWI) in Jordan estimated the annual per capita share of water for domestic uses at 147 cubic meters in 2010 and 126 cubic meters in 2015 indicating a continuous decline in the ability of Jordan's water sector to provide water for the growing population; while, and for the same years, the annual groundwater uses for all purposes increased from 511 million cubic meters (MCM) to nearly 602 MCM indicating an increased reliance on groundwater to meet increasing demands.[1] According to the above mentioned indicators, Jordan is on the list of the ten countries with the least availability of water resources. Strong population growth and influx of refugees, climate change and unsustainable practices in water management are likely going to exacerbate current conditions (AFD 2011).

One of the central challenges of water governance in Jordan is the ongoing overexploitation of its groundwater resources (Kubursi *et al.* 2011). While the safe yield of groundwater pumping is estimated at 418.5 MCM in 2015, abstractions surpassed this level by 205.8 MCM in 2015.[2] Another pivotal challenge of water management in Jordan remains the so-called non-revenue water (NRW). NRW denotes water that enters the networks at the input level but remains unmetered at the output level, which is either due to technical (e.g., leaks) or administrative losses (e.g., surpassed meters). In 2016, the Jordanian Ministry of Water and Irrigation (MWI) reported that, on average, 126 liters of water were pumped into countrywide supply systems per person and day (MWI 2016b). Yet, only 61 liters reached the water users, while the remaining 65 liters, i.e. 52 %, got lost during conveyance. The low availability of water in combination with the high losses during transport has led to a pervasive gap between publicly supplied water volumes and the demands of residential and non-residential consumers. As a result, water shortages and supply intermittency occur throughout the country (WAJ 2015).

Amman is the capital of Jordan, its most populous city and therefore deeply affected by these challenges. The city had a population of around 4 million inhabitants in 2015[3], a value that has doubled within the last decade as a result of rapid urbanization and the aforementioned demographic development. Despite this massive growth, almost universal access of the urban population to the piped network has been achieved (Gerlach & Franceys 2009; USAID 2015). Since the year 2007, the network is managed by the publicly owned utility Miyahuna, which distributed 231 MCM of water in 2015. According to Miyahuna's annual report for the year 2015, 37 % of this water was lost, i.e. NRW, while USAID (2015) estimated this value at 48 % only one year earlier. Miyahuna supplies water through 44 distribution zones in the urban agglomeration of the Amman Governorate, while the Southern and more rural areas are serviced through a separate water system referred to as "Deep South" (USAID 2015). Within the 44 distribution zones of the main network in Amman, supply is highly *intermittent* with individual weekly durations between 12 and 168 hours (WAJ, 2015). Users of water have found various ways to cope with intermittent public supply, for instance by installing rooftop and basement storage tanks to balance supply shortages, by investing in water-efficient appliances or by reducing their water consumption (Rosenberg *et al.* 2008; Rosenberg *et al.* 2007).

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[1] http://www.mwi.gov.jo/sites/en-us/Hot%20Issues/Jordan%20Water%20Sector%20Facts%20and%20%20Figures%202015.pdf

[2] http://www.mwi.gov.jo/sites/en-us/Hot%20Issues/Jordan%20Water%20Sector%20Facts%20and%20%20Figures%202015.pdf

[3] https://www.citypopulation.de/Jordan-Cities.html

Additionally, the gap left by public supply intermittency and shortages forced many consumers to search for additional or alternative water sources like tanker water from small-scale water providers delivering water via trucks, treated water from water vendors and bottled water from supermarkets.

In the market for bulk water, *private tanker water providers* emerged as a response to excess demand. Tanker water providers in Jordan are typically small-scale businesses consisting of a few trucks with load capacities between three and twenty cubic meters (Wildman 2013). Tanker water is sold via phone or at certain congregation points and needs to be purchased in bulk volumes (Gerlach & Franceys 2009). Up to this point, little empirical data about the prices of tanker water exists, besides the information that it is usually more expensive than network water (Gerlach & Franceys 2009; Klassert *et al.* 2015). In previous studies, tanker water has therefore been associated with adverse social effects. Wildman (2013) reports that low-income water users tend to have less storage capacity at their disposal, thus rely more heavily on tanker water in time of discontinued public supply. This results in a situation where, according to the author: "poorer households tend to pay more for water (per unit volume) than better-off households, with refugees typically paying the most" (p. 23). On the other hand, tanker water can also be perceived as being very relevant for residential (poor and non-poor) households by balancing the daily shortcomings of the network and potentially for crisis management (Klassert *et al.* 2015). For a variety of commercial water users, tanker water seems to be not only an additional but instead an alternative water source (CDM 2011).

Amman's tanker water operators fill their trucks at private (licensed and unlicensed) wells in the vicinity of the city and drive the water directly to their customers (Gerlach & Franceys 2009). The city, however, is situated above a groundwater aquifer that is currently exploited to an alarming extent: While the safe yield in the Amman-Zarqa basin is estimated at 87.5 MCM per year, actual abstractions amounted to 166 MCM in the year 2015 (Al-Zyoud *et al.* 2015; MWI 2015). To which extent the markets for tanker water in Amman contribute to this unsustainable practice remains undocumented by official water sector reports. It has, however, been stated in the literature that private tanker water markets in Jordan partially rely on illegal abstractions (Gerlach & Franceys 2009; Wildman 2013). In Amman, the yearly volumes supplied via the tanker water market were estimated to amount to 14 MCM per year for residential users (Klassert *et al.* 2015) and about 10 MCM for commercial users (Zozmann *et al.*, 2020). Against this background it can be assumed that Amman's tanker water markets play a hardly negligible role in groundwater exploitation.

Though no recent evidence of drinking water quality issues has been reported, there is distrust among the population whether piped water is of drinking quality, while tanker water is typically used for purposes such as washing, cleaning and irrigation (Gerlach & Franceys 2009; Potter & Darmame 2010). Potable, non-bulk water can be bought from water vendor shops at rates of up to 24 times the price of piped water per volumetric unit (Gerlach & Franceys 2009). The shops sell treated water in small plastic canisters and bottles. Rosenberg *et al.* (2008) report that in 2008, about 180 of such water shops had been registered in Amman. Beyond that, bottled drinking water can also be bought in the supermarket.

1.2 The perception of private tanker water markets in the literature: A global review

In the past two decades, water supply from private providers in urban centers of Latin America, Africa and Asia has received increased attention in the literature (Kariuki & Schwartz 2005; Opryszko *et al.* 2009). The characteristics of such private water suppliers mainly differ with regard to the form the service is delivered. In most cases, small-scale private water providers fill a gap left by insufficient public supply. In rapidly growing urban centers of the

South, the poorest among the population frequently live in informal settlements unconnected to a public network (Collignon & Vézina 2000). Notwithstanding their connection to a public network, many other urban water users are experiencing water shortages and intermittent public supply and are therefore unable to fully meet their water needs. In both cases, i.e. in areas without public networks and in such that receive intermittent supply, water is provided by private-sector entities that are typically small businesses (Opryszko *et al.* 2009). There is wide evidence for private water providers in form of small-scale water networks, standpipes, water kiosks, tanker water markets, pushcart vendors and water carriers (Kariuki & Schwartz 2005). Depending on the form of delivery, strong differences exist regarding infrastructure needs, prices and types of customers served (Kjellén & McGranahan 2006).

Little systematically gathered information on small-scale private water providers is available in the literature, maybe due to the fact that they often operate (partially) informal and/or illegal and therefore are hard to assess. According to Solo (1999), more than 10,000 water businesses have been reported in around 50 countries, yet systematic study is lagging behind. Sima *et al.* (2013) argue that resulting from this lack of knowledge "there exist no objective measures of sustainability for urban informal systems" (p. 138). Despite these severe knowledge gaps, contrasting opinions and assertions can be found in the literature as to how desirable small-scale private water provision is for sustainable urban water supply. Advocates (e.g., Schaub-Jones 2008; Solo 2003) argue that private entrepreneurs operate demand-driven, efficient and innovative and therefore can adapt flexibly to a changing environment, as opposed to the alleged inertia of public providers. This line of argumentation frequently calls for a formalization of private water providers (Collignon & Vézina 2000) and for including these in partnerships with utilities (Njiru 2004). Other authors, however, challenge notions of competitiveness and free market entry among private providers (Ahlers *et al.* 2013) and argue that private providers mostly service the urban poor at higher rates than the publicly supplied water which is typically available for high-income populations (Amankwaa *et al.* 2014; Bakker 2003). Additionally, small-scale private water providers have been criticized for operating illegally or in absence of regulation (WUP 2003) and associated with burdens for the environment and human health (Marvin & Laurie 1999; Sima *et al.* 2013).

Tanker water supply as one form of private small-scale water provision has been reported in a variety of settings (Collignon & Vézina 2000; Solo 2003; Srinivasan *et al.* 2010a, 2010b). While tankers are used in the Global North to bridge water supply shortages and reach remote areas, they are frequently a regular or at least seasonal component of water supply systems in Southern cities (Constantine *et al.* 2017). Similar to the state of research concerning small-scale private water providers in general, little is known about private tanker water markets because only a handful of studies consider these in detail. Nonetheless, three core characteristics can be identified by the literature:

- Tanker water is usually provided in situations where public supply is insufficient (see above)
- Tanker water is (in terms of market prices) usually more expensive than its alternatives, such as water from the public network or from standpipes and boreholes (Amankwaa *et al.* 2014; Wildman 2013; WUP 2003)
- Tanker water provision has at least two basic requirements: (i) a sufficient road and traffic infrastructure and (ii) customers with comparably large storage capacities (Solo 2003; Whittington *et al.* 1991).

A number of studies which investigate tanker water provision in depth suggest that its high price constitutes an economic burden, especially for the urban poor who may depend more heavily on tanker-supplied water than better-off water users (Venkatachalam 2014; Wildman 2013). Srinivasan *et al.* (2010b) have studied tanker water provision in Chennai, India, and reach the conclusion that it “results in resource misallocations and substantial welfare losses” (p. 255). Similarly, Baisa *et al.* (2010) argue that expensive tanker supply in Mexico-City should be addressed by balancing public supply intermittency because “gains in distributional efficiency from reliable water service are very large in magnitude” and “costs are borne by those with infrequent deliveries and/or smallest storage capacities” (p. 11). Apart from that, allocation inefficiency, groundwater depletion and conflicts between urban and agricultural users of water have been attributed especially to tanker water provision (Prakash *et al.* 2015; Srinivasan *et al.* 2010b).

In summary, there is limited literature which comprehensively investigates and evaluates small-scale private water providers and private tanker water markets. While urban water markets are connotated both positively and negatively, in literature, private tanker water markets are predominantly criticized as negative (inequitable distribution, inefficient allocation, groundwater overuse, water use conflicts etc.). Most studies concerned with tanker water markets, however, seem to derive these claims from limited empirical evidence, such as household surveys which provide only a partial look on these markets from the perspective of private households. This lack of empirical evidence is strongly related to the decentral and informal nature of tanker water markets, which impedes data collection and the validation of models. In addition, studies of tanker water supply rarely seem to investigate the sustainability of the urban water supply system in its entirety (i.e. including network supply). Finally, certain assertions about the demand for and the welfare effects of tanker water supply seem to result from an rather one-dimensional perspective of water services, which are shaped by characteristics such as their service level and reliability.

1.3 Objectives of this study

As pointed out in the beginning, private tanker water markets, providing water from nearby private wells via trucks to urban customers, currently play a key role in balancing the daily shortcomings of intermittent water supply in the city of Amman. Many households and commercial establishments at least partially rely on tanker water, mostly during summer and especially in crisis situations. Despite a variety of claims concerning the desirability and sustainability of tanker water markets, there are limited in-depth empirical studies of tanker water markets, their embedding in institutional structures, the demands of consumers of tanker water as well as the business conduct of suppliers.

Against this background, it seems useful to conduct a thorough empirical investigation and market analysis of the tanker water market in Amman. This study therefore deals with the following **overall research questions**:

- How do private tanker water markets in the city of Amman function and how can they be characterized from a microeconomic market theory perspective?
- What is the institutional framework in which tanker water markets operate?
- Which types of water consumers purchase tanker water services? How is the supply organized?

The research approach does not consider the tanker water market as a separate entity, as is often the case in literature, but as a subsystem of the entire water supply system of Amman. All relevant water users, private households and commercial establishments, shall also be taken into consideration.

The research questions are approached by a **market analysis:** Its objective is to analyze and evaluate Amman's private tanker water markets from a microeconomic perspective. Through a *positive analysis* the following research questions are pursued: What are the relevant basic conditions with regards to supply and supply regulations? How can these markets be characterised? What role do they play for the entire water supply system? Who are the market actors and how do they behave? Within a second step, research questions relating to market performance are investigated: How efficient is water allocation? How does competition work? How effective is governmental regulation?

The market analysis presented in this report establishes an empirical foundation for a more comprehensive analysis of the sustainability of Amman's water supply system. Due to the abundance of the research material, however, this study concentrates on the theoretical and empirical market analysis of Amman's private tanker water markets. Some aspects which would be relevant for a sustainability analysis are discussed in the final chapter which includes a brief characterization of relevant avenues for future research (cf. chapter 5).

A second purpose of this study is to expand the empirical basis for further research on private tanker water markets in Jordan by means of **field surveys**. The review of publicly available data and reports on private tanker water markets in Jordan revealed that there is a need for empirical data and investigations on the supply side of private tanker water as well as on the demand side, especially in terms of commercial establishments who are the major customers of tanker water within cities. Against this background, in the period from September 2015 to October 2016, five mostly quantitative surveys were conducted within the Stanford-led Belmont Forum "Jordan Water Project (JWP)"[4] in order to collect socioeconomic as well as physical and technical data about private tanker water supply and demand in three different Jordanian cities (cf. Sigel *et al.* 2017).

This report documents the methodology and key results of the field surveys which were carried out in Amman. This includes two quantitative surveys (tanker drivers survey, commercial establishments survey) and one qualitative survey (well operators survey) (cf. chapter 3). A special feature is the comprehensive analysis of the demand and water use patterns of commercial establishments in Amman based on 242 survey interviews (cf. chapter 4.2.1 for further details).

[4] The Jordan Water Project (JWP) is an international research effort aimed at "Integrated Analysis of Freshwater Resources Sustainability in Jordan". Available online: https://pangea.stanford.edu/researchgroups/jordan/ (accessed on 18 April 2017).

2 Conceptual framework of analysis: An approach based on microeconomic market theory

2.1 Basic approach

This study investigates how private tanker water markets provide water services in the city of Amman. Approaching this question requires a deeper understanding not only of the private tanker water markets, but also of their integration into the water supply system as a whole. This makes the subject of the study particularly complex and multifaceted. What facets are involved? As already indicated in the introductory chapter, there are several competing water sources (piped water, tanker water, treated water, bottled water) and consequently many different market players acting as public or private suppliers and/or customers. This gives rise to several subsystems or submarkets and supply chains, and market activities, some of which are illegal.

Due to this multifaceted subject of research and the associated manifold economic interdependencies between substitute products and submarkets, a pure partial analysis of Amman's private tanker water markets would be misleading. For this reason, an approach was developed which, although focusing on private tanker water markets, also allows a more comprehensive analysis of the entire water supply system of Amman. This study concentrates on the microeconomic analysis of Amman's private tanker water markets (cf. chapter 1.3). The issue here is less to quantitatively describe mass flows and equilibria, but rather to give a comprehensive description of the markets based on quantitative and qualitative field surveys. The framework of analysis is designed in such a way that in a later analysis, a comprehensive sustainability evaluation could be carried out.

The purpose of this chapter is to concretize the subject of this study, to clarify terms and to develop a framework of analysis that provides a comprehensive approach to the overall research question. This is done on the basis of selected theories and concepts of microeconomic market theory, industrial economics and on the basis of selected results. Thus, this chapter already anticipates some of the results, which will be discussed in detail below. It might be helpful for understanding this chapter to first gain an overview of the empirical basis of this study (cf. chapter 3).

The chapter is structured as follows: Firstly, Amman's water supply system is characterised comprehensively from a microeconomic market perspective (cf. section 2.2). Secondly, an excursus on the conceptual foundations of industrial economics is made (cf. section 2.3). Thirdly, the theory components developed are combined into a framework of analysis, that determines the logical course of the investigation and the integration of theory and empirical facts (cf. section 2.4).

2.2 Characterisation of Amman's water supply system from a microeconomic perspective

The concrete definition of a market always needs to be tailored to the specific purpose of investigation. This section aims to characterise Amman's water supply system from a microeconomic perspective. By definition, a *market* is an institution that mediates the exchange of goods. It is the economic place where supply and demand meet and where pricing and exchange take place. Economists are primarily interested in the quantities and prices of goods exchanged on the market when reaching an equilibrium (Gawel 2009, p. 36). An exchange relationship can only arise if there is at least one economic good as an object of exchange (objective market definition) and one supplier and one buyer (personal market definition). These two market demarcation features generally result in the temporal and geographic demarcation of the market (Piekenbrock & Hennig 2013, p. 162 ff.).

In the following sections Amman's water supply system is characterised on the basis of this basic concept. The corresponding key questions are as follows (cf. sections 2.2.1 to 2.2.3): Which water sources can customers in Amman choose from and how can they be characterized economically? Who are the market actors involved and which subsystems can be distinguished? How should the study area be geographically demarcated?

2.2.1 Multiple water sources

Like in most markets the goods or products on offer – here: the different types of water supply services (hereafter abbreviated to be "water sources") – are not perfect substitutes, i.e. they are *heterogeneous*. In economic theory this is considered by models with product differentiation. They describe markets in which the goods possess different characteristics (Bester 2000). According to the so-called new consumer theory "a good will possess more than one characteristic, and many characteristics will be shared by more than one good" (Lancaster 1966). Theoretically the qualitative characteristics of a good can be described in any detail. From a microeconomic perspective, to completely describe a good, all characteristics which are relevant for consumers' willingness to pay need to be specified (Bester 2000). With respect to water services this refers to quality, price, temporal and spatial availability of water as well as reliability of service.

In Amman, similar to other Jordanian cities (Coulibaly *et al.* 2014), water users can mostly choose between the following four *water sources*[5], the first two being also referred to as *bulk water*:

- Piped water: Delivered by the public service provider Miyahuna
- Tanker water: Delivered by private tanker water operators
- Treated water: Provided by water vendors, generally sourced from tanker water and packaged in containers or bottles of different sizes
- Bottled water: Water of different origin, kept for sale in supermarkets etc.

All these water sources are in active competition, i.e., they belong to one market and shape to an extent substitutes for each other. Of course, consumers' perceptions about the substitutability of goods might vary. For market demarcation the broadest existing perceptions of functional substitutability are crucial. If, for example, some consumers in Amman (sometimes) replace bottled water by (boiled and/or filtered) piped water, because bottled water is too expensive for them, all these water sources are part of one market.

Qualitative characteristics of the good *water supply service*, which generally are crucial for consumer's willingness to pay, are space, time, quality, quantity, reliability (Spellman 2015, p. 288; Gawel & Bretschneider 2016). Within their sustainability- and barrier-oriented approach on how to specify and implement the human *right to water* in practice, Gawel and Bretschneider (2016, 2017) distinguish between four kinds of access hurdles to water: pecuniary, spatial, temporal, and qualitative. The three non-pecuniary hurdles (spatial, temporal, and qualitative) correspond with the first three criteria of Spellman, which underlines their im-

[5] For a complete list of all available water sources, note that to a very limited extent, some urban households are harvesting rain water.

portance. Moreover, reliability of service can be considered part of the temporal availability criterion.

In the following, the above-mentioned four water sources of Amman are roughly described according to the criteria space, time, quality, quantity and reliability:

- **Space:** This refers to the place where the water is supplied. In Amman, piped water is usually delivered directly to the customer via the house connection. Also tanker water is typically transported directly to the customer. Treated and bottled water must be purchased at stores. Some stores may also offer delivery. The space of delivery leads to different opportunity costs for the customer, e.g., costs of time for acquiring and storing water.
- **Time:** This refers to the time when the water is supplied. Piped supply in Amman is highly intermittent with individual weekly durations between 12 and 168 hours. Tanker water can be ordered in principle at any time. For treated and bottled water the store opening hours are decisive.
- **Quality:** This refers to the extent to which the water is free of contaminants and suitable for the intended use. In principle, all four water sources should provide drinking water quality. In fact, however, most customers in Amman only rate treated and bottled water as being of drinking water quality.
- **Quantity:** This refers to the total volume of water the source can supply. In terms of piped water, time and quantity are closely linked due to intermittency. Customers try to meet their quantitative needs by storing water in rooftop and basement tanks. Tanker water can basically be ordered in any quantity, but there are minimum and maximum quantities per delivery (depending on the tanker volume of the trucks). Filtered water and bottled water generally are not limited in quantity.
- **Reliability:** This refers to the reliability of the service, for example if there are service interruptions. Intermittency has a negative influence on reliability of piped water supply in Amman (pressure variations, quality variations, partly uncertain and/or variable supply times etc.).

From the above brief characterisation of the four main water sources of Amman's drinking water supply system, it becomes clear that above all the two bulk water sources *piped water* and *tanker water* as well as the two packaged two water sources *treated water* and *bottled water* compete with each other. If consumers want to use water directly for drinking or cooking purposes, they generally buy treated or bottled water. If they can't afford, however, they treat the bulk water independently at home (boil, filter, etc.). If they want to use the water for non-drinking purposes, they can buy tanker water as an additional and/or alternative bulk water source to piped water.

There may be further criteria relevant to consumers' willingness to pay for water supply services in Amman, like for example modalities of payment or flexible supply on demand and in time. This study examines the preferences of commercial establishments in this regard based on the *commercials survey* (cf. chapter 4.2.1).

At this point it should be briefly pointed out that from the consumer's point of view the criterion *quality* is associated with high uncertainty. As it is very difficult to determine the quality of water purchased directly, the consumer must have some confidence in the quality of the service provided. Economically speaking, water is a *good of trust* or, if one assumes that the quality is revealed in the train of ongoing use, a *good of experience* (Bracht 2008, p. 189; Gawel 2009, p. 804 ff). Markets with *quality uncertainty* are characterised by information

asymmetry between buyers and sellers which means that sellers are better informed about the quality of the good or service than customers. This can lead to allocation problems, such as sellers offering high qualities at necessarily higher prices being pushed out of the market (adverse selection problem or the so-called "market for lemons"). The quality of the tanker water depends primarily on its origin. As it is difficult for buyers to access this information, water-tanker drivers may be tempted to sell water from unsafe, illegal sources (e.g., rivers, unlicensed wells) for which they pay less, or even nothing. The surveys show that water quality aspects play a major role in the purchasing behaviour of private water tanker operators (cf. chapter 4.3.3.1) as well as of commercial establishments (cf. chapter 4.2.1.6). Obviously, the buyers of tanker water feel sufficiently capable of detecting differences in water quality.
There is another factor that plays an important role regarding water quality issues: As the temporal availability of piped water is very limited, water users generally store water in rooftop and basement storage tanks. Also tanker water needs to be stored. The *storage of water* has a negative effect on water quality. For this reason alone, users do not usually use their bulk water directly for drinking or cooking purposes. Water users who i.e. buy both bulk water sources, *piped water* and *tanker water*, usually store the two water sources in the same storage facilities (cf. Figure 2.1). As a result, existing differences in water quality become less important.

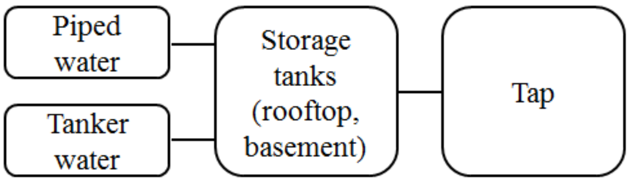


Figure 2.1: Combined storage of piped and tanker water (Source: Own illustration)

2.2.2 Market actors and subsystems

The water sources or market goods described above directly give rise to certain market actors, i.e. persons who act as suppliers or buyers. This section tries to give an overview of the market actors and corresponding markets relevant to Amman's water supply system and in particular the private tanker water markets. The two bulk water sources *piped water* and *tanker water* are taken into account and also treated water, which is almost exclusively prepared from tanker water. Bottled water does not play a significant role for the subject of this study because its volume in overall water consumption is rather low and therefore not an issue here.

The following figure shows the relationship system (arrows) between the main market actors identified (circles). The rectangles symbolise either special rights that one actor transfers to another (here: water abstraction licenses) or markets in which two actors exchange goods (water) for money. In addition, the logical linkage of the individual relationships is depicted along the supply chain of the good (water), starting with the ownership rights of water resources, and continuing with their extraction, distribution and consumption (from left to right).

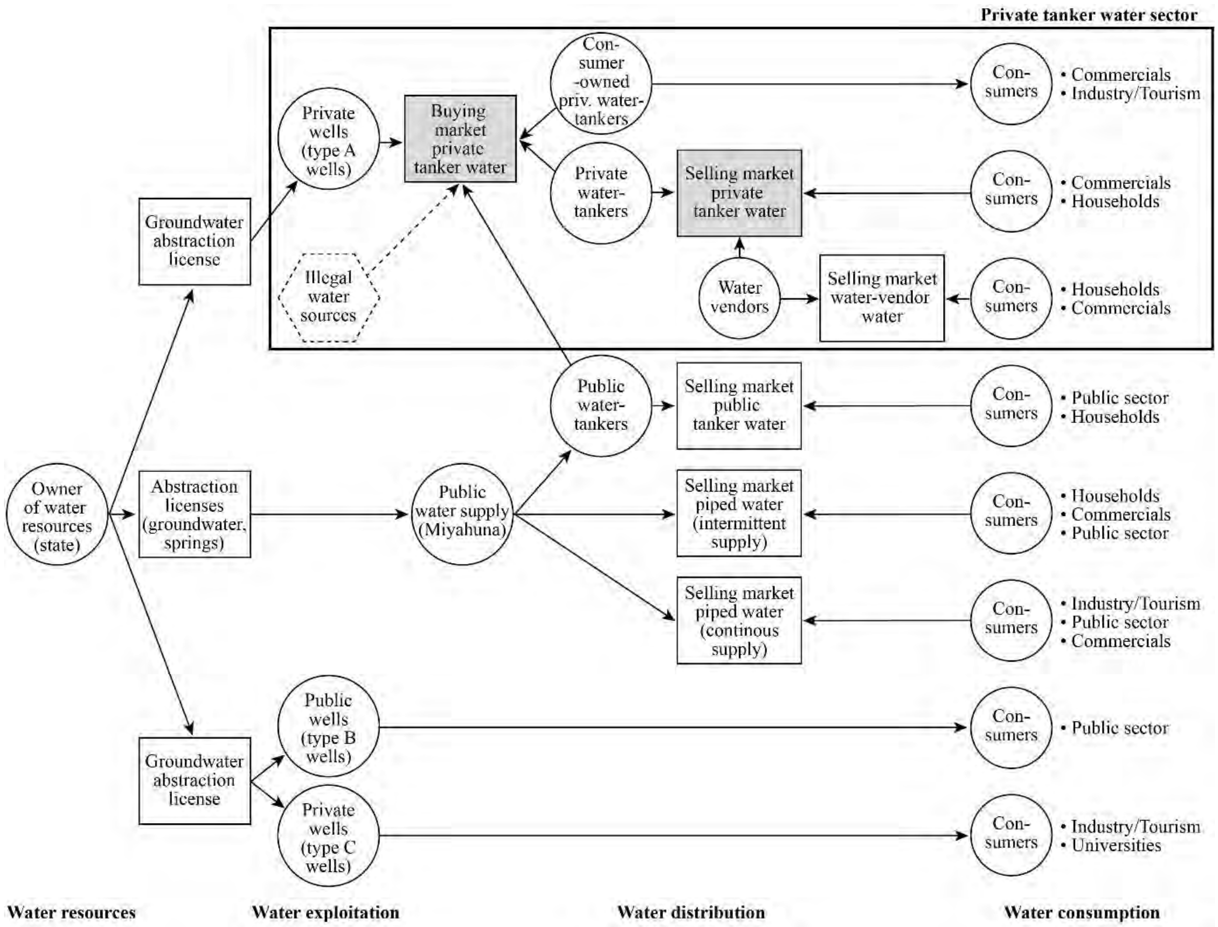


Figure 2.2: Amman's water supply system from a microeconomic market perspective (Source: Own illustration)

The focus of the study, the relationship system of Amman's private tanker water markets, is highlighted by the bold framed rectangle referred to as *private tanker water sector*. Highlighted with grey filling are two core submarkets of this sector: the buying market and the selling market of private tanker water. The terms buying market and selling market are derived from the perspective of private tanker water operators who are the key market actors in this sector: The *buying market* is the market where they act as buyers by purchasing groundwater from private well operators. The *selling market* is the market where they act as sellers by selling tanker water to different consumers. Both markets are highly interrelated and, according to these definitions, arranged in such a way that the buying market always precedes the selling market.

In Jordan, all water resources, surface and ground waters, are owned and controlled by the State (circle leftmost). If a landowner wants to extract and use groundwater, he/she needs to obtain a groundwater abstraction license from the State (rectangle). This license regulates how much groundwater he may extract and for what he may use it. If he wants to sell the groundwater to water-tankers he needs a written approval (cf. chapter 4.1.2.5).

The water sold through Amman's private tanker water markets usually comes from private, licensed wells. However, there is also some evidence of *illegal activities*. Jordanian policies, laws and regulations, for example, identify the following problems in this regard: (i) private wells sell water without having a license, (ii) private wells extract more water than specified in their license, (iii) tanker drivers sell stolen water, e.g., water from springs, rivers or illegal abstractions from the piped network (cf. chapter 4.1.4). These illegal activities, in the form of illegal services or illegal goods (here: stolen water), is represented in the figure by the dotted elements.

The main consumers of tanker water are commercial establishments and households (circles rightmost). Many hotels and larger commercial establishments in Amman are completely dependent on the supply of tanker water (CDM 2011). According to the *commercials survey*, 56 % of the interviewed establishments use tanker water as the only bulk water source (cf. chapter 4.2.1.2). The *commercials survey* also provides empirical evidence that there are commercial establishments that have their own water-tankers with which they purchase water directly on the buying market for tanker water (supply chain at the top). Among them are, for example, car washes, gas stations, hotels or restaurants (cf. chapter 4.2.1.6). It is reasonable to assume that this would also be the case for individual industrial companies and the tourism sector. The figure also illustrates that the sale of the water source *treated water* acts as a kind of submarket of the selling market of private tanker water. The reason is, as revealed by the *commercials survey,* that there is a WAJ regulation that prevents water vendors from buying piped water from Miyahuna (cf. chapter 4.2.1.1).

Below the depiction of the relationship-system of Amman's private tanker water sector, the supply chains of the *public utility Miyahuna* are shown. Unlike private well owners, Miyahuna has the right to abstract not only groundwater but also surface water from, e.g., springs, for drinking water supply (rectangle left). In general, Miyahuna supplies piped water intermittently, with individual weekly durations between 12 and 168 hours (WAJ, 2015). This water is usually used by households and commercial establishments (horizontal supply route). In addition, there are user groups who have a special right to access continuous supply, for example the industry and public sector (universities, authorities etc.). The *commercials survey* gives evidence that there are commercial establishments like hotels and hospitals which enjoy a continuous supply. Most common, however, are supply durations of 24 and 48 hours per week (cf. chapter 4.2.1.1). According to personal communication, Miyahuna also operates a small fleet of water-tankers that are used (i) in case of crisis and emergency situations (e.g., line breakage) (ii) by selected public sector institutions (e.g., government buildings) and (iii) by remote rural households not connected to the piped network. Interestingly, these public water-tankers collect their water not only directly from the public supplier Miyahuna, but also from private wells. This was observed empirically; one of the surveyed private wells in and around the city of Amman sells 5 % of its water to public trucks (cf. chapter 4.3.3.2). Conversely, however, private water tanker operators are not allowed to buy water from the public supplier Miyahuna. A special case was reported in interviews from Irbid: here, the public supplier Yarmouk Water Company even ordered private water tankers to ensure supply in crisis and emergency situations. This could also be the case for Amman.

To complete the overview of Amman's water supply system, it is worth mentioning that there are user groups in Jordan that have special rights to abstract water directly from public or private wells (supply chain at the bottom). According to the *Groundwater By-Law,* three types of wells can be distinguished in Jordan (cf. chapter 4.1.2.5):

(i) Agricultural wells (type A wells), which form the supply basis for Amman's private tanker water sector (see above),
(ii) "wells which belong to Government Departments, official public institutions, public institutions and municipalities" (type B wells), and
(iii) "wells for industry, production, tourism or university purposes" (type C wells).

The presence of type B and C wells in the city of Amman is documented by Theodory (2000, p. 99), who conducted a survey with non-residential WAJ-subscribers in Greater

Amman and came to the conclusion that there are many hotels, and some schools and hospitals, that have their own wells. In terms of the *industrial sector* in Jordan, the MWI (2016b, p. 46) points out that it obtains most of its water from private wells, but piped water is becoming increasingly important. According to Bonn (2013, p. 141), there are 10 large petrochemical industry companies in Jordan that consume more than 86 % of all industrially used water (phosphate mines, cement and fertiliser producers). These large companies obtain their water from their own wells. Thus, this portion of the industrial sector does not play an important role in this study as it is not dependent on private tanker water. Smaller industrial and commercial establishments, however, are generally supplied by public piped supply and/or tanker water and are therefore of high interest for this study. To clearly distinguish between "industry" and "commerce" is not considered necessary here. With regard to the *tourism sector*, Bonn (2013, p. 140) notes that since the 1990s, hotel operators in Jordan have increasingly drawn their water from private water suppliers to alleviate bottlenecks in public supply during the summer months. The use of private wells is, however, in contrast to Theodory (2000, p. 99), not reported there.

In summary, the following conclusions can be drawn from this basic characterisation, which are pertinent to the overall research question:

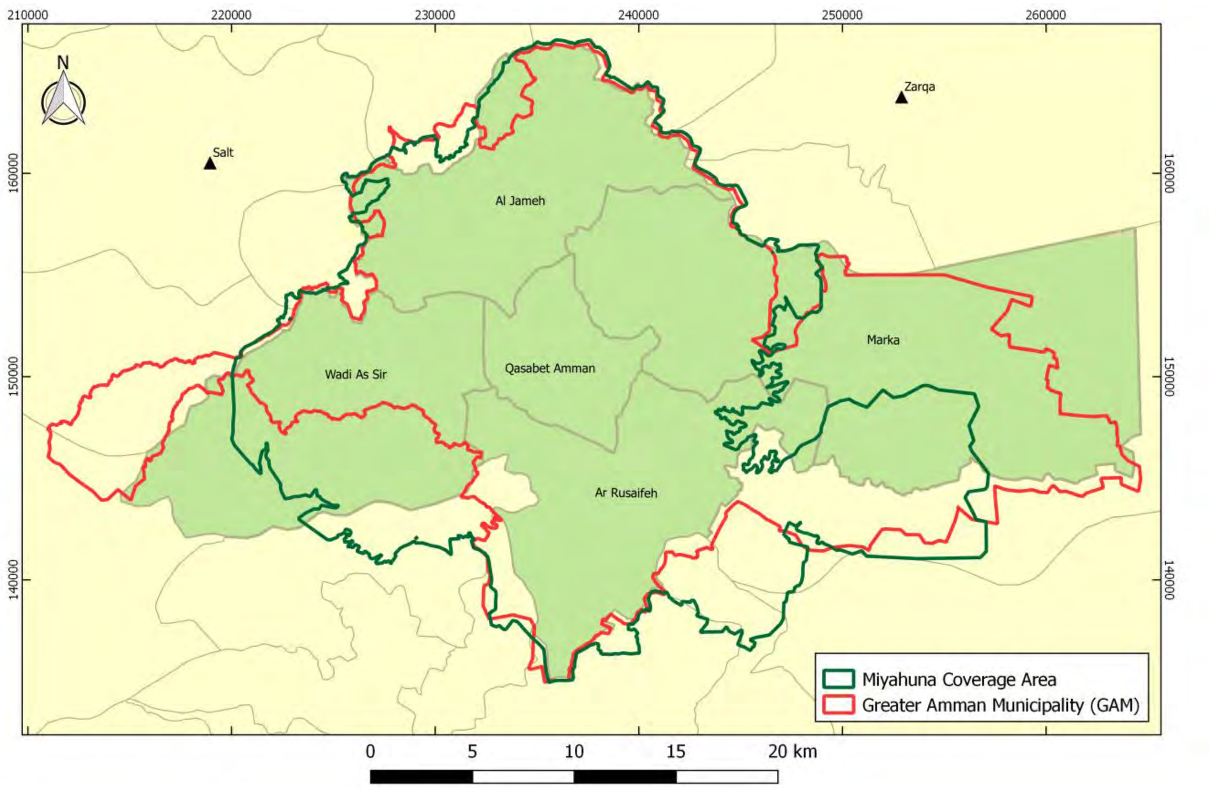
- Piped water and private tanker water are part of one market with a one-sided dependence: In the case of emergency and crisis situations, public piped supply is *structurally* dependent on the existence of private tanker water markets (by public water-tankers buying at private wells or by replacing the whole public service delivery for a certain time by private water-tankers). In part this also applies during normal operation (e.g., the supply of public sector institutions or remote rural households)
- The Jordanian State has various roles to play. Firstly, it plays a regulatory role, e.g., by issuing licences. Beyond that, it acts as a supplier, by selling public piped water through Miyahuna. In special situations and cases (see above), Miyahuna is a buyer on the buying market for tanker water. Finally, the state acts as a buyer on the selling market for tanker water (cf. consumer group *public sector*).
- There are illegal activities in form of illegal services or illegal goods (here: stolen water) which can have an impact on the sustainability of the whole water supply system.

2.2.3 Geographic demarcation of the study area

The geographic demarcation of a market is generally a result of the defined traded economic good, the sellers and buyers of this good together with the geographic expansion of their market activities. However, the precise practical determination is often difficult. Theoretical approaches try to use variables such as purchase prices, procurement times, possible legal limits (e.g., embargo on exports) or aspects of economic geography (e.g., traffic limits, costs) in order to demarcate markets.

Factors that play an important role with regard to the geographic expansion of Amman's private tanker water markets are, amongst others: the location of the private wells, the location of the customers, the associated transport costs, delivery times, conditions of the roads, and seasonality. The *tanker drivers survey* indicates that, based on the mean distances travelled by water-tanker operators to transport the water from a certain private well to the point of delivery, there is an overlap between the private tanker water markets of Amman and other larger cities like Zarqa and Salt (cf. Map 4.1, chapter 4.4.2.1). A spatial demarcation of these individual markets does not seem to be possible. Another limitation of using a map to demarcate Amman's private tanker water markets is the possible presence of privately owned, partially illegal wells not covered by the survey selling water to private water-tankers, who deliver this water to Amman (cf. chapter 3.3.1.1). Thus, Amman's private tanker water markets are probably larger than the coloured area on the map suggests. Further spatial aspects of Amman's private tanker water markets, which go beyond the question of geographic expansion and demarcation, are discussed in detail for both submarkets further below (cf. chapters 4.3.2.1 and 4.4.2.1).

Due to the described difficulties, this study does not attempt to clearly define the geographic expansion and demarcation of Amman's private tanker water markets. Instead, to simplify matters, the city of Amman is declared as the *study area*. The following map shows several boundary lines that play a role in this regard: the boundary of Greater Amman Municipality (red line), the five main sub-districts of Greater Amman Municipality (green area) and the coverage area of the public piped water supplier Miyahuna (green line). That these boundary lines are not exactly congruent does not play a role in the further course of the investigation.



Map 2.1: Geographic demarcation of the study area

2.3 Excursus: Conceptual foundations of industrial economics

Industrial economics (or: industrial organisation) investigates the interaction between markets and firms. The market is the place where providers and consumers of goods and services meet. Providers are firms or businesses who have to bear costs to purchase the production factors for the production of their supply. Consumers take a buying decision depending on their preferences, the prices of the offered goods and their income. The singular decisions of the consumers determine overall market demand. In general a *market* or an *industry* can be described by the providers and their production costs and market demand. Industrial economics uses microeconomic concepts and methods. However, unlike microeconomics, it is limited to *partial models*, i.e. it concentrates on an isolated industry or market and neglects interdependencies with other markets. In general, a particular market can be regarded as an economic subsystem with such a high internal degree of interdependence that it constitutes the reference framework for the market behaviour of the involved providers and consumers. The degree of interdependences among goods depends on their functional substitutivity from the perspective of consumers. To clearly define the boundary of a particular market for a *partialanalytic investigation* if there are differentiated or *heterogeneous goods* is always challenging. Another special feature of industrial economics is that it concentrates on markets with *incomplete competition* (Bester 2000).

In the industrial economics literature, *industry* is defined as a group of companies with the same production basis. This means that these companies use the same or similar production techniques and processes to produce similar products. Thus, they are at least potentially in an area of effective competition and can be assigned to a *market* (cf. Bracht 2008, p. 40). Consequently, the terms industry and market can be used largely synonymously. In this study the term industry is replaced by the term *sector* to express that the provision of the economic good "tanker water" is rather a service – a type of water supply or water delivery service – than a production process.

A purely partialanalytic investigation of Amman's private tanker water sector is insufficient with regard to the overall research question, as consumers in Amman can choose between several at least partially substitutable water sources (cf. section 2.2.1). However, some of the industrial economic concepts are nevertheless helpful in order to methodically deepen parts of the analysis to be carried out in this study. In many industrial organisation studies a broad descriptive *model* is used to describe economic performance of particular industries or markets by identifying sets of attributes or variables and building theories about the interlinkages between these attributes and end performance (Scherer & Ross 1990, p. 4). According to this model which is called the *structure-conduct-performance paradigm*, the performance of a particular industry or market depends upon the conduct of sellers and buyers which in turn depends upon the structure of the particular industry or market. The structure is determined by a variety of basic conditions. If the basic conditions are deemed to be exogenous, a market can be described as a largely deterministic static game.

Main causal relationships flow from market structure and/or basic conditions to conduct and performance. Thus, ultimate performance is deemed to be predictable from the observation of structure, basic conditions, and conduct. However, as it has been argued by advanced theories of industrial economics, there are also important feedback effects between these four components which degrades the predictive power of the structure-conduct-performance paradigm (cf. Scherer & Ross 1990, p. 6). The consequence is that both, basic conditions and market structure attributes, are endogenous, i.e. not determined by outside forces but defined by the whole system of relationships. Irrespective of the potential strengths and weaknesses of the structure-conduct-performance paradigm it can help to structure theories and facts. The sequence, however, shouldn't be overemphasised and the specific interactions of the four components always should be taken into consideration (cf. Scherer & Ross 1990, p. 6).

In this study the structure-conduct-performance paradigm is used to systematise the analysis of Amman's private tanker water sector from a microeconomic market perspective (cf. chapters 4.3 and 4.4). Therefore, in the following, the variables and attributes for the four components *basic conditions*, *market structure*, *market conduct* and *market performance* mentioned in the literature are described in more detail below (cf. Bracht 2008; Martin 2002; Scherer & Ross 1990).

Basic conditions:

- Distribution of resources and raw materials (location, ownership, rights of use, abstraction licenses)
- the nature of the relevant technology
- Product durability
- Time pattern of production
- General institutional, political and legal framework within which industries operate
- Patterns of demand (e.g., price elasticity of demand at various prices, availability of substitute products, rate of growth and variability over time of demand, cyclical and seasonal character, methods employed by buyers in purchasing)

Market structure:

- Number and size distribution of sellers
- Number and size distribution of buyers
- Degree of product differentiation
- Presence or absence of barriers to the entry of new firms
- the degree to which firms are vertically integrated from raw material production to retail distribution

Market conduct (of suppliers):

- Sales policy (prices policies and practices, quantities)
- Product policy (product differentiation)
- Advertising policy (marketing, advertising strategies)
- Cooperation (overt or tacit)
- Foreclosure behaviour towards current or potential competitors

Market performance:

- Production and allocation efficiency
- Progress, rate of innovation
- Quality of products on offer
- Stable full employment, labour productivity
- Equity (distribution of income), price stability

2.4 Conceptual framework of analysis

As already explained in Section 1.3 above, this study aims to allow a comprehensive microeconomic and sustainability analysis of the entire water supply system of Amman with a clear focus on private tanker water markets. The framework of analysis developed for this purpose is shown in the following figure.

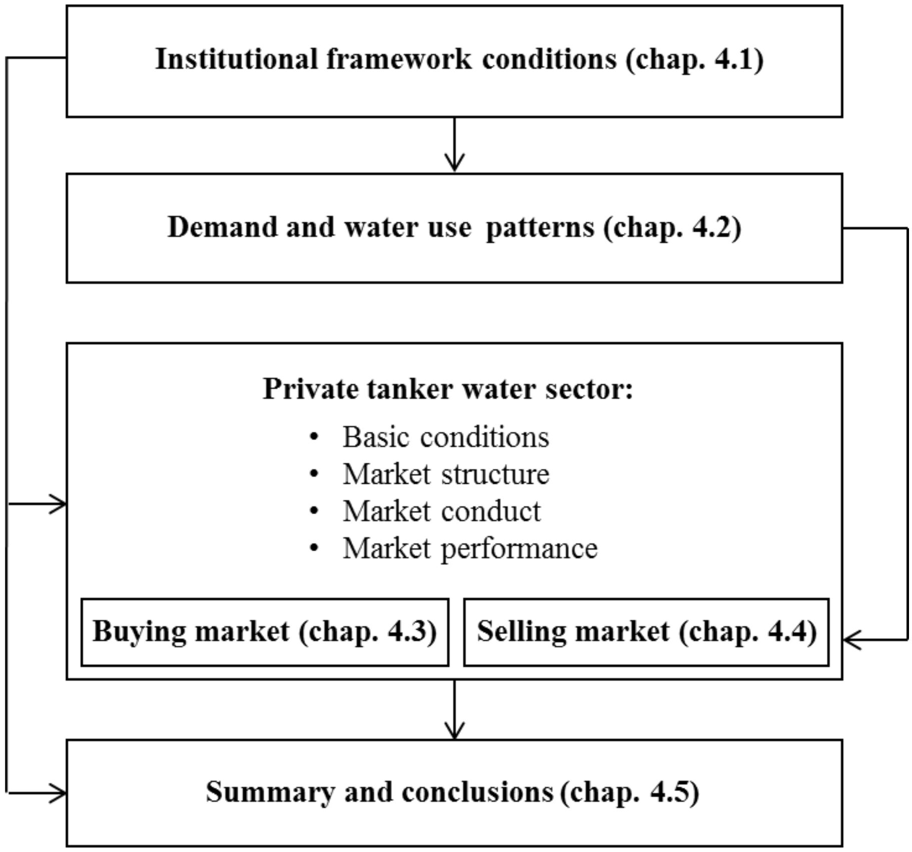


Figure 2.3: Conceptual framework of analysis

In Chapter 4.1, the institutional framework conditions of Jordan's urban water supply sector are resolved through a comprehensive analysis of relevant policy and legal documents. This chapter is very extensive and covers the entire urban water supply sector of Jordan with a focus on the city of Amman and private tanker water markets.

In Chapter 4.2, the demand and water use patterns of the main consumers of tanker water in Amman – commercial establishments and private households – are carved out. Especially, the commercial establishments are treated in great detail including consideration of the substitute goods of tanker water (piped water, treated water, bottled water). The empirical basis for this is the *commercials survey* conducted from September 2015 to February 2016 in Amman (cf. chapter 3.3.3).

The two core chapters of this study then follow. The microeconomic market analysis of Amman's private tanker water sector is broken into two submarkets: (i) the buying market of private tanker water (cf. chapter 4.3) and (ii) the selling market of private tanker water (cf. chapter 4.4). An important empirical basis for this analysis is the *well operators survey* and the *tanker drivers survey* conducted in the period from September/October 2015 to January 2016 in and around Amman (cf. chapters 3.3.1 and 3.3.2). Both chapters are structured according to the four components of the structure-conduct-performance paradigm as it is used in industrial economics: basic conditions, market structure, market conduct and market performance (cf. section 2.3). As far as the basic conditions are concerned, a distinction is made between "physical, technical and economic conditions" and "supply regulations". The content of the latter is essentially based on chapter 4.1. From an industrial economic perspective, the demand and water use patterns could also be described as part of the basic conditions of the selling market of private tanker water, as they have a direct influence on market developments here (that is why the arrow from chapter 4.2 leads directly to chapter 4.4). Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** gives a summary and conclusions of the results from the previous chapters and concludes with a final outlook of the study (cf. chapter 5). The analysis in Chapter 4 is preceded by a chapter explaining the empirical basis of the study (cf. chapter 3).

As far as the development of this study in general is concerned, it should be kept in mind that the analyses and conclusions drawn have to be handled with care for several reasons. Firstly, it has to be taken into account that in general it is very difficult to get trustful data and information about water-related issues in Jordan. Even official data and documents are often contradictory, biased and fragmentary (Bonn 2013). This especially holds for the private tanker water markets which are 'on the fringe' according to the Jordanian water authorities given their partially illegal nature. Finally, it is very difficult to get a comprehensive picture of the prevailing water governance and management system within a country from the perspective of an outside researcher who, additionally, does not speak the national language. Additionally, the field surveys carried out and the existing literature and documents from various sources (e.g., scientific articles, national policy documents, reports from international organisations) are unable to satisfy existing knowledge gaps, and address inconsistencies and uncertainties.

3 Methodology of field surveys

3.1 The survey objectives

The review of publicly available data and reports on private tanker water markets in Jordan revealed that there is a need for empirical data and investigations on private tanker water supply as well as on the demand side of the market. A particular focus should be placed on commercial establishments, because they are the largest consumers of tanker water within Amman and probably also other Jordanian cities.

Against this background, in the period from September 2015 to October 2016, five mostly quantitative surveys were conducted within the Stanford-led Belmont Forum "Jordan Water Project (JWP)"[6] with support from the USAID-PEER Project 3-39 "Enhancing water education at the university level in Jordan by incorporating an innovative multi-agent modeling and analysis tool"[7] in order to collect socioeconomic as well as physical and technical data about private tanker water supply and demand in three different Jordanian cities.[8] Surveys were prepared jointly by the two teams in English, translated and conducted in the field to Arabic, and then results where tabulated in English.

The objective of these five surveys was to provide an empirical basis for two major fields of investigation:

- Socioeconomic studies (e.g., market analyses) on the impacts of private tanker water markets on water supply in the city of Amman with a focus on sustainability issues, i.e. the content of the study at hand.
- Modeling studies on private tanker water markets in Amman (Zozmann *et al.,* 2019) and in entire Jordan as part of a hydro-economic model on freshwater resources sustainability in Jordan, e.g., estimation of demand functions for piped and tanker water of commercial establishments, simulation of partially illegal markets of private tanker water providers, spatial statistical analyses of commercial water consumption (Klassert *et al., in preparation, 2021a, 2021b*).

Three of the surveys were conducted in Jordan's capital Amman and targeted the following key market actors of tanker water: (i) operators of private wells selling water to private water-tankers, (ii) water-tanker drivers purchasing water from private wells and delivering the water throughout the city of Amman and (iii) commercial establishments using piped and/or tanker water. In order to broaden the empirical basis for advanced modeling studies and simulations on the country level, the survey with commercial establishments was repeated in a slightly modified version with (iv) commercial establishments in the city of Irbid and (v) commercial establishments in the city of Ajloun.

With regard to the study at hand, the main objective of the field surveys was to collect socioeconomic as well as physical and technical data about the private tanker water sector in Amman, and analyse this data from a microeconomic market perspective to identify the impacts

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[6] The Jordan Water Project (JWP) is an international research effort targeting an "Integrated Analysis of Freshwater Resources Sustainability in Jordan". Available online: https://pangea.stanford.edu/researchgroups/jordan (accessed on 18 April 2017).

[7] The USAID PEER project is a Jordanian Project funded by USAID and titled: „ Enhancing water education at the university level in Jordan by incorporating an innovative multi-agent modeling and analysis tool" https://sites.nationalacademies.org/PGA/PEER/PEERscience/PGA_152062 (accessed on August 3rd, 2018).

[8] A description of objectives, design and methodology for all five surveys including survey questionnaires can be found at Sigel *et al.* (2017).

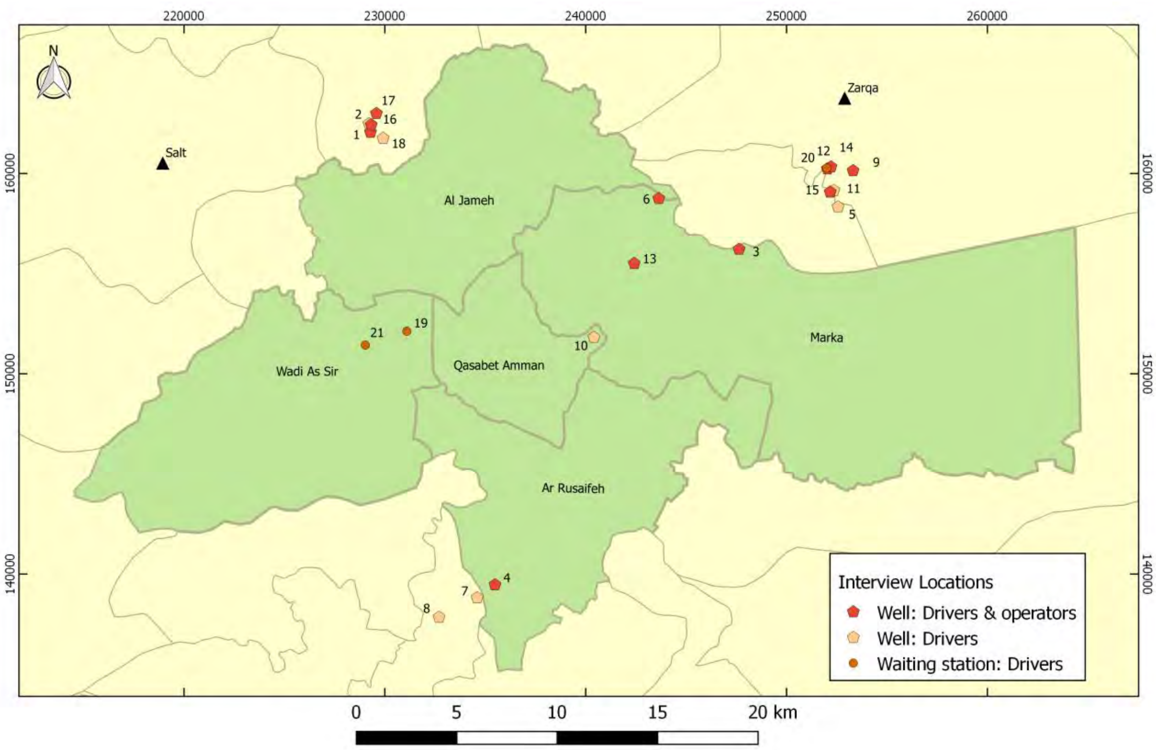
of private tanker water markets on urban water supply. The survey data substantially feeds into the analyses of market structure, market conduct, and market performance of the tanker-water selling and buying market (cf. chapters 4.2 to 4.4). The fact that the surveys target three different market actors – private well operators, water-tanker drivers and commercial establishments – allows for an analysis of market interactions from various perspectives. Several questions were intentionally designed in such a way that cross-checking of answers was possible.

The Interviewers were instructed to collect GPS data for each interview location in Amman during the course of the survey. Each location was classified as a private well, a tanker-water waiting station, or a commercial establishment. This data was collected to develop GIS maps (cf. Map 3.1 and Map 3.2) and to enable the development of a comprehensive spatial simulation model which describes and analyzes commercial demand for network and tanker water in Amman (Zozmann *et al.* 2019).

In the following chapters the design and methodology of the surveys are described in detail (cf. section 3.3) including information on the interview locations (cf. section 3.2).

3.2 Locations of survey interviews

The interviews with water-tanker drivers (n = 300) were conducted at two different types of locations: private wells in and around the city of Amman and so-called "waiting stations" which serve as inner-city supply stations for tanker water. In total, 18 private wells and 3 waiting stations were surveyed. At 11 of the 18 private wells surveyed the well operators were interviewed in addition to the drivers (cf. Map 3.1).



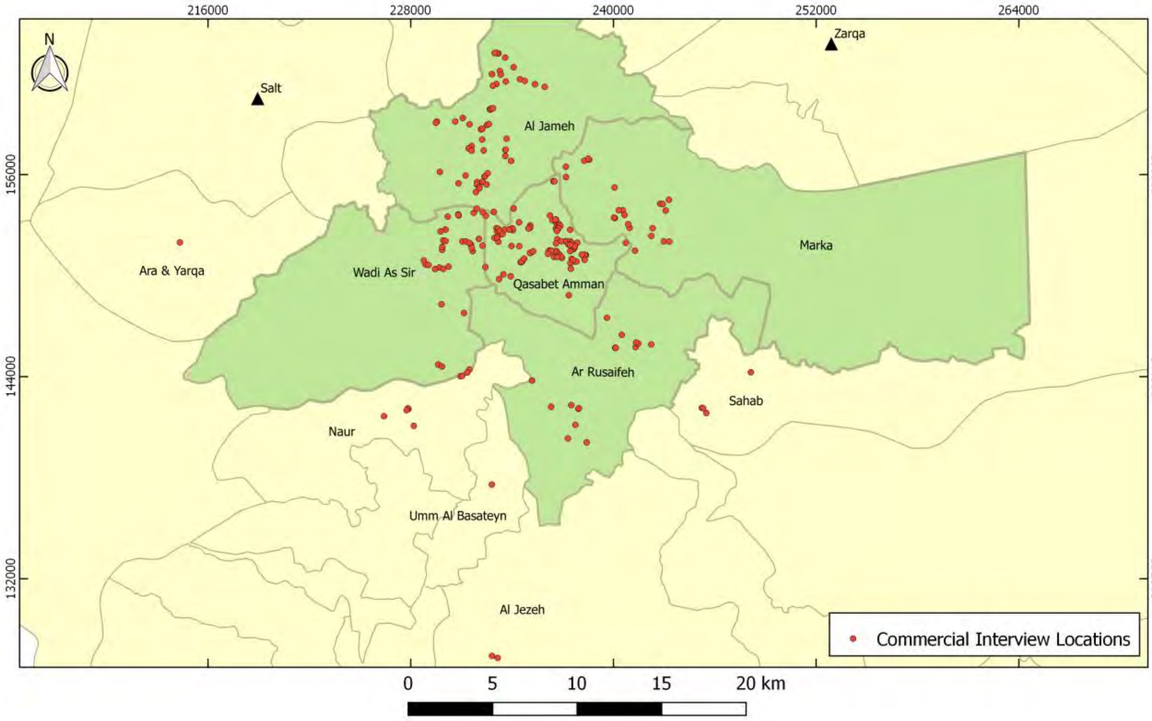
Map 3.1: Locations of surveyed private wells and tanker-water waiting stations in and around the city of Amman

The following table indicates the number of interviews conducted with drivers and well operators at the different survey locations.

Table 3.1: Locations of survey interviews with water-tanker drivers and well operators in the city of Amman and corresponding number of interviews

Location No.	Tanker drivers survey		Well operators survey
	Number of interviews	Percentage	Number of interviews
Private wells			
1	5	1.7 %	1
2	23	7.7 %	-
3	17	5.7 %	1
4	8	2.7%	1
5	8	2.7 %	-
6	6	2 %	1
7	24	8 %	-
8	15	5 %	-
9	8	2.7 %	1
10	21	7 %	-
11	9	3 %	-
12	18	6 %	1
13	19	6.3 %	1
14	10	3.3 %	1
15	20	6.7 %	1
16	19	6.3 %	1
17	15	5 %	1
18	22	7.3 %	-
Waiting stations			
19	13	4.3 %	-
20	9	3 %	-
21	11	3.7 %	-
Total	**300**	**100 %**	**11**

The interviewed commercial establishments (n = 242) are distributed across the entire city with a focus on the five main sub-districts of Greater Amman Municipality (GAM): Qasabet Amman, Marka, Ar Rusaifeh, Wadi As Sir, and Al Jameh (cf. Map 3.2). The number of interviewed commercial establishments per sub-district is listed in Table 3.2.



Map 3.2: Locations of surveyed commercial establishments in the city of Amman (in green: the five main sub-districts of Greater Amman Municipality) [9]

Table 3.2: Number of surveyed commercial establishments (commercials) in the city of Amman per sub-district (the 5 main sub-districts of Greater Amman Municipality are marked by "")*

	Sub-district	**Number of surveyed commercials**		
		Frequency	Percent	Valid Percent
Valid	Qasabet Amman District*	94	38.8 %	39.7
	Al Jameh District*	53	21.9 %	22.4
	Wadi As Sir District*	34	14.0 %	14.3
	Marka District*	22	9.1 %	9.3
	Ar Rusaifeh District*	18	7.4 %	7.6
	Naur District	8	3.3 %	3.4
	Sahab District	4	1.7 %	1.7
	Al Jezeh District	2	0.8 %	0.8
	Ara and Yarqa District	1	0.4 %	0.4
	Umm Al Basateyn District	1	0.4 %	0.4
	Total	**237**	**97.9 %**	**100**
Missing	*no GIS data*	5	2.1 %	
Total		**242**	**100 %**	

[9] The number of red circles is smaller than sample size (n = 242) because the GIS data for 5 surveyed establishments is missing.

3.3 Survey design and methodology

3.3.1 Well operators survey

This qualitative survey aims to investigate the supply of water from privately owned wells that sell (parts of their) water to private water-tankers, who deliver water throughout the city of Amman. The survey is intended to cover a large variety of well types, such as wells with different licenses (drinking, agriculture, industry etc.), ownership structures, and also business strategies (e.g., wells belonging to agricultural or non-agricultural sites).

3.3.1.1 Survey sampling, data collection and analysis

From September 2015 to January 2016, a total number of 21 randomly selected privately owned groundwater wells were visited to conduct structured, guided interviews with well operators and water-tanker drivers. A total number of 11 well operators were willing to participate in an interview, thereof 2 well *owners* (the location of the 11 wells is depicted in Map 3.1, section 3.2).

A first version of the questionnaire was piloted with one well operator. The final survey questionnaire consisted of the following five sections: (i) general questions about the technical features of the well and well operation and management, (ii) water quantities sold, (iii) pricing, sales and customer service, (iv) business costs, and (v) closing questions about factors influencing the business and expected business challenges in the future.

The interviews were carried out in Arabic by one and always the same interviewer and lasted between 20 and 33 minutes (mean: 26 minutes). The data of the 11 questionnaires was translated in English, entered into Microsoft Excel, checked for consistency and finally analysed in Excel.

No consistent official data could be identified that revealed the total number of privately owned wells that sell (parts of their) water to private water-tankers delivering drinking water to Amman. In addition, several sources suggest that illegal wells are operated in the vicinity of the city. It is therefore not possible to make a reliable statement about the extent to which the survey covers private drinking water wells around Amman.

3.3.2 Tanker drivers survey

This quantitative survey aims to assess key socioeconomic and technical characteristics of private water-tanker drivers that deliver groundwater, both drinking and non-drinking quality, throughout the city of Amman.

3.3.2.1 Survey sampling, data collection and analysis

From October 2015 to January 2016, a total of 300 randomly selected water-tanker drivers were engaged for structured, guided interviews. The drivers were met at 18 private groundwater wells and 3 waiting stations (cf. Map 3.1 and
Table 3.1 in section 3.2). 291 out of the 300 interviewees (97.0 %) were driving a green tanker (drinking water) and 9 (3.0 %) a blue one (non-drinking water). Thus, this survey mostly covers private tanker water classified as drinking quality.

The drivers were normally willing to conduct the interview (high response rate), not least because they were in the mode of waiting for something: to get served at the well, to get their tanker filled or for customers to come. Several interviews took place in a non-anonymous atmosphere where the interviewee was surrounded by several other drivers joining the conversation. In these cases the presence of a third party might have distorted the interview responses to some extent.

The 300 face-to-face interviews were guided by a questionnaire developed on the basis of comprehensive pretests. The pretests were intended to scrutinize the applicability of certain questions, refine their wording and identify possible omissions, i.e. significant aspects which had not yet been considered in the draft versions. In addition, the tests helped to optimize interview duration.

The final questionnaire consisted of several questions structured according to the following thematic core sections: (i) job description and income, (ii) technology, (iii) water sources, (iv) water quantities sold, (v) pricing, sales and customer service, (vi) costs, (vii) water quality, and (viii) closing questions about the business, influencing factors and future challenges.

The interviews were conducted in Arabic by two different interviewers who worked independently. The interview duration was between 13 and 30 minutes (mean: 18 minutes). The responses from the 300 questionnaires was translated in English, transferred into Microsoft Excel and checked for consistency. Afterwards, the data was entered into SPSS *Statistical Package for the Social Sciences* (Version 24) for statistical analysis. In SPSS, some variables were transformed, recoded or newly generated, and missing values were specified.

According to recent data from the Jordanian *Department of Motor vehicles and Licensing* the total number of private water-tanker trucks in the governorate of Amman is 1469 (data from 2015-2016), as shown in Table 3.3. Based on this figure the survey covers more than 20.4 % of the licensed private water-tankers circulating throughout the city of Amman (JDMVL, 2016).

Table 3.3 Distribution of vehicle number potable water, non-potable water, and water for general purposes (December, 2016)

City	Potable water	Non-potable water	Water (general purpose)
Irbid	330	316	21
Balqaa	213	52	9
Zarqa	255	67	20
Tafila	34	16	12
Amman	1,036	349	84
Aqaba	57	25	6
Karak	126	98	26
Mafraq	247	238	84
Jerash	71	12	2
Ajloun	26	50	0
Madaba	138	183	9
Maan	103	66	45
Mohafazat	34	54	6
Blank	580	226	116
Total	**3,251**	**1,752**	**440**

3.3.3 Commercials survey

The commercials survey, also designed as a quantitative survey, aims to collect and analyse data about the water consumption behaviour of commercial establishments in the city of Amman with a special focus on tanker water. No preselection was made with regard to the bulk water sources used. The survey covers establishments that use private tanker water as well as others that do not.

3.3.3.1 Survey sampling, data collection and analysis

The commercials survey in Amman was carried out from September 2015 to February 2016 on the basis of structured, guided interviews. The sampling strategy aimed to cover the commercial sector of Amman in a representative way, with a focus on small and medium sized establishments. The surveyed establishments were classified according to the following 6 categories:[10]

- S: Retail stores, service establishments, sports facilities, supermarkets, others (e.g., car washes, dry-cleaners, bakeries)
- R: Restaurants, coffee shops
- H: Hotels, hostels, hospitals
- O: Office buildings (large buildings where water is managed and paid centrally)
- C: Construction sector
- V: Water vendors (water stores selling or delivering filtered water in containers)

The categories allow for analysing the water consumption patterns of different user groups, but also for identifying the establishment sizes through tailored questions in the questionnaire, which are used as basis for estimating demand functions. In order to obtain a representative sample, the city was divided into geographical zones. Interview were conducted across each zone, and within each zone as many different categories of establishments as possible were included. In total, 242 establishments were interviewed by face-to-face interviews, 216 of them located in the five main sub-districts of Greater Amman Municipality (cf. Map 3.2 and Table 3.2 in section 3.2).

For comparative purposes, the commercials survey in Amman was complemented by two smaller surveys in the cities of Irbid and Ajloun. While in Irbid a total of 50 interviews were conducted, 49 were carried out in Ajloun. This served the purpose of establishing a point of reference to compare commercial water consumption patterns against (cf. section 4.2.3).

The proportion of each establishment category surveyed in all three cities is indicated in Table 3.4 below.

Table 3.4: Number of surveyed commercial establishments by category

Number of surveyed commercials per category	Frequency	Percent
Amman		
S: Retail stores, service establishments, sports facilities, supermarkets, others	65	26.9
R: Restaurants, coffee shops	69	28.5

[10] Establishments can fall in more than one category, such as office buildings that include a restaurant.

H: Hotels, hostels, hospitals	43	17.8
O: Office buildings	15	6.2
C: Construction sector	26	10.7
V: Water Vendors	24	9.9
Total	***242***	***100***
Irbid		
S: Retail stores, service establishments, sports facilities, supermarkets, others	25	50
R: Restaurants, coffee shops	4	8
H: Hotels, hostels, hospitals	9	18
C: Construction sector	7	14
V: Water Vendors	5	10
Total	***50***	***100***
Ajloun		
S: Retail stores, service establishments, sports facilities, supermarkets, others	26	53.06
R: Restaurants, coffee shops	8	16.33
H: Hotels, hostels, hospitals	2	4.08
C: Construction sector	1	2.04
V: Water Vendors	12	24.49
Total	***49***	***100***

In the main survey in Amman, 75 % of the interviewees were employees of the establishment, 22 % owners and for the remaining 3 % their exact status was unclear. The overall response rate of interviews was lower than with the water-tanker drivers; several representatives of establishments visited denied an interview.

The 242 face-to-face interviews were guided by a questionnaire which was pretested in the same way as described for the tanker drivers survey. The final questionnaire consisted of 5 core sections with detailed questions about the following topics: (i) water sources and water use, (ii) bulk water consumption and expenditure, (iii) size of the establishment, (iv) piped water use, and (v) tanker water use. Section (iii) was split up into specific blocks of questions for the different establishment categories, which asked for category-relevant parameters that could be used to determine the size of the business (e.g., number of beds in hotels and hospitals).

The field team consisted of 8 interviewers and 1 supervisor. In the majority of cases the interviewers went into the field separately. The interviews were conducted in Arabic and lasted between 10 and 60 minutes (mean: 19 minutes). The data from the 242 questionnaires was translated into English, transferred into Microsoft Excel, and checked for consistency. Afterwards, it was entered into SPSS *Statistical Package for the Social Sciences* (Version 24) for statistical analysis. In SPSS some variables were transformed, recoded or newly generated, and missing values were specified.

4 Microeconomic analysis of Amman's private tanker water sector

4.1 Institutional framework conditions of Jordan's urban water supply sector

To understand the functioning of urban water supply and private tanker water markets in Amman, the formal institutional framework conditions of Jordan's urban water supply sector needs to be analyzed. This was undertaken on the basis of a comprehensive analysis of relevant policy and legal documents. This section substantially feeds into sections 4.3.1.2 and 4.4.1.2 where the basic conditions in terms of supply regulations are described for the buying market and the selling market of tanker water.

The section is structured as follows: First, the current urban water supply policy in Jordan is discussed (cf. section 4.1.1). Second, the institutional actors and their legal competences are described, with a focus on specific regulations for water-tankers, financing of water services, setting and monitoring drinking water quality standards, and groundwater protection and management (cf. section 4.1.2). Then follows a brief critical reflection of the current institutional framework conditions on the basis of literature (cf. section 4.1.3). Finally, some conclusions are drawn (cf. section 4.1.4).

4.1.1 Jordan's urban water supply policy

In light of the severe challenges Jordan's water sector is facing, the changing needs of water users and the adoption of the Sustainable Development Goals (SDGs), the Ministry of Water and Irrigation (MWI) released the *National Water Strategy* for the years 2016-2025 (MWI 2016b) which replaces and updates the former strategies *Water for Life: Jordan's Water Strategy 2008-2022* (MWI 2009) and *Jordan Water Strategy and Policies* formulated in 1998. Similar to the superseded strategies, the *2016 strategy* includes a set of individual policies targeted at different fields of activity within the water sector, for instance the *Water Demand Management Policy* (MWI 2016c), *Water Reallocation Policy* (MWI 2016d) or *Groundwater Sustainability Policy* (MWI 2016a).

In general, the *2016 strategy* presents Jordan's overall water sector strategic goals and approaches including key issues like water, sewage and sanitation services, water for agriculture, energy, industry and tourism, and cross-cutting issues such as institutional reform, capacity development, risk disaster management and climate change adaptation. An important challenge for Jordan's water sector according to the *2016 strategy* is that "… there remains a critical imbalance between supply and demand, especially in a context of regional insecurity and the social, economic and environmental impacts of climate change" (p. 1). The *2016 strategy* also mentions new developments in the water sector which need to be addressed like "… the increased demand resulting from the pressure of Syrian refugees on water resources, increased cost of production specifically the effect of electricity and fuel increased prices and the fiscal strain affecting the service delivery" (p. 2).

4.1.1.1 Overall objectives: Sustainability, IWRM and SDGs

The *2016 strategy* acknowledges the severity of water scarcity in Jordan and emphasizes the need for long-lasting, sustainable approaches in accordance with the concept of integrated water resources management (IWRM). Correspondingly, in the foreword it is stated that "…there is a need to protect national water resources while ensuring equitable and efficient water allocations to meet all social and economic development needs, with secured wastewater/sanitation services to un-served populations." This also requires a shift of prevailing water governance and management paradigms (p. 3). In line with the water-related Sustainable Development Goals (SDGs) Jordan aims to achieve the "sustainable management of water and sanitation for all Jordanians" with safe drinking water delivery constituting a key issue (p. 7).

4.1.1.2 Urban water supply policies, supply enhancements, water demand management

According to the *2016 strategy* municipal and domestic water supply receives highest priority in water allocation with a clear focus on urban areas (p. 12). All citizens shall have "access to sufficient, safe and affordable water for personal and domestic uses" (p. 32). MWI quantifies this to be "120 litres per capita per day in Amman, 100 in other cities and 80 in rural areas" (p. 12). At this point, it is not further explained why basic water requirements of households differ between cities or between urban and rural areas. In 2014, households in Jordan received 61 litres per capita per day on average, while nearly 65 litres per capita and day were lost due to NRW (p. 13). Thus, the targeted quantity of water supply for households is far beyond the status quo. The *2016 strategy* identifies two infrastructure needs which shall be addressed by the Sector Capital Investment Program 2016-2025:

> "1. Expansion of services to cover upcoming forecasted demand consistent with projections. Such services include developing new water resources to satisfy growing demand along with infrastructure that supports access to such resources; (…);
>
> 2. Rehabilitation/replacement of existing infrastructure. Such projects entail improving drinking water and collection networks and irrigation water networks; rehabilitating deteriorated assets in all parts of the water service cycle; and reducing non-revenue water (NRW)" (p. 6-7).

In terms of new, non-conventional water sources which shall be increased to bridge the existing demand-supply gap in public water provision, the *2016 strategy* suggests reclaimed water and desalinated seawater provided by the Red Sea-Dead Sea Project (RSDSP) (p. 9). Further potential drinking water sources mentioned are the exploitation of deep aquifers, dam water treatment, increased water pumping in Disi and other wells, and the development of new groundwater wells including the purchase of wells that are currently in private hands (p. 27-28). In general, to meet future water demand, the *2016 strategy* clearly focuses on supply enhancements and the development of new water sources including "harvesting rainwater, brackish and seawater desalination, increased storage of surface water runoff, artificial recharge, where feasible, more treated wastewater and more importantly, sustaining existing levels of supply" (p. 25). In addition, the *2016 strategy* refers to the *National Water Demand Management Policy (MWI 2016c)* and the need to implement "options to reduce water demand within each sector" (p. 33).

4.1.1.3 Water-rationing program, intermittency, continuous supply

In Jordan, connection rates to the piped network are high, but in all cities except for Aqaba water supply is intermittent. Referring to this, the *2016 strategy* states that "the government has implemented a strict water-rationing program" with the consequence that "households that are not connected to the formal networks or have limited storage capacity, including those in informal settlements, nomadic communities, the poor, refugees and migrants, consume less water" (p. 12). Intermittency is regarded as problematic as it creates "additional risks that may compromise water quality due to intrusion of pollutant to the supply network and during storage for long time" (p. 13). That a change towards continuous supply is intended for other cities besides Aqaba is expressed as follows: "MWI will work to complete the separation and corporatization of all water and wastewater utilities and build their capacities to manage the change to continuous supply" (p. 33). In this context, the Red Sea-Dead Sea project is regarded as crucial as it has "great potential for permanently securing a consistent, continuous water supply for municipal water and irrigation wastewater for the long term" (p. 43). Additionally, on the MWI webpage, it is explicitly stated that supply interruptions shall be removed: "Specific improvements in Jordan's water distribution systems include the removal of inadequacies in the various components of the existing systems, such as operational problems, metering problems, supply interruptions, underdesign of pipes, high operation pressures, and absence of pressure zones."[11]

Bonn (2013, p. 135) argues that the real reason why intermittency was introduced in Amman is not water scarcity and the need to *ration* water but the bad state of the piped network. Due to severe leakages it makes sense to provide water only for some hours of the week. Intermittency officially is termed as a "rationing program" to deflect public attention from the incompetency struggle of authorities to reduce physical NRW. Thus, the "rationing program" in effect is a "rotation programme" (p. 136).

4.1.1.4 Financing, subsidisation, cost-recovery, water pricing, affordability, NRW reduction

Water and sanitation services are strongly subsidized in Jordan. In the future, according to the *2016 strategy*, the following objective shall be pursued in this regard (p. 9): "In the context of equity and affordability, the government policy requires that these services be subsidized. However, the subsidy burden needs to be minimized by improving utilization efficiency, maximizing wastewater collection and minimizing Non-Revenue Water (NRW). Service provision costs would need to protect affordable delivery of basic water service levels while setting the total recovery rates to match the full cost of service provision". Thus, the *2016 strategy* explicitly strives for minimized subsidies and full cost-recovering water prices in the water and sanitation sector. In terms of the affordability of water for households, the *2016 strategy* states that "combined water and sewer bills amount to less than 0.92 % of the total household annual expenditures". This figure is not further discussed which indicates that according to MWI at present there is no affordability problem in this regard. To improve the cost-recovery of water companies like Miyahuna the *2016 strategy* proposes two types of measures (p. 21):

> a. Cost savings from: (i) improvements in energy efficiency by modernizing key infrastructure, including the introduction of renewable energy generation near pumping stations; (ii) a reduction of physical water losses; and (iii) system optimization.
>
> b. Revenue measures: WAJ proposes a gradual approach to: (i) reduce administrative water losses (for instance, unauthorized connections and billing inefficiencies); (ii) increase revenue collection through administrative improvements and the outsourcing of billing to third parties; and (iii) increase water and wastewater service costs for households, industry and farmers.

In terms of the financial sustainability of the water sector, the *2016 strategy* states that full cost-recovery shall be achieved through fiscal reforms and that water prices shall "reflect all the costs associated with operation, maintenance, replacing the infrastructure, opportunity costs and cost of externalities including environmental degradation and damage" (p. 26). Another important factor for fiscal reform put forward by the *2016 strategy* is the reduction of

[11] See http://www.mwi.gov.jo/sites/en-us/SitePages/Water%20Policies/Water%20Policy.aspx, accessed 13 August 2016.

Non-revenue water (NRW). In this regard, it is stated that NRW shall be reduced "by 3-6 % per year with a targeted reduction to 25 % nationally by 2025 and technical losses reduced to below 15 %" (p. 15).

4.1.1.5 Drinking water quality, health risks

In terms of drinking water quality, according to the *2016 strategy*, water supplies shall adopt a water safety management and risk management approach "including the whole supply chain from source (catchment) to tap (consumer ends)" (p. 9-10).

4.1.1.6 Illegal abstractions, illegal water sold through water-tankers

According to the *2016 strategy*, illegal water uses such as water from illegal, unauthorized groundwater wells shall be stopped by enforcing existing legislation, tightening penalties, and "strengthening the criminalization of water theft" (p. 15). The same holds for illegal abstractions from the network through "service connections" (p. 15) which is a form of administrative NRW, for example illegal fixtures in the water network that are used for unmetered water abstractions. According to MWI, 50 % of NRW can be traced back to illegal abstractions (Bonn, 2013, p. 132). Bonn (2013, p. 133) assessed reports of the newspaper Jordan Times in 2010 to ascertain that in Amman 8,400 cases of illegal abstractions are registered per year. Possible reasons provided by the author included (p. 133): no strict action of authorities, inadequate monitoring, thin staffing level and consumer resistance. In Rusayfa, a city with 360,000 inhabitants in Greater Amman Municipality, about 70 % of the water lines above ground and are thus prone to damage (and possibly also illegal abstractions) (p. 134).

Tanker water markets are not explicitly mentioned in the *2016 strategy*. Only in the context of illegal water uses is the term "tankers" used, where it is stated that illegal water which is "used for irrigation or sold through water-tankers (…) reduces the amount available for supply to customers and increases the revenue losses to government" and therefore should be stopped (p. 15).

4.1.1.7 Groundwater protection and management

Alongside the *2016 strategy*, MWI issued a specific policy for the future use of groundwater resources named *Groundwater Sustainability Policy* (MWI 2016a). Because 79 % of the municipal water supply in Jordan is provided by renewable and non-renewable groundwater resources (p. 1) and because groundwater abstracted via private wells constitutes the primary source of water for tanker water providers in Amman, Jordan's groundwater policy is of particular interest for this study.

According to MWI, a specific sustainability policy for groundwater is strongly needed because renewable groundwater resources in Jordan "suffer from depletion caused by overpumping, particularly for irrigation issues in the Highlands" (p. 1). The policy objectives set by MWI for groundwater management in Jordan as summarised in the following Box hold for all wells, whether public or private, and for all types of uses. Some of these are explicitly tackled in the *Groundwater By-Law No. 85* of 2002 (cf. section 4.1.2.5).

Box 4.1: Excerpts from the "Groundwater Sustainability Policy" (MWI 2016a)

2. The agricultural sector's share of ground water resources shall be capped in favor of other sectors that show a higher economic return per cubic meter consumed.
4. Expropriation of use rights arising from legal use of groundwater, or of water rights established on springs from groundwater, reservoirs shall not be made without clear higher priority need, and against fair compensation.
5. Wells shall be closed against compensation for land value or water rights where their designation is zero or negative return.
8. Recharge areas for aquifers shall be protected against pollution caused by whatever means such as solid and liquid waste disposal, mining, landfills, brine disposal, agricultural inputs and the like.
9. Protection zones for all groundwater recharge zones shall be delineated and monitored.
11. Appropriate water tariffs and incentives for groundwater abstraction used in irrigation shall be introduced in order to promote water efficiency in irrigation and higher economic returns for irrigated agricultural products.
12. Legislations pertaining to groundwater management are enforced equally on all well-owners. Strict measures that deter future violations shall be designed and enforced.
19. Farmers and well-owners shall be educated through various means about the value of groundwater for them and the wellbeing of the country for the sustainability of life, and for economic and social development.
23. The quality of groundwater shall be safeguarded by surveying and monitoring all water resources for water quality, and ensuring that water quality standards are consistently being met.
25. Abstraction from all groundwater wells shall be metered, and monitoring of abstraction shall be made periodically to assure conformity with the provisions of the abstraction permits.
33. Prohibition of well licensing for agricultural purposes shall be sustained, and incorporated in pertinent legislation.

4.1.1.8 Implementation and enforcement of the 2009 strategy

The *2016* s*trategy (MWI 2016b)* has been issued too recently to allow for an assessment of whether the strategic goals presented in the document have been put into concrete policy action. It can therefore be helpful to compare it with the previous *2009 strategy* for the years 2008-2022 (MWI 2009) to get an idea as to what extent the former strategic goals have been implemented and enforced. The need for institutional reform, for a reduction of groundwater abstraction towards safe yields, as well as a reduction of NRW had already been recognized in the *2009* s*trategy*. Up to this point, however, in all three topics of concern, no substantial progress has been documented. Two central goals for institutional reform from the 2009 s*trategy* (p. 8/7), the passing of a comprehensive water law and the creation of a central water regulatory body, have not been attained. Groundwater abstraction rates have stagnated between 140 % and 160 % of the annual safe yield in the years 2009 to 2013 (MWI 2013). Out of Jordan's

12 groundwater basins, half are over-exploited and four are at their capacity, whereas only two aquifers are exploited at levels below the safe yield (MWI 2016b, p. 14). Between 2009 and 2013, the share of NRW in public water supply has increased from 44 % to 48 % (MWI 2013, p. 15). In 2014, the share increased to 52 %, with Miyahuna's service area in Amman, Balqa and Zarqa having the highest total water loss (MWI 2016b, p. 15-16).

4.1.2 *Institutional actors and their legal competences in the provision of urban water supply services*

The water supply and sanitation sector in Jordan is shaped by a variety of actors. With regard to public urban water supply and private tanker water provision a number of key actors can be considered relevant (cf. Figure 4.1).

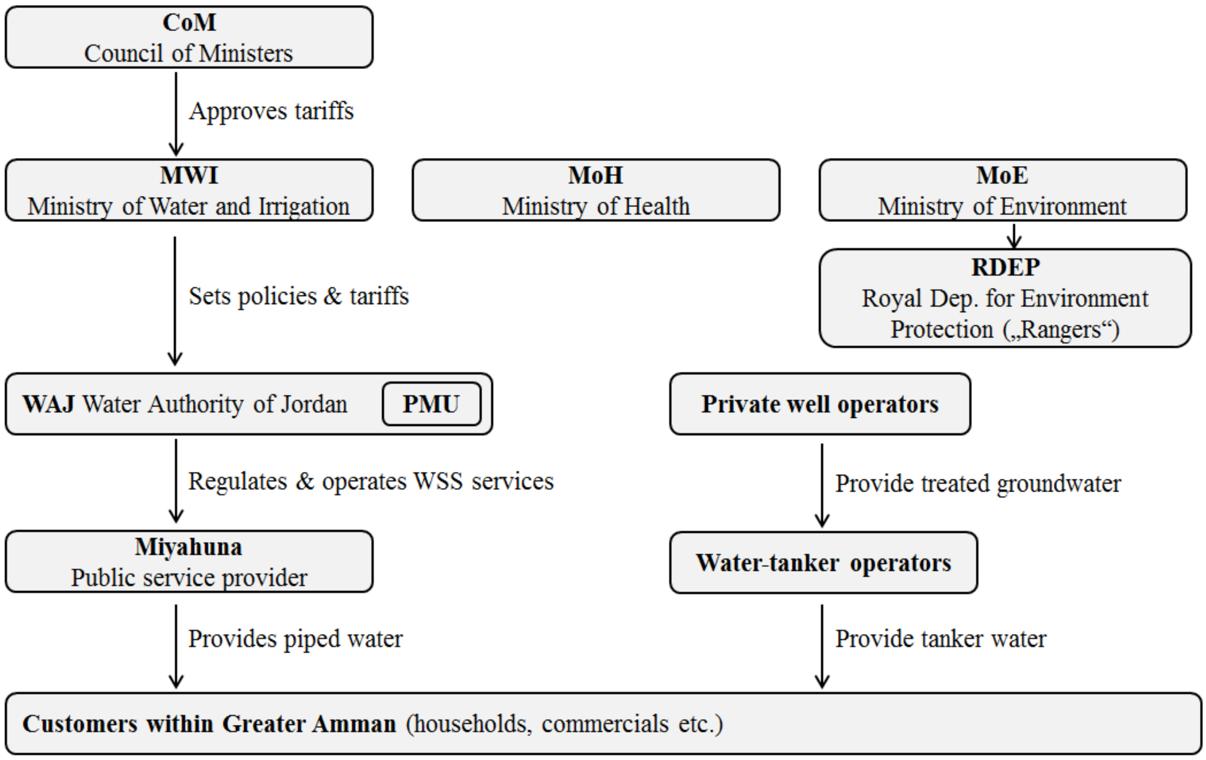


Figure 4.1: Responsibilities for urban water supply services in Amman including tanker water provision (Source: Own compilation based on Dombrowsky et al. (2010) and GTZ (2006))

Since 1992, the *Ministry of Water and Irrigation (MWI)* is entrusted with all water-related issues in Jordan, including the formulation of national policies and strategies, the monitoring of water resources and the establishment of an information system, as well as overall sector planning (OECD 2014, p. 47). Besides that, MWI carries "full responsibility for all water and wastewater systems and related projects" (WAJ Law, Art. 5). Water policies formulated by MWI have to be transmitted to the *Council of Ministers (CoM)* for adoption. Price regulation is also done by the MWI, which is allowed to set tariffs that cover at least operation and maintenance costs (O&M) (GTZ 2006). Furthermore, MWI coordinates the work of the Water Authority of Jordan (WAJ) and cooperates with the WAJ in the management of water resources. The Ministry of Water and Irrigation can therefore be regarded as the leading authority in the country's water regulation system (Saidam & Ibrahim 2006, p. 15-18).

The Minister of Water and Irrigation is concurrently the chairman on the Board of Directors of the *Water Authority of Jordan (WAJ),* an organization that has both operational and regulatory functions in Jordan's water supply system (Steiner 2008, p. 51). WAJ was founded in 1983 as a financially and administratively independent autonomous corporate body and derives its mandates mainly from Law No. 18 of 1988 (the so-called WAJ Law). WAJ is the national authority responsible for water supply and sanitation services (GTZ 2006) and entrusted with conserving, managing and developing different water resources for their implementation and use. An exception is that they do not have a mandate for managing the use of irrigation (WAJ Law Art. 6a.). Other selected functions of WAJ are: implementing approved water policies related to domestic and municipal waters[12] and sanitation (Art. 6b.), directing and regulating the construction and drilling of public and private wells (Art. 6c.), preserving water and water basins and protecting them from pollution (Art. 6e.), regulating the uses of water, preventing its waste, and conserving its consumption (Art. 6h.). An amendment of the WAJ Law in the year 2001 enabled the organization to delegate duties or individual projects to other public or private entities, which served as a basis for a more extensive involvement of the private sector in water governance (OECD, 2014, p. 32). WAJ fully owns or holds majority shares in the utilities Miyahuna, Aqaba Water Company and Yarmouk Water Company. These three companies serve 45 % of the Jordanian population and account for about 70 % of delivered water volumes. The remaining 30 % are delivered to end-users by WAJ directly (OECD 2014, p. 23). In 1997, the *Programme Management Unit (PMU)* was set up within WAJ in order to monitor and manage the contracts made with corporate operators (Steiner 2008, p. 51). For the last two decades, the piped water supply through utilities has been in a process of decentralization and commercialization that is steered and controlled by WAJ. In Amman, piped water has been supplied by the public utility *Miyahuna* since 2007, following the end of a service contract with the private enterprise LEMA. Miyahuna is 100 % owned by WAJ and provides water and wastewater services for Amman as well as Balqa, Zarqa and Madaba with a total of 550,000 customers (MWI 2016b, p. 18).

The *Ministry of Environment* (MoE) is responsible for the protection of natural resources in Jordan and has a mandate to monitor the quality of all water resources and to investigate quality violations and pollution. MoE therefore created an executive arm in 2006, the *Royal Department for Environment Protection (RDEP),* which conducts random quality investigations in the field (OECD 2014, p. 43-44). RDEP officials are referred to as "environmental rangers/police" and conduct drinking water quality controls and enforce the provisions for the groundwater protection zones.[13]

The *Ministry of Health* (MoH) is responsible for all health affairs in the country and thus also for drinking water quality and hygiene (cf. section 4.1.2.4).

4.1.2.1 The legislative and regulatory framework: An overview

In Jordan the water supply sector is regulated by a number of individual laws, regulations, and standards. An overview of the legislation relevant for urban water supply and tanker water provision in particular is presented in the following table.

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[12] According to the WAJ Law the term "municipal waters" means "waters that are used for domestic, commercial, industrial and touristic purposes and which are supplied through the public networks" (Art. 6b.)

[13] See http://www.menawater-2011-berlin.de/abstracts/Mj_Mohammed_Al_Rahahleh.html, accessed 9 August 2016.

Table 4.1: Regulatory frameworks with relevance to urban water supply and tanker water provision in Jordan[14]

Regulatory framework	Relevant provisions
MWI By-Law No. 54 of 1992[15]	• Establishes the organizational structure and mandates of MWI
WAJ Law No. 18 of 1998, last amended in 2001	• Establishes the organizational structure and mandates of WAJ • Stipulates that all water resources within Jordan's borders are considered to be property of the state (Art. 25a) • Obliges anyone wishing to sell or transport water to obtain WAJ's written approval (Art. 25c.) • Establishes penalties for unlicensed well-drilling and pollution (Art. 30 A, B)
Groundwater By-Law No. 85 of 2002, last amended in 2004[16]	• Stipulates that groundwater is owned and controlled by the State (Art. 3) • Stipulates that any drilling or extraction shall be according to a license issued pursuant to the By-Law (Art. 8) • Restricts the yearly abstractions from wells to quantities defined in the licenses (Art. 9) • Regulates licenses fees, water prices for water extraction and service charges (Art. 37-39) • Determines mechanisms for license removals (Art. 17)
Public Health Law No. 47 of 2008	• Instates the MoH as being responsible for all matters pertaining to health (Art. 3) • Instates the MoH for controlling drinking water regardless of its source (Art. 36) • Instates the MoH for controlling drinking water resources, their networks and methods to be used in the treatment, transmission, distribution, and storage of drinking water (Art. 38) • Establishes penalties for anyone who sales or distributes polluted or untreated water according to the technical rules or the approved relevant standard specifications (Art. 62)
Environmental Protection Law No. 52 of 2006[17]	• Establishes the mandates of MoE • Outlaws the discharge of harmful substances into water bodies (Art. 11)

[14] The first five laws depicted in this table are also mentioned by the *2016 strategy* as being relevant for water and sanitation.

[15] This By-Law has been replaced by a new version No. 14 of 2014. In this study the former (but cancelled) version No. 54 of 1992 is assessed as the new version couldn't be obtained.

[16] In this study the 2002 version is assessed as the new 2004 version couldn't be obtained.

Environmental Control and Inspection Act No. 65 of 2009, issued under paragraph (A) of Art. 25 of the Environmental Protection Law No. 52 of 2006	• Regulates control over facilities to assess their compliance with legislation to prevent environmental pollution (Art. 3) • Organizes environmental protection procedures (Art. 3) • Specifies types of environmental inspections, rules for the inspectors, and reporting mechanisms
Water Protection Regulation of 2005, issued under section (3) of paragraph (A) of Art. 23 of the Environmental Protection Law No. 1 of 2003	• Determines the cooperation between MoE and water authorities • Regulates the monitoring of water quality (Art. 3) • Stipulates MoE's mandate to protect water resources from pollution and contamination (Art. 4, Art. 10, Art. 11) • Prohibits the use of any substance for treating, decontaminating, transferring, or preserving drinking water, mineral water and bottled water without prior approval of MoE (Art. 8) • Prohibits the production of drinking water, mineral water and bottled drinking water without a license from MoE (Art. 9)
Standard for Drinking Water Quality No. 286 of 2001 (2008, 2015)[18]	• Specifies the microbiological, chemical, physical and radiological requirements and procedures for monitoring and evaluating the quality of drinking water, whether from public or private source
Standard for Bottled Drinking Water No. 1214 of 2004	• Determines the biological, chemical and physical requirements for bottled drinking water (including water bottled in appropriate containers at retail stores)
Standard for Natural Mineral Water No. 200 of 2001[19]	• Regulates packaged natural mineral water
Description of the Conditions and Requirements that must exist in Tanker Trucks, granted under Art. 10 and 22 of the temporary traffic law No. 47 of 2001	• Provides information about the physical requirements of tanker trucks (in general) to make them roadworthy (tanker body, drain pipes and hoses, exterior shape, paintings and writings, additional equipment)
Transportation Costs and	• Provides recommendations about the physical and technical

[17] See http://www.moenv.gov.jo/EN/LegislationAndPolicies/Legislation/Regulations/Pages/EnvironmentalProtectionLaw.aspx#.V6su_npRw8v, accessed 10 August 2016.

[18] See http://www.jsmo.gov.jo/en/Eservices/pages/StandardsAndTechnicalRD.aspx?mfn=5510&Itemcart=0. accessed 13 August 2016.

[19] See http://www.jsmo.gov.jo/en/Eservices/pages/StandardsAndTechnicalRD.aspx?mfn=200&Itemcart=0, accessed 13 August 2016.

Conditions of Water Tankers (Executive Summary), MWI 15/30/524 dated 3/2/2008[20]	requirements of water-tankers transporting drinking water, calculating tanker water tariffs, and inspection requirements • Section 4 corresponds with the above-mentioned document but is tailored to water-tankers

4.1.2.2 Specific regulations for water-tankers

Only one regulation could be identified which specifically targets water-tankers, namely the *Transportation Costs and Conditions of Water Tankers* document issued by MWI in 2008.[21] Against the background of tanker water playing an important role for drinking water supply, the MWI called three meetings with representatives of WAJ, MoH, Ministry of Energy and Mineral Resources, Ministry of Transportation, and the Public Security Directorate (traffic department) to provide "recommendations" for tanker trucks transporting drinking water to ensure "high quality standards" and "reasonable prices". The results of the committees' meetings are summarized in the *2008 document*. From the document it is not clear what the exact legal status of these "recommendations" are, and if they are for Jordan in general or for cities like Amman. Under closer inspection the *2008 document* contains recommendations with regard to the following issues:

- Tariffs for tanker water based on transportation costs (section 3)
- The physical and technical requirements of tanker trucks transporting drinking water (section 4)
- Inspection requirements (sections 5.3 to 5.5)

The main statements regarding these three issues are described in the following sections a) to c).

a) Tariffs for tanker water based on transportation costs

The basic idea of section 3 of the *2008 document* is to calculate the costs for transporting tanker water and to derive from these costs recommendations for "reasonable prices". Two case studies on the transportations costs of tanker water are described, the first is on the basis of data provided by WAJ and the second on the basis of data provided by MWI. Fixed costs as well as variable costs are calculated based on various assumptions. The data and results of both case studies are summarized in the following table.

[20] Section 4 of this document corresponds with the above-mentioned document but here it is tailored to water tankers.

[21] The information in the following is based on an unofficial translation of this document.

*Table 4.2: Calculation of tanker water transportation costs according to the 2008 document of MWI. (Data marked with * is not taken from the document but calculated by the authors.)*

	Case study 1 (WAJ)		Case study 2 (MWI)	
		Costs[22] [fils/m³/km]		**Costs [fils/m³/km]**
Basic data:				
Tanker capacity [m³]	8		15	
Number of trips per year (round trip)	1,200		1,200	
Number of trips per month (round trip)	100		100	
Number of trips per day (round trip)	4		4	
Number of working days per year	300		300	
Distance travelled per trip [km]	26		50	
Distance travelled per year [km]	31,200		60,000	
Tanker's value [JD]	9,984*		18,000	
Tanker's operating time [years]	25		25	
Price of gasoline [JD per liter]	0.630		0.630	
Gasoline consumption [liters per 100 km]	44.082		22.22*	
Variable costs:				
Costs for gasoline		34.71		9.33
Oil change costs for every 3000 km [JD]	26	1.08	45	1.00
Costs for replacing six tires each year [JD]	1,500	6.00	1,500	1.67
Costs for spare parts and maintenance fee [per year]	*10 % of tanker's value*	4.00	*10 % of tanker's value*	2.00
Fixed costs:				
Annual interest rate	*10 % of tanker's value*	4.00	*10 % of tanker's value*	2.00
Annual depreciation	*10 % (20 %?) of the remaining tanker's value*	3.20	*20 % of the remaining tanker's value*	1.6
Tanker truck registration fee (non-recurring) [JD]	1830	0.3	1830	0.081
Annual operating expenses (insurance, use of public registration plate) [JD per year]	500 (or: 710)[23]	2 (or: 2.844)	500	0.56
Drivers wage [JD per month]	250	12	250	3.33
Total costs:		**67.29**		**21.571**

[22] One Jordanian Dinar (JD) is 1,000 fils.

[23] The 2008 document states different numbers here, the calculation however is based on the number not within the brackets.

Based on the two case studies the *2008 document* argues as follows: The mean transportation costs resulting from both case studies is 44.431 fils/m^3/km. Assuming that the mean distance travelled for transporting drinking water from the source to the customer is 50 km (round trip) the mean transportation costs paid by the tanker truck operator is 2.22 JD/m^3. To calculate the tariff for one cubic meter of tanker water the *2008 document* suggests using the following equation, considering changes in prices of gasoline as needed:

Tariff for one cubic meter of tanker water = mean transportation costs (2.22 JD/m^3) plus costs paid to private well owner or WAJ (JD/m^3) plus net profit.

In terms of net profit it is suggested to add 10 % of transportation costs to the calculated tariff.

b) Physical and technical requirements of tanker trucks transporting drinking water

The *2008 document* contains requirements for water-tankers "to ensure public health protection and safety" and "to protect the quality of drinking water". These include the "water tanker body" (4.1), the "water drain pipes" (4.2), "the exterior shape of the water-tanker truck (4.3), the "paintings and writings" (4.4) and "additional equipment" (4.5). Among other requirements it is stated that "tanker trucks transporting drinking water shall be painted in green and the words 'potable water' shall be written on both sides and on the back of the water tank in suitable sized letters in white color". Non-potable water shall be transported in tanker trucks painted in blue. Furthermore, every water-tanker truck "shall be equipped with a valid water counter credited with a certificate from the Standards and Meteorology Department".

c) Inspection requirements

The *2008 document* recommends conducting routine inspections of water sources "for filling water tanks and tanker trucks" by liaison officers from each of the relevant Ministries, to ensure compliance with existing standards, instructions and requirements, and to adopt deterring measures against violations and irregularities (5.3, 5.4). Furthermore, each tanker driver shall have a "statement of facts" from each drinking water source used, indicating the water source, the water counter number, and the quantity loaded in cubic meters (4.10, 5.5).

4.1.2.3 Competences to finance water services

The WAJ Law contains only a few Articles related to the financing of water services (cf. excerpts in the following Box 4.2). Thus, most of the following information is taken from related policy documents and secondary literature.

Box 4.2: Financing-related Articles in the WAJ Law No. 18 of 1998

Article 10:
The Board shall undertake the following duties and responsibilities:
f. Recommend to the Council of Ministers tariffs for connections, subscriptions, price rates and deposit fees that should be collected for various water and public wastewater uses.

Article 15:
The Financial Resources of the Authority shall consist of:
a. Revenues from water prices, subscriptions, deposits and other fees the Authority may collect for its services.
b. The income from movables and real estate owned by the Authority and the income of

its investment projects.
c. Loans, donations and subsidies to the Authority agreed by the Council of Ministers.
d. Any Other sources of income of the Authority.

Article 21 C:
Notwithstanding what is stated in any other legislation, no governmental department, official or private corporation, or any natural or corporate body is exempted from the Authority's fees or charges for supplying water or rendering services or from the costs of construction or pipe-laying or from the contribution to the costs of any project or from the prices and fees charged for services rendered by the Authority, according to the provisions of this Law.

a) Tariff regulation

Revenues from water services are an important financial resource of WAJ (cf. WAJ Law Art. 15). However, WAJ can only prepare and submit a tariff change request to the Minister of Water and Irrigation. The Minister in turn can make a recommendation for a change in the tariff to the Council of Ministers (CoM), who has the ultimate power in tariff regulation (cf. WAJ Law Art. 10). Operators such as Miyahuna are able to make recommendations to WAJ on tariffs and fees in their service area but they do not have defined responsibilities in the tariff setting activities (USAID 2013b, p. 31). Generally, tariff regulation in Jordan is a highly political endeavour with the process being rather ad hoc and non-transparent. Furthermore, there is no established methodology for tariff setting (OECD 2014, p. 33). The last tariff increase was in 2016[24].

b) Subsidies, cost-recovery

As mentioned above, two basic principles for financing water supply and sanitation services laid out in the *2016 strategy* are (i) to minimize subsidies, and (ii) to achieve full cost-recovery through water prices reflecting all costs including externalities. Cost-recovery shall be achieved through a variety of measures, amongst others by increasing water and wastewater service costs for households, industry and farmers.

At present, Jordan's water sector is highly subsidized. According to the *2016 strategy* the benefit transferred by the Government to the water sector nearly doubled between 2006 and 2010 and reached approximately 500 million JD in 2010 with a share of 213 million JD for domestic water (p. 20). In general, Jordan spends between 2 % and 4 % of its GDP on the water sector (p. 4). As per OECD (2014, p. 33-36) governmental subsidies to the water sector amounted to 20 % of the government deficit in 2010 and there is a "strong probability" (p. 36) that the Ministry of Finance has to cover WAJ's debts. In terms of cost-recovery, current data suggests that the total revenues of WAJ and the water companies surpassed 100 % of O&M costs and accounted for 60-70 % of total costs (O&M costs plus capital costs) but only in the case that subsidies are not taken into account (MWI 2016b, p. 20). Cost-recovery has decreased since 2005 because of large infrastructure investments (p. 20), but the sector is envisaged to achieve O&M recovery in 2020 (p. 21). As stated by OECD (2014, p. 25) one important reason for low cost-recovery rates and high inefficiencies in the sector is that the water companies have only limited autonomy over decision making in relation to WAJ, for instance in terms of capital investments, financial planning or tariff setting.

[24] See http://www.waj.gov.jo/sites/en-us/Pages/water-Prices.aspx, accessed on 16 November 2017.

c) The public service provider Miyahuna

Miyahuna obtains its revenues mostly from tariffs and a 3 % property tax. The tariff is for water delivery services, wastewater collection services, meter fees, water network connection services, and wastewater connection services. The invoice of Miyahuna comprises three charges (USAID 2013b, p. 31): (i) a fixed fee to cover administrative costs not related to water consumption, (ii) charges for water usage based on consumption, and (iii) charges for sewage collection and treatment based on consumption. In addition, Miyahuna collects a one-time connection fee for water services connections and wastewater connections (USAID 2013b, p. 32). The water and sewerage tariffs for residential and non-residential consumers are different, with non-residential tariffs being significantly lower. For residential water services an increasing volumetric block pricing system is in place. The revenues of Miyahuna and WAJ do not match the increasing O&M costs of water provision, let alone the capital costs of large-scale infrastructure projects such as the Disi Conveyance Project. USAID (2013a, p. 22) explains Miyahuna's inefficiencies as being due to its organizational structure, stating that "as neither a private company nor government agency, it suffers the disadvantages of both with limited benefits of either".

4.1.2.4 Competences to set and monitor drinking water quality standards

The two core laws regulating the system for monitoring drinking water quality in Jordan are the *WAJ Law* of 1998, defining the role of WAJ, and the *Public Health Law* of 2008, defining the role of the MoH.

The MoH is responsible for all health affairs in the country and thus also for drinking water quality "regardless of its source" (cf. Art. 36 Box 4.3) which includes the whole process of drinking water production (cf. Art. 38). In coordination with the relevant authorities, MoH ensures compliance with Jordan's water standards, which have been developed out of adapted standards of the World Health Organization (UN 2014; WHO & UNICEF 2010). The current Jordanian *Drinking Water Quality Standard* of 2001 is issued by the Jordan Institute of Standardization and Metrology. For bottled drinking water and mineral water, there are different standards in place (cf. Table 4.1). A comparison of these standards performed by MWI reveals that the "drinking water quality standard seems to be more restrictive than the natural mineral water standard".[25]

Both entities, WAJ and MoH, are responsible for the monitoring of drinking water quality by sampling and laboratory analysis (UN 2014, p. 9; WHO & UNICEF 2010, p. 3). The Ministry of the Environment, however, also has a mandate to control drinking water quality: Within the *Water Protection Regulation* of 2005 it is stated that any project to produce drinking water, mineral water and bottled water needs a license from the MoE (Art. 9). As reported by Gerlach & Franceys (2009, p. 28), tanker operators require a valid water quality license from MoH and must produce it upon request in random inspections if they want to avoid penalties or loss of license.

According to the *Drinking Water Quality Standard* of 2001, quality control is the responsibility of the owner of a "water enterprise" (see Box 4.4). This means that even the owner of a private groundwater well selling drinking water to water-tankers is obliged to conduct quality

[25] Source: "Development of Drinking Water Quality Standards in Jordan, Dr. Muna Hindiyeh, Water & Environmental Engineering, Water and Wastewater Microbiology, Amman/Jordan, accessed via the internet 13 August 2016.

testing. Similarly, the quality of bottled water has to be controlled by the factory or store producing such water (cf. *Standard for Bottled Drinking Water* of 2004).

Box 4.3: Excerpts from the Public Health Law No. 47 of 2008 (inofficial translation)

Article 36:
The Ministry [Ministry of Health] shall in coordination with the relevant authorities, and in conformity with its own legislations, control the potable water, regardless of its source, in order to ensure its fitness from the health aspect, and take the necessary procedures to prevent the use of any undrinkable water. This would include the taking of samples there from and their testing at its laboratories or any other laboratories approved by it.

Article 38:
The Ministry shall be entitled to control the following:
A- Potable water resources and their networks, in order to ensure that they were not exposed to pollution.
B- The method to be used in the treatment, transmission, distribution, and storage of potable water, in order to ensure the availability of health conditions in such processes, including the quality of materials used in the potable water processes, its transmission, distribution, and packing, as well as the prevention of using any material that may harm the consumer's health.

Article 39:
Any person who is responsible for a water resource, network, station, or potable water bottling factory must inform the Ministry or the Water Authority, or both of them, as the case may be, of the occurrence of any pollution to the water placed under his supervision.

Article 62 (a) 2:
Any person responsible for a water resource, network, plant, tanks, or bottled water industry selling or distributing polluted water, untreated or unconfirmed to the technical rules or the approved relevant specification standard shall be liable to a fine of not less than JD 5,000 and not exceeding JD 10,000 or to imprisonment for a period of not less than four months and not exceeding three years or both.

Box 4.4: Excerpts from the Standard for Drinking Water Quality No. 286 of 2001

4. Quality Control: The suitability of water for drinking and its compliance with the adopted health standards have to be verified/checked by the party owning the water project/enterprise, and it is obliged to conduct the necessary laboratory tests and to maintain official records of the results of those tests and to make them available for the governmental control agencies upon request.

Box 4.5: Drinking water quality related Articles in the WAJ Law No. 18 of 1998

Article 6:
In order to achieve all the objectives intended by this Law the Authority shall exercise the following responsibilities and tasks:

f. Carry out theoretical-and applied research and studies regarding water and public wastewater to achieve the Authority's objectives including the preparation of approved *water quality standards* for different uses and technical specifications concerning materials and construction in order to apply the findings to the Authority's projects in coordination with other concerned departments; and publish the final findings and standards so as to generalize their application by all means available to the Authority.

4.1.2.5 Competences to regulate groundwater protection and management

The main laws regulating groundwater protection and management in Jordan are the *WAJ Law of 1998* and the *Groundwater By-Law* No. 85 of 2002, which define the roles of WAJ, MWI and CoM respectively (cf. Box 4.6 and Box 4.7). Accordingly, WAJ has the main responsibility for implementing the groundwater law, but overall decision making competencies are assigned to MWI and the CoM. For example, the drilling license for a well including the permitted depth and any other conditions shall be issued by the Minister of MWI (Groundwater By-Law, Art. 21 C).

As mentioned above, specific objectives and principles for groundwater protection and management are set in the *Groundwater Sustainability Policy* (MWI 2016a), including policy objectives for the development of public and private groundwater wells. The *Groundwater By-Law* contains concrete provisions and measures for its implementation. The last amendments of 2004 mainly aimed at controlling over-abstraction of groundwater, illegal well drilling and illegal groundwater use (El-Naqa & Al-Shayeb 2009, p. 2387).

a) Property rights

In both the *WAJ Law* (Art. 52a) and the *Groundwater By-Law* (Art. 3), it is stated that all water resources, surface- and groundwaters, are owned and controlled by the state. If a land holder wants to extract and use groundwater, he needs a license issued under the *Groundwater By-Law* prescribing the usage, the extraction quantity and any other conditions.

b) Regulation of groundwater wells

The *Groundwater By-Law* stipulates that everybody needs to have a license for drilling a well and for extracting groundwater (Art. 8). The extraction license is based on a pumping test determining the production capacity, the water quality, the permitted depth, and the annually allowed pumping quantity (Art. 9 A., Art. 21 C.). Most groundwater wells in Jordan are used for irrigation. The *Groundwater By-Law* prohibits “to irrigate any land other than that specified in the water extraction license or to sell this water for irrigation purposes” (Art. 11 A.). Thus, groundwater trading among farmers is not allowed. If wells are selling water “by water-tankers for drinking purposes or any other purpose” they need to have a written approval (Art. 11 B.). This is the only passage where water-tankers are explicitly mentioned in the *Groundwater By-Law*. The well depth shall be fixed in the license and there is also a license for deepening, cleaning or maintaining an existing well (Art. 28). If the licensee violates any of the conditions in the drilling and extraction licenses, WAJ is allowed to cancel the licenses and to shut down the well (Art. 17). The license for water extraction contains several conditions the licensee should comply with (Art. 29), including the responsibility to install and maintain a water-meter, the obligation to pay prices to WAJ for the extracted water, and to keep a register with all data relating to the well which might be inspected by WAJ.

c) Licenses fees, water prices and service charges

When the *Groundwater By-Law* entered into force in 2002, fees for the first time were demanded for agricultural groundwater use (Bonn 2013, p. 126). Three types of fees are distinguished in the law: "licenses fees", "water prices", and "service charges".

WAJ levies fees for the issue of any kind of license (Art. 37), e.g., for the drilling license, the water extraction license, and the well deepening license. For the extraction of water the licensee has to pay a water price (Art. 38) with different prices for (A) agricultural wells, (B) "wells which belong to Government Departments, official public institutions, public institutions and municipalities", and (C) "wells for industry, production, tourism or university purposes".

For type A wells, there are different increasing block tariffs (depending on the water quantity extracted per year) for (i) licensed wells, (ii) wells which are located in the Al-Azraq area, and (iii) active but (still) unlicensed wells. Owners of (i) licensed wells have to pay the lowest water price compared to all types of wells, starting with 0 fils per cubic meter up to 150,000 cubic meters, 25 fils per cubic meter up to 200,000 cubic meters and 60 fils per cubic meter for quantities higher than 200,000 cubic meters.[26] The water prices of (iii) still unlicensed wells are slightly higher with a maximum price of 70 fils per cubic meter. For type A wells no price distinction is made with regard to water use. This could be due to the assumption that agricultural wells use the water only for irrigation and not for other purposes. For type B wells, a distinction is made between water used for agriculture (25 fils per cubic meter) and water used for drinking or any other purpose (100 fils per cubic meter). Type C wells are charged 250 fils per cubic meter when they are designated for drinkable water and 100 fils per cubic meter for non-drinkable water. Last but not least, WAJ collects service charges (Art. 39) for any services rendered to well owners, such as technical field inspection, monitoring of drilling, cleaning, deepening and maintenance works, and testing of well water samples and lab assessment thereof.

The water pricing scheme is not clear in discerning to which type of well (A, B, or C) private wells selling groundwater to water-tankers in Amman belong. Nine out of eleven interviewed well owners stated (cf. *well operators survey*) that their well has always been intended to produce water for sale to tankers, and only five well operators were actually working as farmers. Thus, not all interviewed private wells are typical type A "agricultural wells". In terms of "water prices" eight well owners indicated that they have to pay 250 fils per cubic meter to the government independent of the abstraction rate (the remaining three interviewees answered the question with "don't know"). This corresponds with the "water price" for drinkable water of type C wells. Maybe Amman's private wells selling groundwater to water-tankers are assigned to type C (which wouldn't be in line with the definition given for type C wells) or there is another specific regulation beyond the *Groundwater By-Law* unknown to the authors. Another question is if the "water price" is related to the purpose of water use or not. More than half of the interviewed well owners (six out of eleven) have more than one license, including licenses for drinking, agriculture, and industrial purposes. The *well operators survey* raises the hypothesis that the well owners always have to pay the same "water price" to the government, irrespective of water use, i.e. for example whether they are selling their water to green or blue water-tankers. The *Groundwater By-Law* does not contain any provisions for the sales price of water from wells. The *WAJ Law* states that the selling and transporting of water needs to be approved by WAJ and that it is bound by contracts and agreements (cf. Art.

[26] According to Bonn (2013, p. 126) water prices for groundwater wells were reduced by one-fifth due to a revision of the *Groundwater By-Law* in 2004.

25c). It is possible that these associated documents contain provisions about the well water sales price.

The *Groundwater By-Law* has been heavily criticized by donor organizations and NGOs, particularly after its revision in 2004. A frequent point of criticism is that it fails to set price incentives for more efficient water use and strongly favors the agricultural lobby (Bonn 2013, p. 127; Yorke 2013, p. 42). The fact that the use of water up to 150,000 cubic meters is free leads well owners to use more water than before 2002 (Bonn, 2013, p. 126). The enforcement of the *Groundwater By-Law* is inadequate: water-meters are not installed at every well and are prone to being manipulated; meter reading is conducted irregularly and fees are collected only sporadically (Bonn, 2013, p. 127).

d) Exception rules for selected public and private wells

According to the *Groundwater By-Law* the drilling of wells is only permitted in designated areas (Art. 6 A). However, in cases where "Ministries, Governmental Departments, Official Institutes, Universities, and industry and tourism sector find it impossible to secure their water needs from the public water supply network the Board [Authorities Board of Directors] may grant any of them a license to drill wells in the prohibited areas pursuant to the provisions of this By-Law" (Art. 6 B). The water extracted from these wells can only be used for licensed purposes (Art. 24).[27]

This clause is interesting as it identifies a group of privileged (municipal) water users which obtain specific rights for well drilling and groundwater use to bridge the supply gap of the public network. This explains why tanker water supply doesn't rocket upwards with exorbitant prices in cities like Amman and why it is mostly an issue for households and commercial establishments who are not allowed to drill their own wells.

e) Groundwater pollution and depletion

According to the *WAJ Law* (Art. 30 A 3.) and the *Groundwater By-Law* (Art. 10) water pollution or depletion is strictly prohibited and WAJ has a mandate to penalize the pollution of any water resource. However, as mentioned above, MoE/RDEP is also entrusted with duties and responsibilities for groundwater protection and control, including drinking water quality control.

f) Illegal wells

The *Groundwater By-Law* includes clear provisions about the licensing of private wells and the role of WAJ in regulating abstraction volumes. Nonetheless, unlicensed wells are operated across the country. The *2009 strategy* (MWI 2009, p. 3-1) reports that Jordan's unsustainable groundwater usage has been aggravated through hundreds of illegal wells and by "the lack of enforcement of regulations on private sector well drilling, and the near absence of controls on licensed abstraction rates". Since this assessment, progress has been made in tackling illegal well drilling. MWI (2016a) started a campaign to shut down such wells in 2013. The last official document that has been found concerning the number of illegal wells closed was issued in 2013 (MWI 2015, p. 13) (cf. Table 4.3). The Jordan Times reports that since the beginning of the campaign, MWI has shut down 747 wells (JT, 10 April 2016).[28] Despite MWI's efforts,

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[27] Cf. the different regulations for type A, B and C wells as outlined in the previous section.

[28] See http://jordantimes.com/news/local/authorities-uncover-theft-water-equal-daily-share-48000-people?platform=hootsuite, accessed on 13 August 2016.

the number of illegal wells across Jordan is still estimated at 1164, a share of 31 % of the overall number of wells in the country (USAID 2014, p. 28). Another important question is wheater any progress can be made to address well-owners illegally pumping out more water than their licensed abstraction rate.

Table 4.3: Number of illegal wells closed according to MWI (2015, p. 13)

Year	Number of wells
before 2007	235
2007	26
2008	45
2009	46
2010	57
2011	29
2012	19
2013	141
2014	562
2015	174

Box 4.6: Groundwater related Articles in the WAJ Law No. 18 of 1998

Article 25a:
All water resources available within the boundaries of the Kingdom, whether they are surface or ground waters, regional waters, rivers or internal seas are considered State owned property and shall not be used or transferred except in compliance with this Law.

Article 25c:
All natural and juridical bodies are prohibited to sell water from any source, or grant or transport it, without obtaining in advance the written approval of the Authority and within the conditions and restrictions decided or included in the contracts or agreements concluded between them and the Authority.

Article 30 A):
Any one shall be sentenced to no less than six months, and no more than two years imprisonment or to a fine no less than JD 1000 and no more than JD 5000, or both
punishments if he has committed any of the following acts:
3.: Polluted any water resource, which is under the management or supervision of the Authority directly or indirectly, or caused its pollution and failed to remove the causes thereof within the period fixed by the Authority.
4.: Drilled unlicensed ground water wells or violated the conditions of the license issued to him.

Article 30 B):
Any one shall be sentenced to no less than one month, and no more than six months, imprisonment or shall be fined not less than JD 100 and not more than JD 1000, if he has committed any of the following acts:

3.: The illegal usage of water, water resources, related projects or the public sewers, contravening the provisions of this Law, or regulations issued thereunder, including the selling granting or transporting water, using or utilizing it or committing any act that may cause harm or damage to any of these resources or water related projects, or using the public sewers in a manner that conflicts with the provisions of this Law.

Box 4.7: Excerpts from the Groundwater By-Law No. 85 of 2002

Article 3:

A- The underground water is owned and controlled by the State. Extraction or utilization thereof is prohibited except by a license issued under this By-Law prescribing therein the usage, the extraction quantity and any other condition.

B- Ownership of the land does not include ownership of underground water therein. The license to extract water issued to the landowner is considered merely as a permit to utilize it within the license conditions.

Article 8:

Everybody is hereby prohibited to commence drilling a well or extracting underground water, or changing the specifications of an existing well or drilling a substitute well unless a license to this effect in accordance with the provisions of this By-Law has been obtained.

Article 9 A.:

The licensee to drill a well should carry out under the supervision of the Authority a pumping test before commencement of the utilization thereof, so that the well production capacity and the water quality may be determined, and an extraction license may be issued in which the allowed pumping quantity annually and the rates thereof is defined. […].

Article 10:

Anyone who is granted a license to extract underground water is hereby obligated to refrain from causing any water pollution or depletion, and to comply strictly with the conditions of the license.

Article 11:

The owner or the possessor of a private well is hereby prohibited to do the following:

A- To irrigate any land other than that specified in the water extraction license or to sell this water for irrigation purposes.

B- To sell the water extracted from the well by water-tankers for drinking purposes or any other purpose without obtaining a prior written approval from the Secretary General, or his delegatee, and according to conditions outlined for this purpose.

Article 17:

On the submission of the Secretary General, the Board may take a decision to the following effect:

A- The cancellation of a drilling or an extraction license, if the licensee violates any of the conditions therein, and the shutting down of the well until the breach is rectified.

Article 28:

Licenses for deepening, cleaning or maintaining an existing well shall be granted by a Board decision in accordance with the following conditions:
B The well depth should be fixed in the license provided it does not exceed the level of the water-layer where the well is drilled, and provided that the drilling does not affect the water layer utilized by the Authority for drinking purposes.

Article 29:
A- Every owner of a well drilled and tested in accordance with the provisions of this By-Law should obtain before commencement of utilization thereof a license for water extraction issued by the Secretary General or delegate containing the conditions that the licensee should comply with, including the following:
1- The maximum amount of water that may be extracted from the well within a fixed period of time.
2- The purpose of water use.
3- The maximum area that may be irrigated from the water of the well licensed for agricultural purposes.
4- The installation, at the expense of the owner of the well, of a water-meter after it has been approved and stamped by the Authority. This condition should be complied with prior to the issuance of water extraction license.
5- Notification of the Authority within a period not exceeding 48 hours in case of non-function of the water-meter. The owner of the well shall reimburse the Authority for the fixed maintenance expenses. Of the water-meter
6- Refrainment from taking any measures that impede the flow of water from the well to water-meter directly for the measurement thereof.
7- Obligation by the licensee to pay to the Authority in time the prices fixed for the extracted water.
8- The keeping by the licensee of a register approved by the Authority where all data relating to the well, and extraction process shall be registered regularly in accordance with instructions issued by the Authority. The competent Authority officials have the right to inspect this register.

4.1.3 Institutional shortcomings and envisioned institutional reforms

The *2016 strategy* acknowledges that there is a need to revise the current water legislation as well as the existing organizational structure which is characterized by overlapping responsibilities and administrative gaps (p. 19). A comprehensive water law that closes remaining legislative gaps is considered as an desirable goal in this context (p. 4). Progress is expected from the amendments made to the *MWI By-Law*, implemented in 2014, according to which the political and strategic leadership of the water sector is allocated to MWI (p. 19).

A key problem of the Jordanian water supply and sanitation sector is that there is no clear separation of the competencies of actors/organisations with regard to regulatory, supervisory and operational tasks (GTZ 2006). WAJ, for example, is entrusted with both protecting and extracting water resources. The organisation acts as a supplier as well as a regulator of water services. In addition, WAJ owns public utilities but at the same time regulates these and assesses their performance through PMU. All of these double functions can lead to potential conflicts of interest within the organisation. The ability of utilities such as Miyahuna to work more efficiently and reduce water losses is constrained by limited independence in the organisational set-up of the sector. According to the OECD (2014, p. 25-26) WAJ frequently interferes in the autonomy of the utilities which, for instance, results in long repair times because the companies need WAJ's approval to order spare parts or water meters. The dire financial situation of the water sector is aggravated by the fact that the authority for tariff increases lies outside the sector and with the CoM, reducing the opportunities to raise cost recovery rates and react to increases in water supply costs.

Despite some organisational changes and reforms in the past, the overall water governance system in Jordan has remained rather stationary. Authors such as Steiner (2008) and Yorke (2013) see a structural problem behind this, resulting from a political system of neopatrimonialism and patronage, in which powerful elites and competing agencies have an interest in preserving the status quo. Therefore, a comprehensive change of the water governance system towards a more effective institutional architecture appears challenging.

4.1.4 Conclusions

As presented in the previous sections, there are several policies, laws and regulations which are relevant for the tanker water market in Amman. In the following, the findings of the institutional analysis are summarised and discussed in view of the following questions: How can the tanker water market in Amman be characterised in terms of legality and degree of regulation by the State? Are there significant regulatory gaps or discrepancies? Which recommendations for regulation improvements can be derived?

Urban water supply policies: The analysis of the *2016 strategy* shows that MWI addresses the current challenges relating to urban water supply in Jordan quite comprehensively and explicitly declares to embark on a new path towards freshwater sustainability. The current core problems of the water sector as identified by MWI are: Supply gaps, intermittency, high subsidies, low cost-recovery rates, high NRW, illegal abstractions, as well as depletion and over-abstraction of groundwater. The role of tanker water markets for sustainable urban water supply in Jordan is not discussed. Only in the context of illegal water abstractions does the *2016 strategy* clearly refer to tanker water in stating that illegal water provision which occurs through "tankers" should be stopped. That the existence of tanker water markets needs to be taken into account for developing sustainability strategies in the field of urban water supply becomes obvious when the question is posed whether water services are affordable for households or not. Here, the *2016 strategy* only considers households' expenses for public services, with the consequence that for cities such as Amman, a major domestic financial burden with regard to drinking water – tanker water cost and cost for other water sources – is ignored. Iskandarani showed that effective water prices paid by households in East Amman, including all water sources and indirect water-related expenses (e.g., storage related costs, water treatment expenses), have been up to four times higher than piped water costs during summer (cited in Gerlach & Franceys 2009, p. 438). Other sustainability problems examined by the *2016 strategy* that would require a closer look at the tanker water market are: drinking water quality and health risks, and groundwater protection and management. A coarse evaluation of the implementation success of the *2009 strategy* revealed that a major political challenge of Jordan's urban water supply sector lies with the implementation and enforcement of already existing strategic goals and approaches.

Regulation of the tanker water market in Amman: The existing laws, regulations and standards can be related to the two main market actors of the private tanker water sector in Amman: the private well operators and the water-tanker operators. Table 4.4 summarizes the major responsibilities of MWI, WAJ, MoH, and MoE/RDEP with respect to these two actors as explicated in the previous sections.

Table 4.4: The specific responsibilities of MWI, WAJ, MoH, and MoE/RDAP with respect to tanker water provision.

Private well operators	• Construction and drilling of wells (e.g., drilling license): WAJ • Water extraction (e.g., extraction license, “water prices”): WAJ • Water selling (“written approval” for selling water to water-tankers for drinking purposes or any other purpose): WAJ • Tariffs and sales price for well water: WAJ • Drinking water quality: MoH, WAJ, MoE/RDEP • Water and groundwater protection: WAJ, Moe/RDEP
Water-tanker operators	• Transport license: WAJ • Tariffs and sales price for tanker water: recommendations by MWI, WAJ • Physical and technical requirements (e.g., water counter): recommendations by MWI • Inspection requirements (e.g., “statement of facts”): recommendations by MWI, “liaison officer” • Drinking water quality: MoH, WAJ

In general, it can be noted that several provisions are relevant for the tanker water market in Amman. Those which target private wells are more comprehensive and stringent than those targeting water-tankers. This can be explained by the fact that private agricultural wells in Jordan contribute significantly to groundwater depletion and have therefore been in the focus of policy interventions for quite some time. The tanker water market as a specific type of private groundwater use is comparatively new and does not exist nation-wide across Jordan. The “recommendations” provided by MWI in 2008 for tanker trucks transporting drinking water to ensure “high quality standards” and “reasonable prices” is the only tanker-water specific regulation which could be identified. It contains specific provisions regarding tariffs, “transportation costs”, “physical and technical requirements” of water-tankers and “inspection requirements”. However, it remains unclear how binding this regulation is since its contents are referred to as “recommendations”. This gives rise to the urgent question of whether the transport license for water-tanker operators issued by WAJ, according to the *WAJ Law*, implies that these “requirements” have to be fulfilled *de facto* and whether the license can be removed in case of non-fulfillment. Table 4.4 reveals that most competencies for the provision of tanker water fall under the responsibility of WAJ. The leading institutional actor with regard to drinking water quality standards is MoH. From the table it also becomes obvious that there are some overlaps in responsibility, as several organizations (WAJ, MoE/RDEP, and MoH) are entrusted with similar mandates. In the *2008 document* (cf. section 4.1.2.2) MWI proposes so-called “liaison officers” from each of the relevant Ministries to conduct routine inspections of water sources and water-tankers but their assignment of tasks is not further specified (at least not within this document).

Water price regulation: The government tax or “water prices” private well owners have to pay to WAJ for extracting and selling groundwater for drinking or other purposes highly influences the profitability of groundwater use. The *Groundwater By-Law* is not clear about the “water prices” for private (agricultural) wells selling groundwater to water-tankers. The *well operators survey* implies that the “water price” is set at 250 fils per cubic meter, irrespective of purpose of water use and abstracted water quantities. The same figure is quoted by Gerlach and Franceys (2009, p. 437) for licensed wells in Amman. Maybe the private wells selling water to water-tankers in Amman fall within the category "wells for industry, production, tourism or university purposes" (Art. 38 C IV, *Groundwater By-Law).* The regulatory frameworks analysed do not contain a target sales price for private wells selling water to water-tankers. Though, according to the *well operators survey* and the *tanker drivers survey,* there seems to be a governmental target sales price of about 750 fils per cubic meter (cf. chapter 4.3.3.3). From this it can be concluded that the private groundwater market is strongly price regulated but the *Groundwater By-Law* does not reflect the specific conditions for private agricultural wells selling groundwater to water-tankers. Five out of eleven interviewed well owners stated that they are also farmers. It can be assumed that the price regulations highly influence groundwater use, i.e. whether private well owners sell water to water-tankers or whether they use it for farming. If the expected profit margin from selling water to water-tankers significantly exceeds the profit that can be derived from farming, private well owners will decide to sell their water to water-tankers and perhaps to intensify groundwater abstraction rates – with the respective negative consequences for long-term sustainable groundwater use. For water-tankers only a "soft" tariff regulation by MWI in the form of "recommendations" could be identified, stating that the water tariff should be based on mean transportation costs, the "water price" at the private well and an assumed net profit of 10 % of transportation costs. However, the actual mean tanker water price and its price range, obtained from the *tanker drivers survey* (cf. section 4.4.3.2), indicate that water-tanker operators are not strongly geared to these tariff "recommendations" by MWI. According to Gerlach and Franceys (2009, p. 437), the price of water sold via private water-tankers in Amman is set by WAJ at 2 JD per cubic meter in summer and 1.75 JD per cubic meter in winter. This price regulation, however, is not enforced "rendering tanker-supplied water a free market commodity". As there are no distinct procedures to monitor and control prices, tanker drivers don't risk penalties for selling their water at higher prices (p. 439). The authors also suggest that according to intimate WAJ sources, MWI has an interest in the private tanker water market in itself, as the earnings gained through the "water prices" are remarkable (p. 439).

Drinking water quality regulation: The standards for drinking water quality are the same for piped water and tanker water. Drinking water quality standards are controlled by the MoH "regardless of its source". According to the *2016 strategy*, drinking water quality shall be protected by safety and risk management approaches, including the whole supply chain "from source to tap", i.e. including "treatment, transmission, distribution, and storage of drinking water" (cf. Art. 38, *Public Health Law).* Some of the regulations relating to drinking water quality are tailored specifically to the tanker water market, like the "written approval" private wells need to have to sell water to water-tankers, or the "physical and technical requirements" and "inspection requirements" recommended by MWI for water-tankers. However, aside from the fact that provisions to protect and control drinking water quality should be compulsory and not set in the form of "recommendations", the question arises as to whether the whole supply chain of tanker water is actually covered by the existing regulations, given that water is abstracted, treated, transported, distributed and stored in many ways before it is consumed. Furthermore, it can be doubted that it is possible to efficiently enforce existing drinking water quality regulations within a highly complex market with plenty of actors. The tanker water market in Amman includes a multitude of (official) private wells and water-trucks together with their associated staff, and additionally the consumers themselves, who take responsibility for water storage within their buildings. Gerlach and Franceys (2009, p. 439) identify this part of the supply chain – household storage together with the risk of microbial re-growth in household tanks – as an "entirely unregulated area" which needs further attention. Nevertheless, they conclude that health aspects and water quality standards are "well regulated and enforced" by MoH. If tanker drivers do not meet these standards, which are routinely monitored by MoH, they have to carry heavy levies (p. 439). The fact that water-borne diseases are not of major concern in Amman can largely be attributed to the preventive behavior of the water consumers themselves. They normally do not consider the water coming from the piped network or water-tankers as drinking water quality, but use other water sources as drinking water, such as bottled water from the supermarket or treated water from water vendors. Another important precautionary measure is to boil and filter the water at home before consumption.

Groundwater protection regulation for private wells: The regulations for groundwater protection and management relevant for private wells are quite comprehensive. In addition to provisions for installing a new well (e.g., drilling license, permitted well depth, extraction license, water-meter provision, approval for selling water etc.) there are also provisions for maintaining and operating an existing well (e.g., annually allowed abstraction rate, permitted deepening, cleaning and data registering provisions, etc.). Some of the licenses need to be extended regularly. The major concern of groundwater policy in Jordan is to prevent groundwater sources from depletion and salinisation. The most important provision in this regard is the extraction license together with the abstraction permit which determines the maximal amount of water allowed to be extracted from a well within a fixed period of time. The abstraction rate could be measured and controlled relatively straightforwardly through metering. Nonetheless, illegal pumping in excess of the licensed abstraction rates is a serious problem in Jordan, because of a lack of water- meters, manipulation of existing water- meters, and absence of controls (cf. MWI 2009, p. 3-1). Most of the surveyed private wells in and around Amman have been built in the 1960s and 1970s. Five out of eleven interviewees in the *well operators survey* stated that the well had to be redrilled or relined which might be an indicator for sinking groundwater levels and general over-abstraction. Regarding groundwater pollution, the important question remains as to whether the prescibed protection zones for groundwater recharge can be enforced for groundwater wells which are frequented by hundreds of trucks per day.

Amman's private tanker water markets can be characterised as semi-regulated: According to new institutional economics, markets can be characterised as formal or informal. *Informal markets* are based on informal rules, i.e. on rules which are not codified (e.g., oral agreements). Often such markets arise because of a lack of formal rules. Thus, informal markets in this understanding are the same as formally unregulated markets. Activities taking place in such kinds of informal markets, therefore, are not necessarily illegal. There is a wide discussion about the institutional settings required for successful markets and efficient allocation. Easter *et al.* (1999), for example, analyse the conditions for effective water markets, either formal or informal, illustrated by examples from different countries. They conclude that water markets can be very effective for reallocating scarce water resources, if they are supported by sound institutions. The authors used the following criteria to evaluate water markets and their institutional setting: preventing groundwater overdrafts, countering monopoly pricing, keeping transaction costs low, and security of water supply. With respect to the "optimal" degree of regulation, no general answer can be provided by the authors; in some cases informal markets are advantageous compared to formal markets and vice versa. From a new institutional economics perspective, the private tanker water market in Amman can be characterised as rather formal because a significant number of formal rules and regulations are in place: The government controls through licensing who is permitted to enter the market and what prices may be charged for well water and tanker water (the latter only in form of non-binding "recommendations"). Beyond that, there are also regulations for groundwater and drinking water quality protection. However, as it has been illustrated, there are also significant regulatory gaps. Thus, in summary, Amman's tanker water market can be characterised as being more formal than informal or *semi-regulated.*

Amman's private tanker water markets can be characterised as partially illegal: "Informal has an entirely different meaning in the context of underground or shadow economy. A common definition of shadow economy is: "[the] market-based production of goods and services, whether legal or illegal, that escapes detection in the official estimates of Gross Domestic Product" (Philip Smith, 1994, cited in Schneider and Enste, 2000, p. 78). The largest part of legal shadow economy, also known as "black" labour or shadow economy in the narrower sense, are value-added activities which would generally be taxable but are not reported to the tax authorities on purpose (Schneider and Enste 2000, p. 79). An inherent characteristic of such legal and illegal shadow economic activities is that the individuals involved wish to escape detection because of the fear of prosecution and punishment. Shadow economic activities are against the rules and therefore, are a typed of informal activity. Schneider and Enste (2000, p. 79) developed a taxonomy of underground economic activities, including monetary and non-monetary transactions as well as legal and illegal production. Based on this taxonomy the following table has been developed to categorise different forms of informal economic activities within private tanker water markets in Jordan, assuming that the vast majority of businesses are monetary transactions.

Table 4.5: Taxonomy of informal[29] economic activities within private tanker water markets in Jordan. Own compilation based on Schneider and Enste (2000, p. 79).

Monetary transactions	
Illegal production	a. Illegal goods: Trade in stolen water (e.g., water from springs and rivers, water from illegal abstractions from the piped network) b. Illegal services: Operating a private well and/or a water-tanker without having a (drinking water) license
Legal production	• Tax evasion: Unreported income from self-employment; wages, salaries and assets from unreported work related to legal services and goods • Tax avoidance: Employee discounts, fringe benefits

Informal economic activities based on *legal production* – tax evasion and tax avoidance of private well and/or water-tanker operators – harm state tax authorities because of lower tax revenues and declining social contributions. Against the background of this study they are only of relevance insofar as they lead to a distortion of competition and lower the price of tanker water. Informal economic activities based on *illegal production*, however, need to be investigated further. Here, it is helpful to distinguish if the good – water – is a stolen good and/or if the offered services – operation of a private well or water-tanker – are illegal or rather unlicensed. All combinations of legal and illegal production are conceivable, i.e. illegal as well as legal tanker water (good) can be sold by both licensed and unlicensed water-tankers (service). Gathering information about the occurrence of informal or illegal economic activities is always problematic, because no one who engages in such activities wants to be identi-

[29] In this context "informal" means "against the rules".

fied. Accordingly, within the *well operators survey* and *tanker drivers survey,* no direct questions on illegal activities were posed. However, there is some evidence that illegal activities play an important role within Amman's private tanker water markets. The analysed policies, laws, and regulations address the following types of illegal activities in connection with private tanker water markets: (i) water from unlicensed, illegal wells, (ii) illegal abstraction in excess of licensed abstraction rates, and (iii) illegal water sold through water-tankers. On closer inspection, however, the picture is much more diverse.

– In terms of *private groundwater wells*, it can be assumed that the majority of wells where Amman's water-tankers source their water are licensed and have a written approval for selling water for drinking. However, as the number of illegal (unlicensed) wells is still very high in Jordan, it is very likely that tanker water in Amman is also partially abstracted from illegal wells and from legal wells which are not designated for drinking water. Another question is whether legal wells always adhere to the licensed abstraction rates. The deficits in metering and enforcement of abstraction rates, which has been criticized in the 2009 strategy for all of Jordan, certainly also holds for the private wells in the Amman region. Beyond that, a variety of illegal activities relating to rule violations are conceivable in the course of well operation and maintenance, for example unlicensed redrilling and deepening of wells, manipulation of water-meters, inadequate water quality measurements and treatment of water. These rule violations can occur within legal production as well as within illegal production.

– Moreover, with regard to *water-tankers* it can be expected that the trucks driving through Amman are to a large extent licensed. Most drivers do this job for a living and therefore try to avoid penalties or loss of license. Nevertheless, even licensed truck drivers might sometimes infringe rules. Examples of illegal activities which could be detected during field observations in Amman and which came up in informal conversations outside of the interviews are: selling water from illegal wells, abstracting and selling water from rivers and springs (water theft) and selling non-potable water as potable water by pumping it from blue into green tankers. It also might be possible that water stolen from the piped network in Amman is sold through water-tankers. Additionally, water-tanker operators might commit rule violations such as not adhering to the cleaning provisions of tankers. The *Jordan Times* (October 12 2016), for example, reports that in Wadi Al Seer, a city about 10 kilometers southwest of Amman, two people were detected selling untreated water from a spring which was abstracted through several pipes which could be connected to water-tankers[30]. The 2008 MWI document contains "requirements" which aim to improve control over water-tanker operators, like for example the "statement of facts" which requires proof of the source of water – information which was also referred to in this article of *Jordan Times*. However, it is questionable whether all truck drivers in reality always adhere to these requirements.

All in all, the private tanker water markets in Amman can be characterised as legal markets in the sense that tanker water production and trading is legalised by the State. If one assumes that the majority of operators of private wells and water-tankers are licensed and most of the sold tanker water is not stolen, this indicates a predominantly legal market. However, there is also evidence of a strong lack of enforcement of rules and regulations, and illegal activities are a daily occurrence. Thus, the private tanker water markets in Amman are *partially illegal*. According to Wehinger (2011), two types of "illegal markets" can be identified that exist

[30] See http://www.jordantimes.com/news/local/authorities-hunting-suspects-wadi-al-seer-water-theft, accessed 24 October 2016.

within Amman's private tanker water markets: Type II (the good was stolen) and Type V (rule violations occur within production or trading).

To evaluate the impacts of illegal activities within tanker water businesses on sustainable water supply, two aspects need to be taken into account: (i) the (volumetric) quantity of illegal abstractions and (ii) the economic, social, political and environmental consequences of illegal activities in general. Illegal abstractions are undesirable because they increase the depletion and over-abstraction of groundwater resources and the drying of springs and rivers. Furthermore, illegal activities can negatively impact groundwater protection and drinking water quality, health and hygiene. For Amman's private tanker water markets there is no data on the quantity of illegal abstractions. However, even if the size is not significant, the consequences (ii) can still be of high relevance – at least on a small scale or periodically, e.g., during drought seasons.

Recommendations for regulation improvements: The following recommendations for regulation improvements can be derived from the above-mentioned analyses: (i) several provisions need to be tailored to the specific conditions of the tanker water market and associated regulatory gaps need to be closed; (ii) overlaps in responsibility of the competent institutional actors need to be removed; (iii) controlling of abstraction rates from private wells needs to be enforced; (iv) controlling of compliance with drinking water quality standards and groundwater protection needs to be enforced; (v) water abstracted from illegal sources needs to be combated.

4.2 Demand and water use patterns: The role of private tanker water for commercial establishments and private households

Access to piped water provided by Amman's public supplier Miyahuna is almost universal with a degree of connection of about 95 % in 2015 (USAID 2015, p. 128). However, public supply is intermittent, with water only delivered for about 48 hours per week on average (WAJ, 2015). This requires water consumers to use additional, non-piped sources of water such as bulk water from private tankers, treated water purchased from water vendors, bottled water from stores and sometimes also harvested rainwater.

This section examines the role of private tanker water as an additional and/or alternative bulk water source for Amman's commercial establishments and private households. For both consumer groups, water demand and water use patterns are investigated with a special focus on tanker water. The results of this demand-side analysis will feed into the subsequent analysis of the selling market of private tanker water (cf. section 4.4).

The section is structured as follows: Firstly, commercial establishments, who are the major consumers of private tanker water within Jordanian cities, are investigated (cf. section 4.2.1). This section is mostly based on the *commercials survey*, a quantitative survey undertaken with commercial establishments (n = 242) that was carried out in Amman from September 2015 to February 2016 (cf. chapter 3.3.3). Secondly, a preliminary look is taken at private households with the help of relevant information elicited from the literature (cf. section 4.2.2).

4.2.1 Commercial establishments

4.2.1.1 Connection rates, supply duration and water storage

a) Connection rates

Out of the 242 surveyed commercial establishments 107 (44.2 %) are connected to publicly piped water supply; the majority (135 or 55.8 %) is not connected to the supply network and thus uses tanker water as the only bulk water source (cf. Table 4.6). In all of the surveyed five main sub-districts of Amman there are establishments that have no connection to the piped water network. The surveyed water connection rate is quite low compared to a countrywide urban drinking water coverage rate of 93 % in 2015 ("piped onto premises")[31] or 95 % in Amman (USAID 2015, p. 128).

With regard to sewage, the survey reveals a connection rate of 81.0 %. Most of the interviewed establishments (96.2 %) that are connected to public water supply also have a sewage connection (n = 105). In reverse, if an establishment is not supplied by Miyahuna, the survey reveals a sewage connection rate of 72.5 % (n = 131). All possible combinations of connections to water supply and/or sewage occur.

Table 4.6: Connection rates of water supply and sewage (Source: Commercials survey)

Commercials (all categories)	Frequency	Percent	N
Water supply connection	107	44.2	242
Sewage connection	196	81.0	242

The following figure shows the surveyed connection rates of water supply and sewage by establishment category.

[31] https://www.wssinfo.org/documents/?tx_displaycontroller[type]=country_files, accessed 9 May 2017.

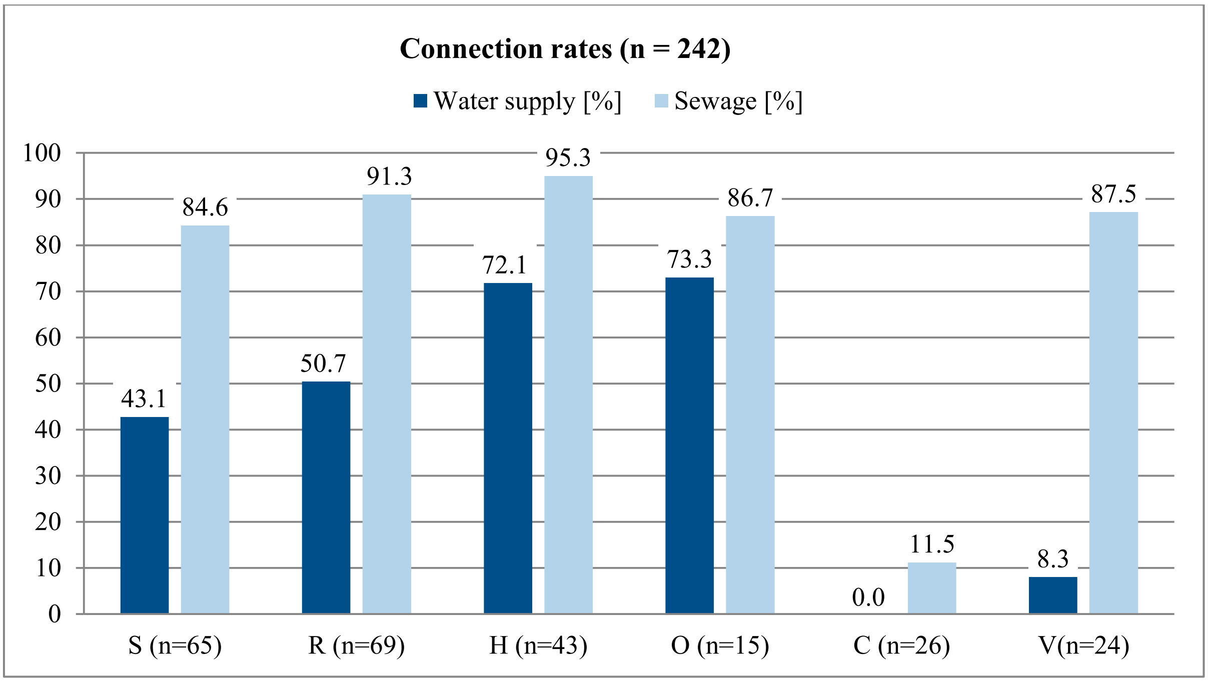

Figure 4.2: Connection rates of commercial establishments by category (Source: Own commercials survey).

- *S: Retail stores, service establishments, sports facilities, supermarkets, others (e.g., car washes, dry-cleaners, bakeries)*
- *R: Restaurants, coffee shops*
- *H: Hotels, hostels, hospitals*
- *O: Office buildings (large buildings where water is managed and paid centrally)*
- *C: Construction sector*
- *V: Water vendors (water stores selling or delivering filtered water in containers)*

The majority of establishments of categories H (hotels, hostels, hospitals) and O (office buildings) are connected to piped water supply. The former are typically high consumers of bulk water (cf. section 4.2.1.2). Two categories of establishments, the construction sector and water vendors, show remarkably low water connection rates. This can be explained as follows:

- **Water vendors:** Only few of the surveyed water vendors (8.3 %) stated they were connected to piped water supply and thus mostly rely on tanker water. The reason for this, as carved out by the survey interviews, is that there is a WAJ regulation preventing water vendors from buying water from Miyahuna.
- **Construction sites:** According to interviews with construction workers, construction sites in Jordan generally need to be finished before they can be connected to the piped water supply system. Thus, this sector seems to rely completely on tanker water. The water can be from blue tankers (non-drinking) or from green tankers (drinking).[32] The interviewees also pointed out that tanker water demand from construction sites is particularly high in summer because cement needs to be mixed with water three times as frequently in summer than in winter.

[32] Of the 300 interviewed truck drivers only 9 operate a blue tanker. Thereof, 7 deliver their water to construction sites and 2 to agricultural sites. The low number of surveyed blue tankers indicates that water from green (drinking water) trucks is also used for non-drinking purposes, like for example construction works.

b) Supply durations

The empirically surveyed water supply durations range from 12 hours to 168 hours (equivalent to a 24/7 water supply) per week, with a mean of 47.6 hours per week. Most frequent are supply durations of 24 and 48 hours per week (cf. Figure 4.3). All surveyed commercial establishments with 24/7 water supply belong to category H (2 hotels and 2 hospitals).

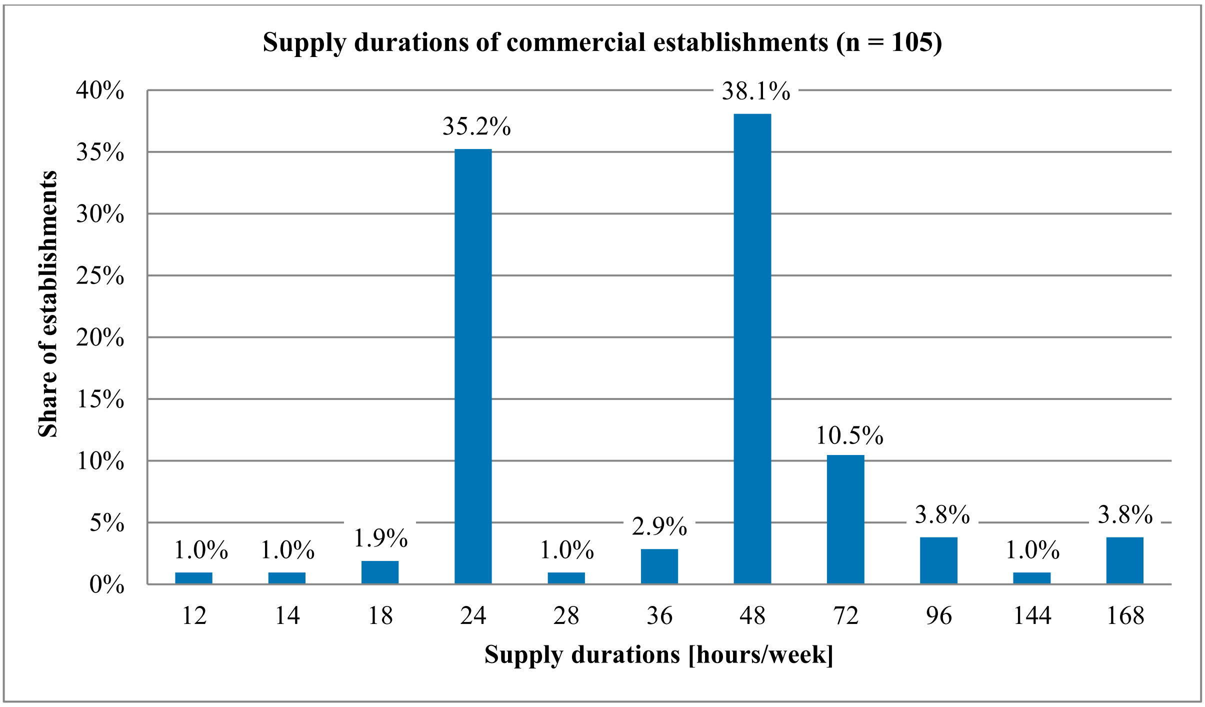

Figure 4.3: Supply durations of commercial establishments (Source: Own commercials survey).

An analysis of supply durations by establishment categories reveals that establishments of category H (hotels, hostels, hospitals) seem to be slightly privileged in terms of access to piped supply (cf. Figure 4.4). Correspondingly, this category shows high piped water consumption levels (cf. section 4.2.1.2).

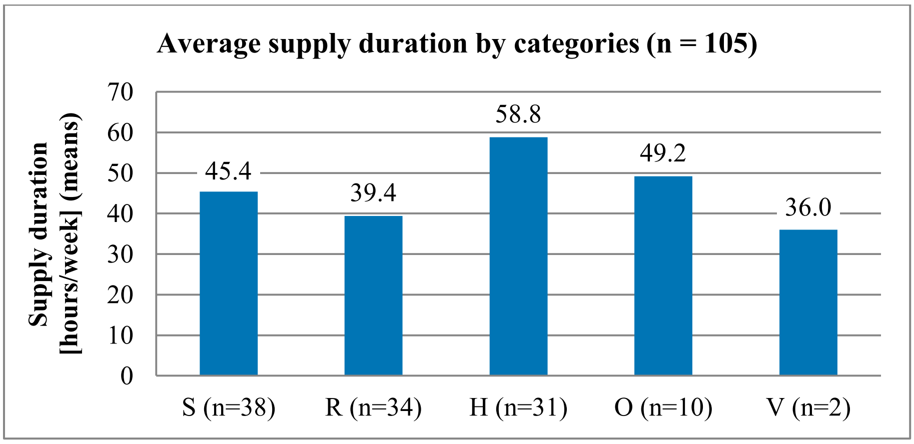

Figure 4.4: Average supply durations of commercial establishments by categories (Source: Own commercials survey).

Supply durations in Amman mostly depend on the geographical location of the customers because the water distribution plan of Miyahuna is organised in distribution zones with a high variability depending on the geographic location.[33] In addition, the *commercials survey* shows that supply duration is determined not only by the geographical location but also by other factors. For example, several interviewees stated to have individual agreements (so-called "VIP subscriptions") with Miyahuna in terms of price conditions, supply durations or water quantities supplied. This held, for example, for a four star hotel and a hospital, who both enjoyed a continuous water supply.

c) Water storage

As piped water supply is intermittent, Amman's customers heavily depend on storage tanks. Nearly all of the interviewed commercial establishments (88.3 %) own water storage tanks (n = 240). The remaining establishments without water storage (11.7 %) mostly belong to the construction sector. Some construction workers reported in the interviews that they use private water-tankers as temporary storage tanks. The surveyed total storage capacity ranges from 2 to 3,000 cubic meters with a mean of 57.4 cubic meters (n = 210). The highest storage capacities were found among establishments of category H (hotels, hostels, hospitals) (cf. Figure 4.5), who also showed the highest bulk water consumption (cf. section 4.2.1.2). Accordingly, a high correlation between total storage capacity and bulk water consumption can be observed for commercial establishments with a Pearson coefficient of 0.84 (summer and winter).

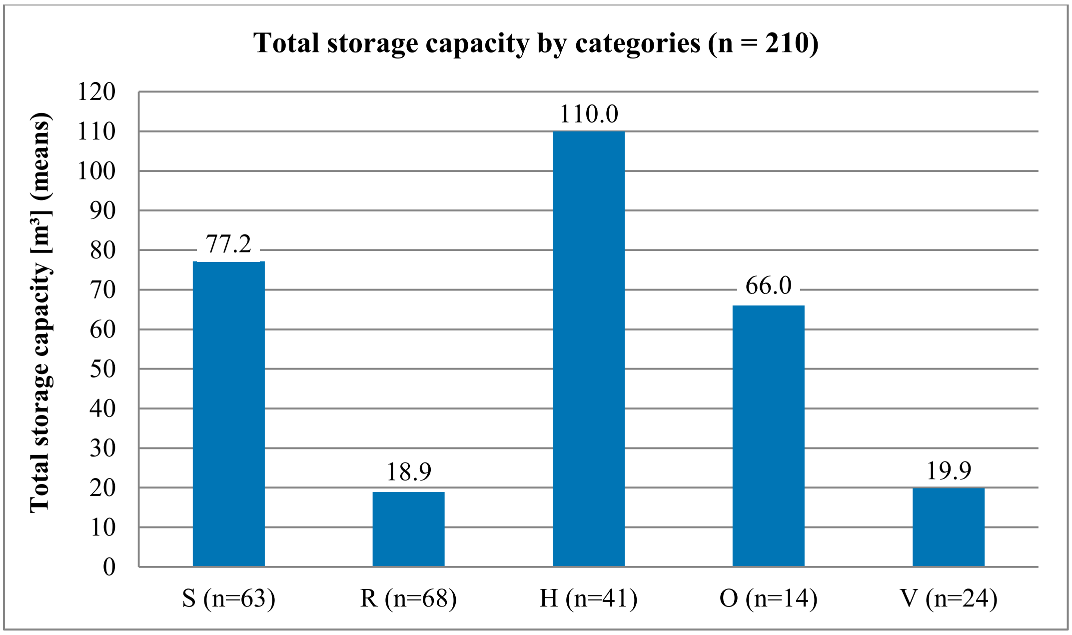

Figure 4.5: Total storage capacity by categories of establishments (Source: Own commercials survey).

[33] Detailed spatial statistical analyses of commercial consumption of network and tanker water, based on the survey data are the subject of Zozmann *et al.* (2019).

The type of facilities for water storage used by the surveyed commercial establishments is presented in the figure below (multiple answers possible). Here, the most common are rooftop storage tanks.

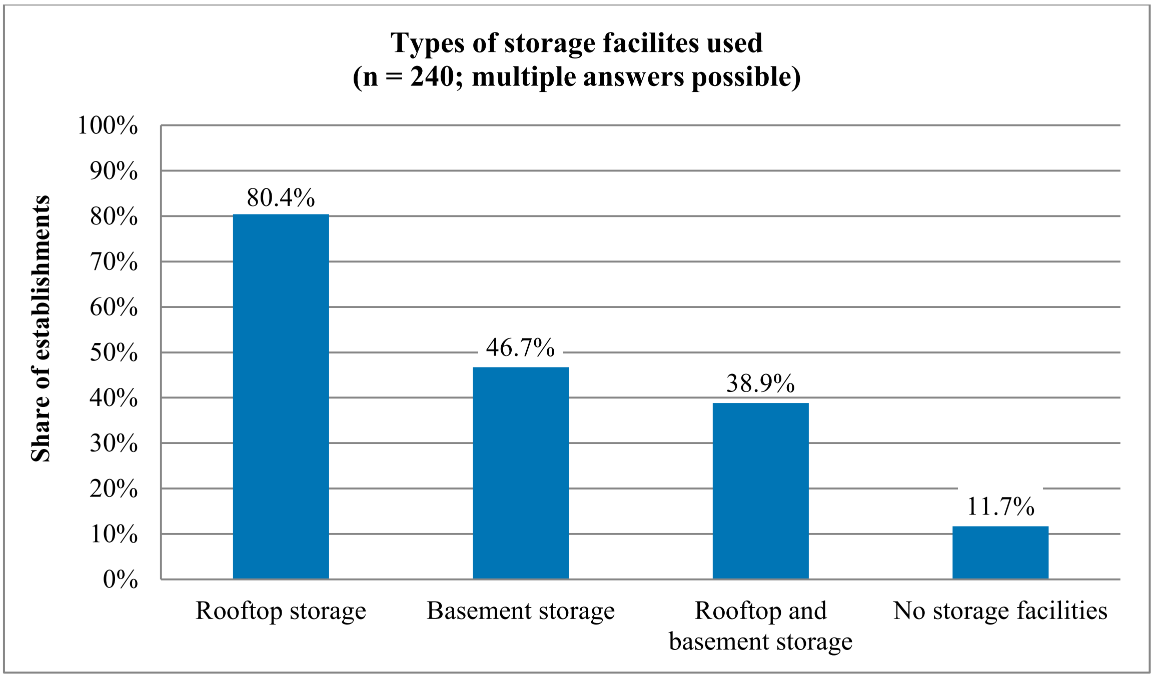

Figure 4.6: Types of storage facilities used by commercial establishments (Source: Commercials survey).

4.2.1.2 Water supply sources and consumption

a) Use of bulk water sources

The survey reveals that the vast majority of interviewed establishments (76.5 %) augment or meet their water supply by buying tanker water from private providers. More than half (55.8 %) use tanker water as the only bulk water source. Only a small proportion of establishments (23.6 %) do not consume any tanker water and instead buy their water in bulk only from Miyahuna. Another small proportion (20.7 %) uses both bulk water sources, piped water and tanker water (cf. Figure 4.7). These shares hold for summer. In winter, the percentage of tanker water using establishments is somewhat less (66.1 %).

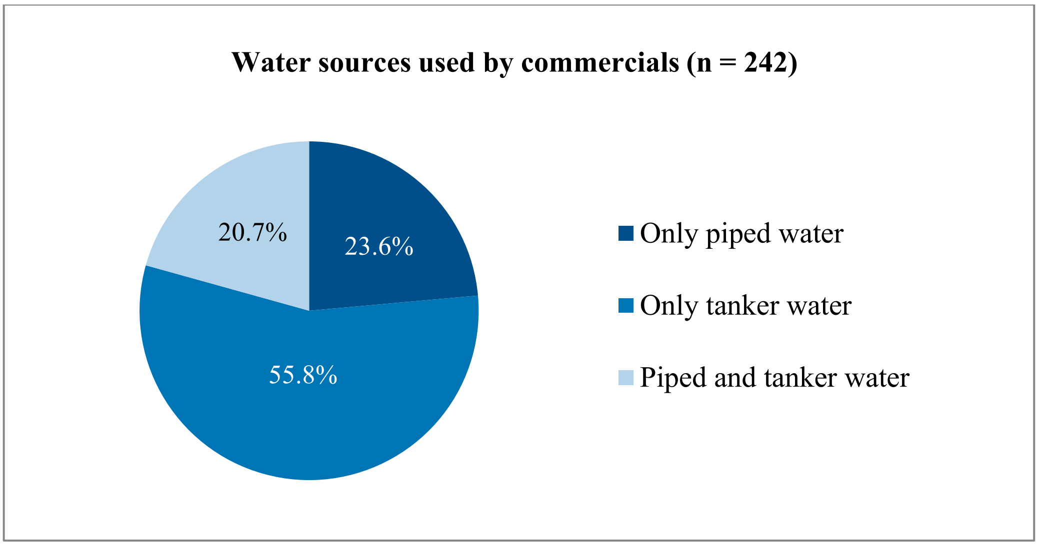

Figure 4.7: Bulk water sources used by commercial establishments in summer (Source: Own commercials survey)

An analysis according to the establishment categories shows that tanker water is used across all categories and always by a vast majority of establishments (over 72.5 %). Only for office buildings does the proportion of tanker water-reliant establishments seem to be relatively low (33.3 %) (cf. Figure 4.8).

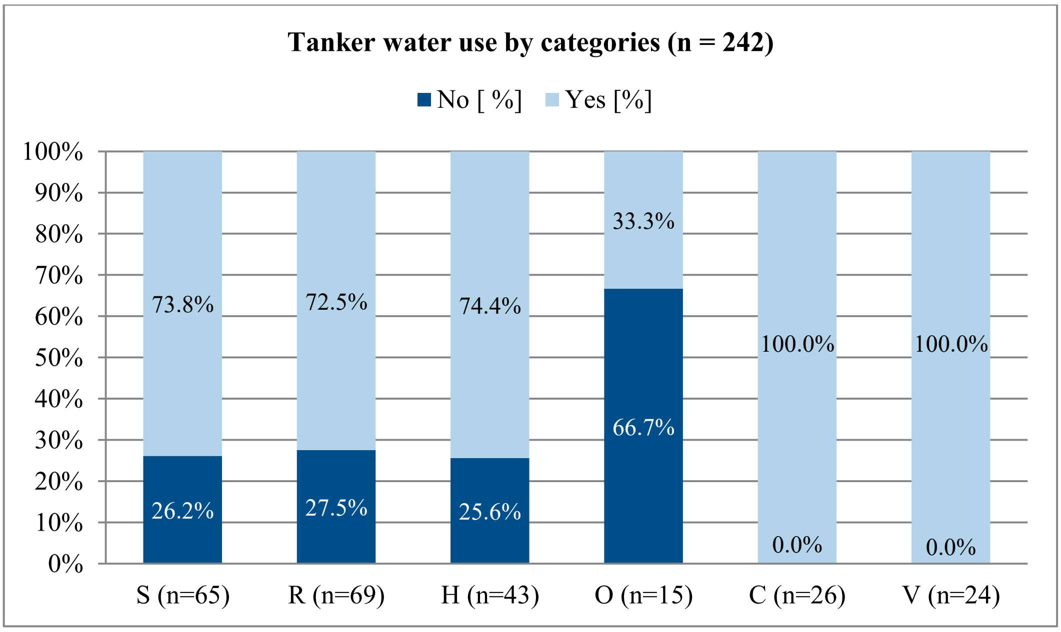

Figure 4.8: Tanker water use of commercial establishments by categories (tanker water as additional or alternative bulk water source) (Source: Own commercials survey)

A closer look at the 55.8 % of establishments using tanker water as the only bulk water source reveals a high dependency on tanker water for category S establishments (retail stores, service establishments, sports facilities, supermarkets, others) and category R establishments (restaurants, coffee shops). About half of the surveyed establishments of these two categories (56.9 % and 49.3 %) use tanker water as their only source of bulk water. This corresponds with remarkably low water connection rates. Establishments in categories C (construction sector) and V (water vendors) represent special consumer groups in this regard, as they do not have access to piped water (category C) or are not allowed to use piped water (category V) (cf. section 4.2.1.1).

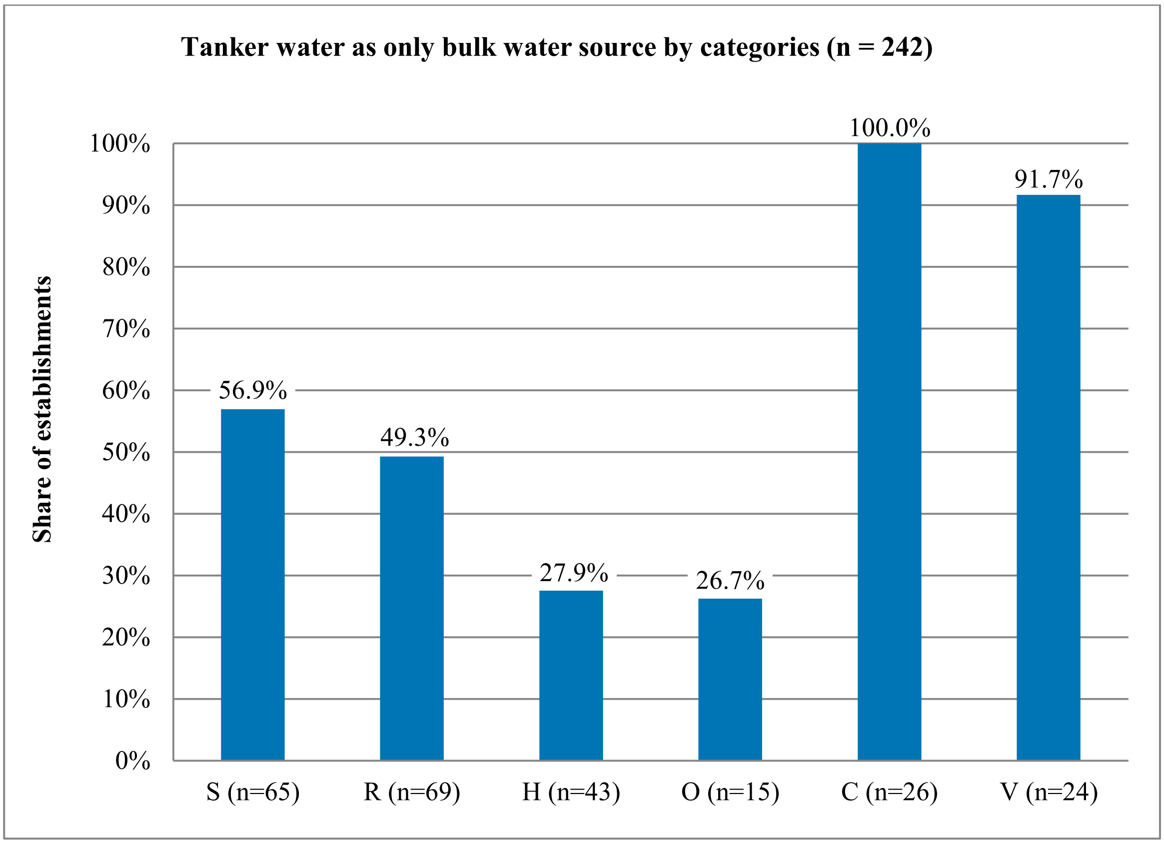

Figure 4.9: Tanker water as the only bulk water source for commercial establishments by categories (Source: Own commercials survey)

b) Bulk water consumption

The high proportion of commercial establishments using tanker water as additional or alternative bulk water source (76.5 %) is reflected in the remarkably high consumption volumes of tanker water. In summer, about 65 % of the bulk water consumed by commercials is tanker water. In winter, the share of tanker water in bulk water consumption decreases slightly to about 62 % (cf. the following two tables). Overall, the data shows significant seasonal consumption patterns with a seasonality factor of 1.53 for total bulk water consumption and 1.61 for tanker water consumption.

Table 4.7: Bulk water consumption of commercial establishments in summer (Source: Own commercials survey)

Summer	N	Minimum	Maximum	Mean
Total bulk water [m^3/week]	228	1,381	2,000	65.734
Piped water [m^3/week]	228	0	1,400	21.974
Tanker water [m^3/week]	238	0	2,000	43.760

Table 4.8: Bulk water consumption of commercial establishments in winter (Source: Own commercials survey)

Winter	N	Minimum	Maximum	Mean
Total bulk water [m^3/week]	225	1,381	1,375	43.393
Piped water [m^3/week]	227	0	1,000	16.287
Tanker water [m^3/week]	238	0	1,375	27.106

The analysis of bulk water consumption by categories of establishments reveals that establishments of category H (hotels, hostels, hospitals) are by far the highest consumers of bulk water, followed by establishments of categories S (retail stores etc.), O (office buildings) and V (water vendors) with rather equal bulk water consumption levels (cf. Table 4.9 and Figure 4.10 for summer and Table 4.10 and Figure 4.11 for winter). Category H establishments (hotels, hostels and hospitals) typically base their water supply on both bulk water sources, with their privileged status regarding high piped water supply durations supporting their high level of piped consumption (cf. section 4.2.1.1). Category S and R establishments cover bulk water demand mostly by tanker water and category C and V establishments are completely reliant on tanker water. The bulk water consumption patterns are quite similar in summer and winter for all categories of establishments.

Table 4.9: Bulk water consumption of commercial establishments by category in summer (Source: Own commercials survey)

Summer: Categories of establishments	N	Total bulk water (mean) [m^3/week]	Piped water (mean) [m^3/week]	Tanker water (mean) [m^3/week]
S: Stores, service, sports, other	61	65.367	8.229	57.138
R: Restaurants	67	39.032	11.525	27.508
H: Hotels, hostels, hospitals	36	149.792	86.208	63.584
O: Office buildings	13	62.713	46.578	16.135
C: Construction sector	26	36.996	0.000	36.996
V: Water vendors	24	52.161	1.125	51.036

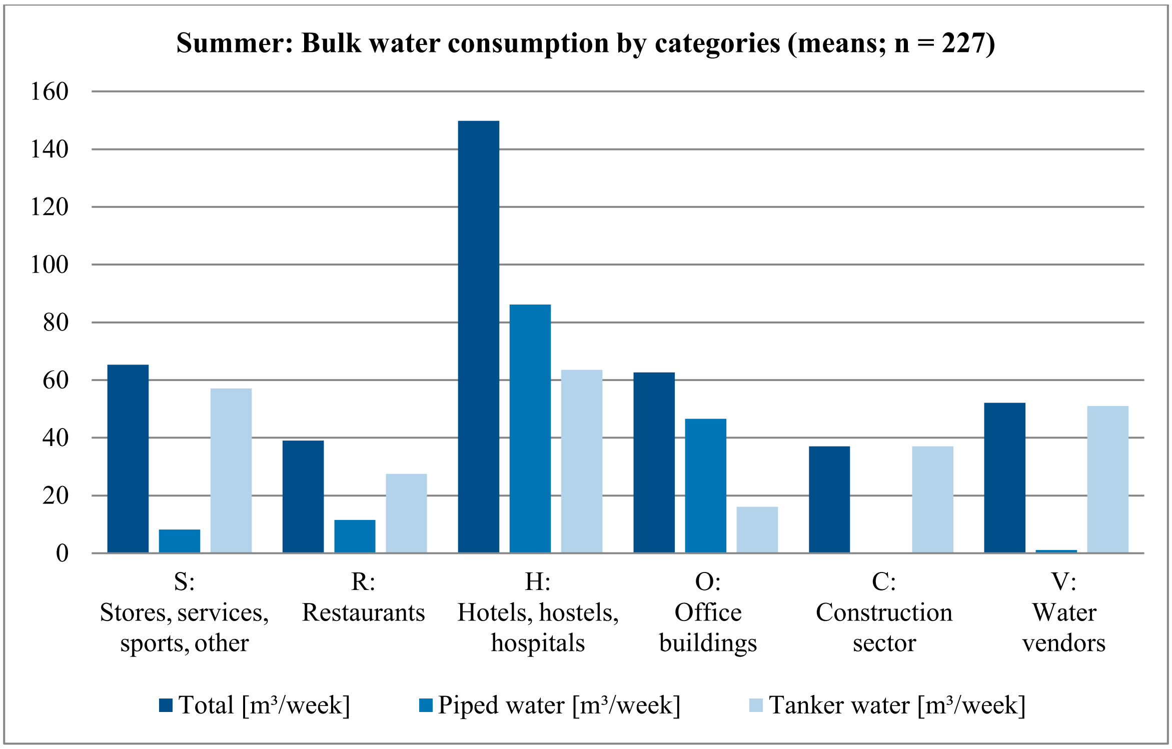

Figure 4.10: Bulk water consumption of commercial establishments in summer by category (Source: Own commercials survey).

Table 4.10: Bulk water consumption of commercial establishments by category in winter (Source: Own commercials survey)

Winter: Categories of establishments	N	Total bulk water (mean) [m^3/week]	Piped water (mean) [m^3/week]	Tanker water (mean) [m^3/week]
S: Stores, service, sports, other	60	43.264	6.228	37.035
R: Restaurants	67	25.704	9.754	15.863
H: Hotels, hostels, hospitals	36	100.319	61.716	40.825
O: Office buildings	13	41.976	33.713	8.264
C: Construction sector	25	26.622	0.000	26.622
V: Water vendors	24	28.854	0.414	28.440

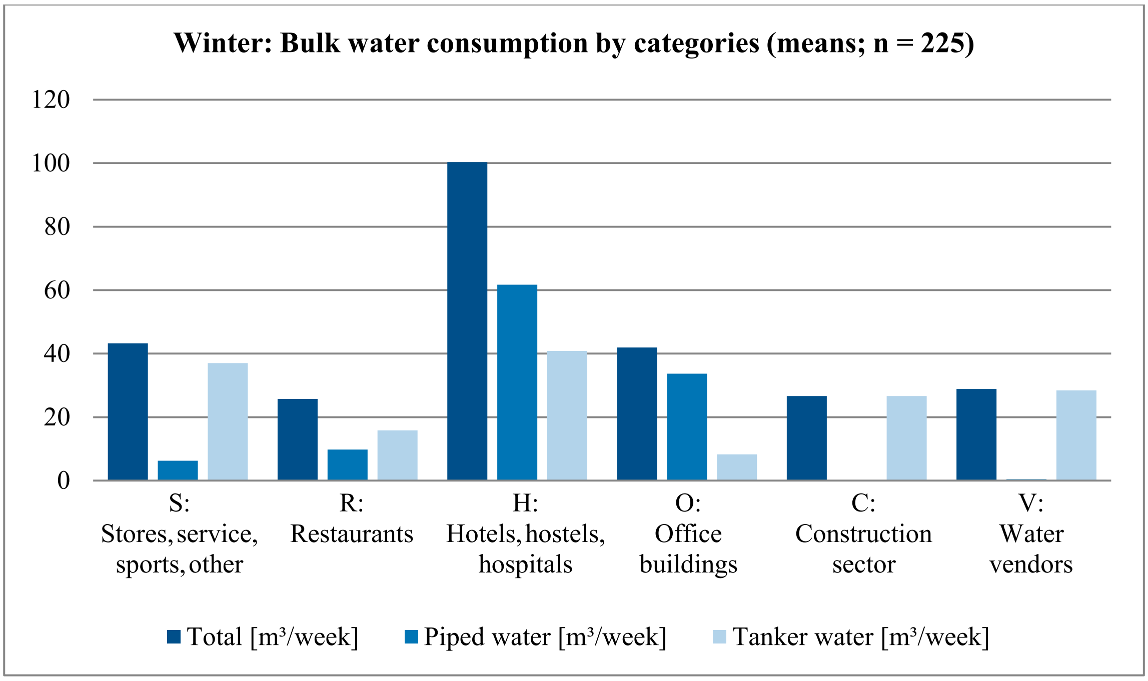

Figure 4.11: Bulk water consumption of commercial establishment in winter by category (Source: Own commercials survey).

c) Bottled and treated water

More than half of the surveyed establishments (57.9 %) buy additional water in the form of bottled water from stores and treated water from water vendors (n = 242). Thus, the dependence of commercial establishments on additional supply sources is quite high. Bottled and treated water is mainly used for drinking because neither Miyahuna nor private water-tankers provide water of safe drinking water quality. Since water vendors depend entirely on tanker water (cf. 4.2.1.1), tanker water is not only an essential bulk water source, but indirectly also an essential drinking water source.

A majority of establishments (56.4 %) supplement their bulk water consumption only by bottled water, significantly less (32.9 %) only by treated water, with just a minority (9.3 %) buying both bottled and treated water. Two entities (1.4 %), a huge supermarket in Wadi As Sir District and a bakery in Al Jameh District, harvest rainwater. These figures together with the data on the volumetric consumption of bottled and treated water (cf. Table 4.11) reveal that overall bottled water is the preferred additional water supply source for commercial establishments although it is more costly.

Table 4.11: Consumption of bottled and treated water (Source: Own commercials survey)

Water consumption [m³/week]	N	Minimum	Maximum	Mean
Bottled water	86	0.018	1.800	0.350
Treated water	59	0.018	3.000	0.250

4.2.1.3 Bulk water prices

a) Piped water prices by Miyahuna

The water and wastewater tariff system of Miyahuna for commercial establishments (non-residential) in Amman is quite simple: For a consumption exceeding 6 cubic meter per quarter the water price is 1.3 JD per cubic meter and 2.165 JD per cubic metre if there is also a wastewater connection. The *commercials survey,* however, indicates that the contract landscape of Miyahuna is much more complex. Several interviewed commercial establishments stated that they had individual agreements (so-called "VIP subscriptions") with Miyahuna in terms of price conditions, supply durations or water quantities supplied (cf. section 4.2.1.1).

b) Tanker water purchase prices

There is a wide range of prices commercial establishments pay for tanker water (cf. Table 4.12). In summer, the maximum price is significantly higher than in winter; minimum prices and mean prices are similar for both seasons.

Table 4.12: Tanker water purchase prices in summer and winter (Source: Own commercials survey)

Tanker water purchase prices [JD/m³]	N	Minimum	Maximum	Mean	Mean (volume-weighted)
Summer	179	0.863	7.143	2.770	2.341
Winter	156	0.863	5.833	2.720	2.316

According to a survey conducted by Theodory (2000, p. 98) in 1999 in Greater Amman, non-residential WAJ-subscribers paid about 1.5 to 2 JD per cubic meter for tanker water. Gerlach and Franceys (2009, p. 437) have determined a tanker water price for Amman's commercial customers of 1.25 JD per cubic meter based on a tanker driver survey. These comparative data indicate that tanker water has become more expensive for commercials in recent years.[34]

The following figure shows the scatter diagram for tanker water purchase prices in summer and in winter as sourced from the *commercials survey*, and indicates that almost all establishments pay the same price for tanker water all year round.

[34] A comparison of the tanker water purchase prices determined here with the results from the *tanker drivers survey,* i.e. the tanker water sales prices, is made in section 4.4.3.2.

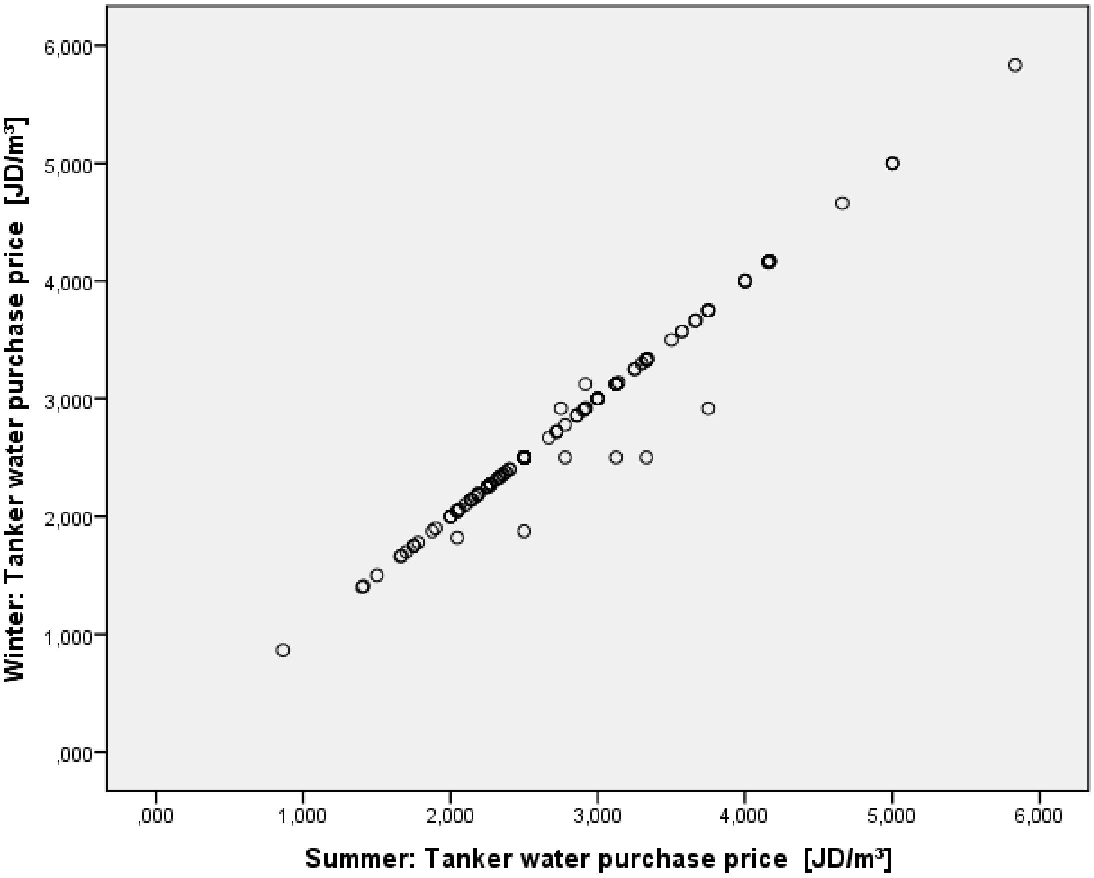

Figure 4.12: Tanker water purchase price in summer and winter (Source: Own commercials survey).

The prices that commercial establishments pay for tanker water are striking due to the presence of some very low minimum prices. One reason for this could be that some commercial establishments have their own water-tankers (cf. section 4.2.1.6), and therefore can buy tanker water at the pure transport costs without overheads. Within the *commercials survey*, a total of 6 establishments indicated that they possess their own trucks (3 car washes, 1 gas station, 1 hotel, 1 restaurant). These establishments buy their water directly at the wells at the following prices: (n = 3): 0.630 JD per cubic meter (car wash), 1.670 JD per cubic meter (car wash), and 1.750 JD per cubic meter (restaurant). Another reason could be that a few of the surveyed establishments have long-term supply contracts with one tanker water supplier and have therefore secured particularly favorable purchase prices (cf. section 4.2.1.6).

The following figure indicates what the individual establishment categories pay on average for tanker water. Establishments in category H (hotels, hostels, hospitals) pay the least, followed by S, C, V. O and R. These price differences roughly correspond to the different quantities of tanker water consumed by the establishments: the more tanker water needed, the larger the trucks that can be ordered and the cheaper the water becomes (cf. Figure 4.10 in section 4.2.1.2).

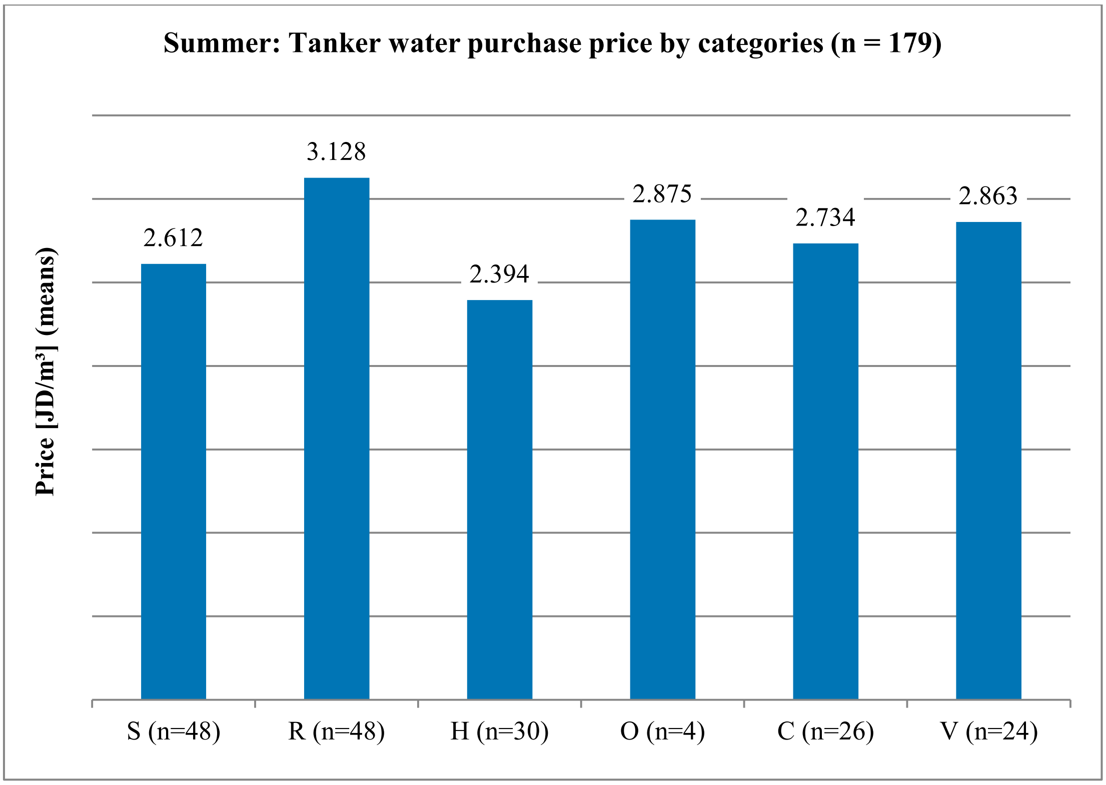

Figure 4.13: Tanker water purchase prices in summer by category (Source: Own commercials survey).

- **Construction sites:** The figure also reveals that construction sites pay more or less the same tanker water price compared to the other establishment categories even if they are allowed to purchase tanker water of less quality, i.e. non-drinking water from blue trucks. However, according to the *tanker drivers survey*, there are only a few blue trucks circulating through Amman. Out of the 300 surveyed truck drivers, only 9 operated a blue truck, even though a total of 54 drivers were interviewed at private wells whose operators claimed not to have a drinking license. Out of these 9 blue trucks, 7 delivered their water to construction sites. This indicates that the formal distinction between “green” and “blue” tanker water plays a minimal role in practice.

4.2.1.4 Water uses and practices

According to the *commercials survey*, piped water and tanker water are used for the same variety of purposes. Uses reported by almost all interviewed establishments include bathrooms (toilets, sinks), cleaning and washing. Some establishments (39.0 %) that use piped water also use it for cooking and drinking after filtering (n = 100). For tanker water, this share is significantly higher (67.6 %, n = 182) which could be regarded as an evidence that tanker water is perceived to be of higher quality than piped water (cf. section 4.2.1.5). Very few establishments use water for car washing, irrigation and the swimming pool, and, in the case of construction sites, for mixing and irrigating cement. If consumers use tanker water as an additional bulk water source, the two water sources usually get mixed in a storage tank which means that any differences in water quality no longer play a role anyway.

4.2.1.5 *Reasons for using tanker water*

The reasons why commercial establishments use tanker water as an alternative or additional bulk water source are manifold. The following figure presents what interviewees answered on the openly-formulated question “why do you use tanker water?” (coded answers, multiple answers possible, n = 158). The construction sector (n = 26) is pre-excluded from the analysis as construction workers cannot choose between different bulk water sources (cf. section 4.2.1.1).

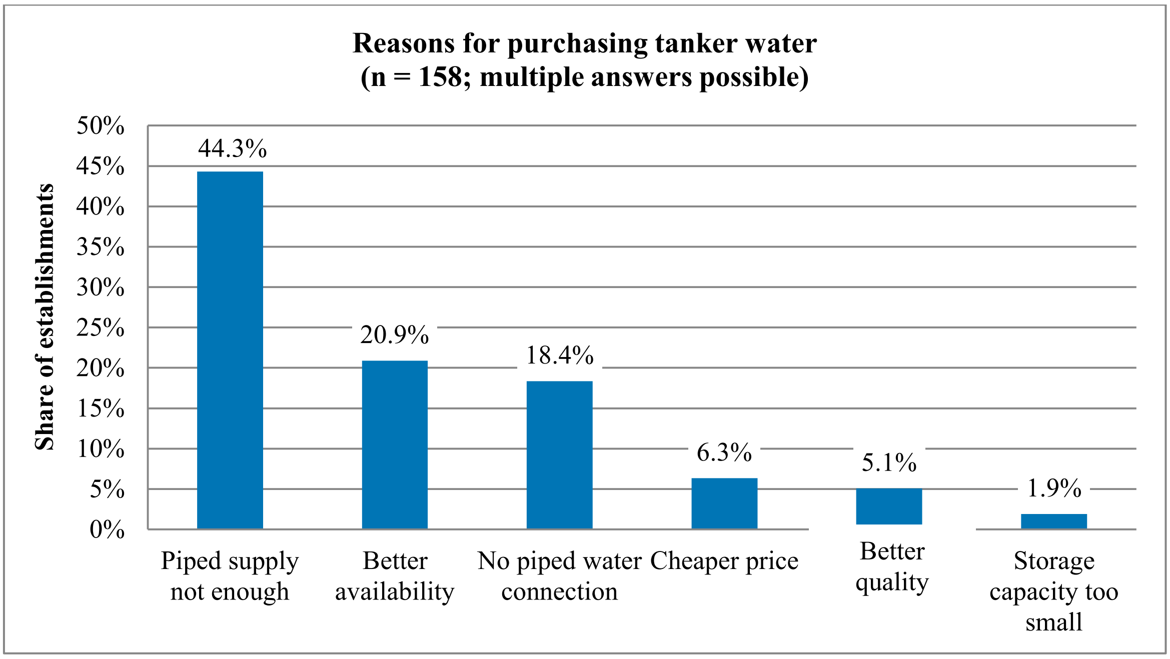

Figure 4.14: Reasons for purchasing tanker water (Source: Own commercials survey).

- **Supply quantities:** The most prominent reason for purchasing tanker water as stated by almost half of the interviewed establishments (44.3 %) is that piped supply is not enough, i.e. that the provided water quantities do not cover demand. Water supplied in bulk from private providers, on the contrary, is not limited. Some respondents pointed out that quantity constraints play a role only in summer or during extreme situations.
- **Temporal availability (reliability):** Several respondents (20.9 %) argued that they buy tanker water because it is “better available” than piped water. This aspect, not further explained by the respondents, presumably refers to the fact that tanker water can be ordered at any time in flexible quantities. Maybe the respondents also expressed here that service and management of tanker water supply is of higher quality and reliability than piped supply.
- **Water connection:** Some respondents (18.4 %) stated that they buy tanker water because they are not connected to the piped system. This can be for technical reasons (e.g., the region or building has not yet been connected to the supply network) or for administrative and interpersonal reasons (e.g., the existing connection is not working because of unpaid water bills or contractual conflicts with Miyahuna). In the vast majority of cases, however,

it can be assumed that commercial establishments that are not connected to the piped system decided intentionally not to be connected.[35]

- **Prices:** According to a few establishments (6.3 %), tanker water is used because it is cheaper than piped water. At a first glance this seems to be surprising as tanker water prices in general exceed piped water prices. On closer inspection, however, it is entirely possible that certain commercial establishments purchase tanker water for a lower price than piped water. Tanker water prices have a wide price range with minimum prices starting from 0.863 JD per cubic meter (cf. section 4.2.1.3). Especially in cases where establishments have their own trucks, tanker water prices are highly competitive. This applies all the more for establishments that are not connected to the sewage network of Miyahuna and thus only pay 1.3 JD per cubic meter (water tariff) and not 2.165 JD per cubic meter (water and wastewater tariff). Beyond that, some respondents might have wanted to express that they are unsatisfied with the service quality of Miyahuna and that they think that Miyahuna's water prices are not justified. Several interviewees argued in this way.
- **Water quality:** A few establishments (5.1 %) claimed to use tanker water because tanker water is perceived to be of better quality than piped water. This is in accordance with the survey results on water quality issues (cf. Table 4.13). According to a slight majority of respondents (55.1 %) tanker water is of higher quality than piped water. Fluctuations in water quality are perceived to be rather small for both bulk water sources. The fact that the proportion of establishments treating[36] their water is approximately the same for both bulk water sources also suggests that the water qualities are assessed rather similarly and that the two water sources are used for the same purposes (cf. section 4.2.1.4).

Table 4.13: Water quality of piped and tanker water as perceived by commercial establishments (Source: Own commercials survey).

Question	N	No	Yes
Tanker water of better quality than piped water?	178	44.9	55.1
Variation in piped water quality?	103	92.2	7.8
Variation in tanker water quality?	185	88.1	11.9
Do you treat piped water?	105	59.0	41.0
Do you treat tanker water?	185	57.8	42.2

- **Water storage:** Only a small minority of establishments (1.9 %) use tanker water because their storage capacity is too small to store enough piped water. This can be explained by the fact that storage systems are comparatively inexpensive. This corresponds with findings of Klassert *et al.* (2015, p. 24) for residential consumers in Amman where, based on modeling studies, the authors show that under baseline conditions the storage constraint is not binding for any household.

[35] Theoretically, 55.8 % of all commercials surveyed (n = 242) should have given this reason because they are not connected to the piped network (see section 4.2.1.1). Probably the interviewees preferred at this point to give more in-depth reasons for why they don't use piped water.

[36] Treating in this context means filtering and, depending on the purpose of water use, also softening and/or boiling. Filtered water can be used for drinking and cooking purposes.

4.2.1.6 *Purchasing policy*

Establishments that use both bulk water sources were asked if they consume all available piped water before deciding to buy additional tanker water. The majority (69.4 %) answered in the affirmative (n = 49). Assuming that in most of the cases tanker water is more costly than piped water, this indicates that the majority of establishments strive for price optimisation with regards to the two bulk water sources. Others may prefer to have some level of water safety buffer in the form of residual piped water.

a) Choice of tanker water supplier

To find out how establishments decide on a tanker water supplier, the interviewees were asked to prioritize the following 3 criteria: reliability of service, water price, and water quality. The results are depicted in Figure 4.15.

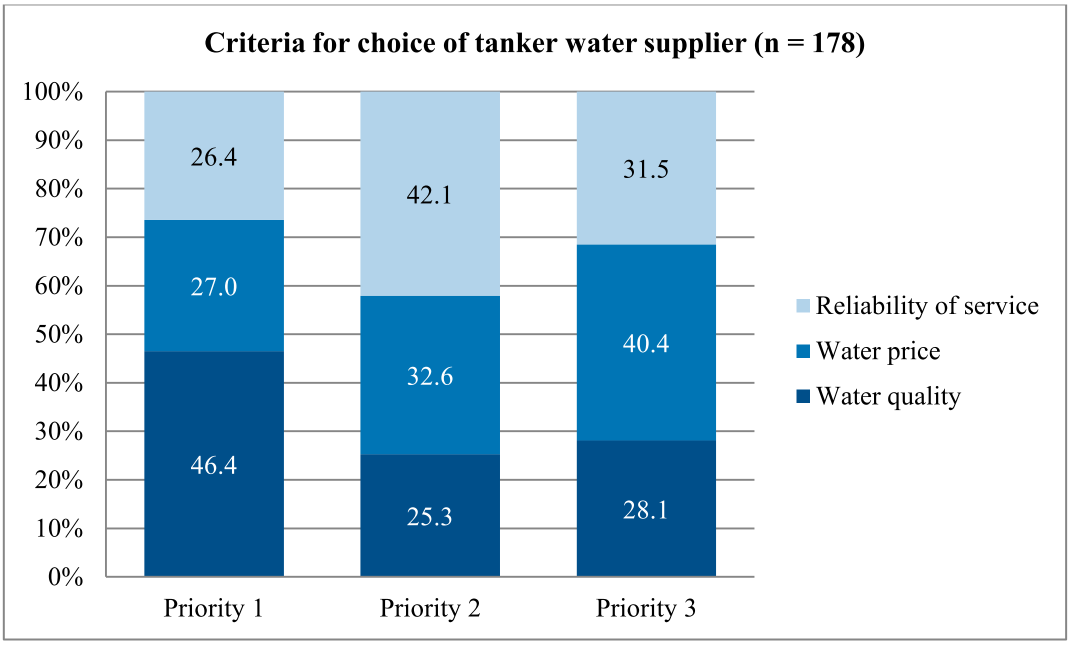

Figure 4.15: Criteria for choice of tanker water supplier (Source: Own commercials survey).

For first priority, water quality had the highest score (46.4 %), for second priority, reliability of service had the highest score (42.1 %), for third priority, water price had the highest priority (40.4 %). Even if the expressed differences in priorities are rather small, the results indicate that both water quality and reliability of service seem to be more crucial for selecting a tanker water supplier than water price. The high importance assigned to water quality is in line with the fact that drivers claimed to select their most preferred private well primarily according to the well's water quality (cf. section 4.3.3.1).

b) Supplier loyalty

Only very few (4.9 %) of the surveyed establishments have a long-term supply contract with one supplier (n = 182). Long-term supply contracts can be found within all categories of establishments but are mostly preferred by establishments of category H (hotels, hostels, hospitals; 4 cases). However, in case that there is no long-term supply contract, nearly all (95.4 %) of the respondents stated that they use the same supplier (n = 173). This high loyalty to one supplier underlines that the establishment's preferences for selecting a tanker water supplier are not only price-related. As stated before, the surveyed establishments assign high importance to water quality and reliability of service – supply characteristics that are affected by high uncertainties and thus depend on continuous relations between customers and suppliers.

c) Size of water-tankers ordered

The size of the ordered water-tankers is very diverse and ranges from 2 to 22 cubic meters (mean: 14.2; n = 181). This indicates that drivers align the size of their truck with customer preferences. Most common are large trucks with a size of 20 cubic meters, followed by trucks sized 6, 12 and 22 cubic meters. In addition, there also seems to be some demand for very small truckloads of only 2, 3, and 4 cubic meters (cf. Figure 4.16).

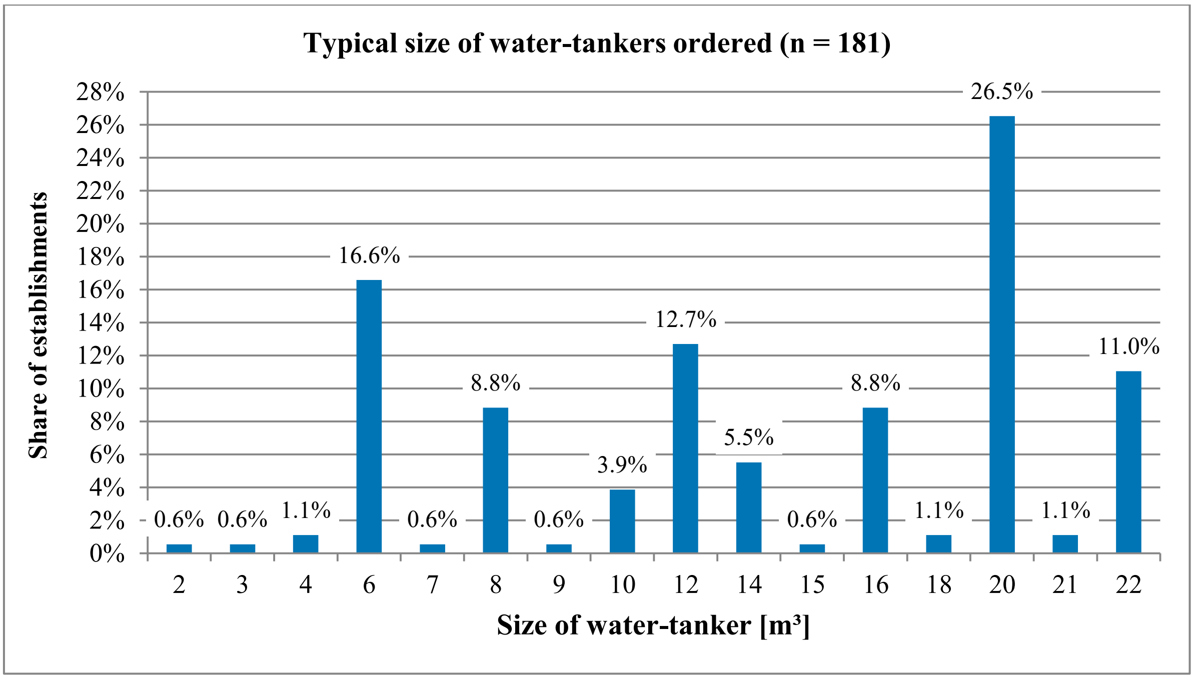

Figure 4.16: Typical size of water-tankers ordered by commercial establishments (Source: Own commercials survey).

The data suggests that establishments typically order larger water-tankers if they consume a lot of tanker water. The Pearson correlation between these two variables is 0.28 (cf. also Figure 4.17):

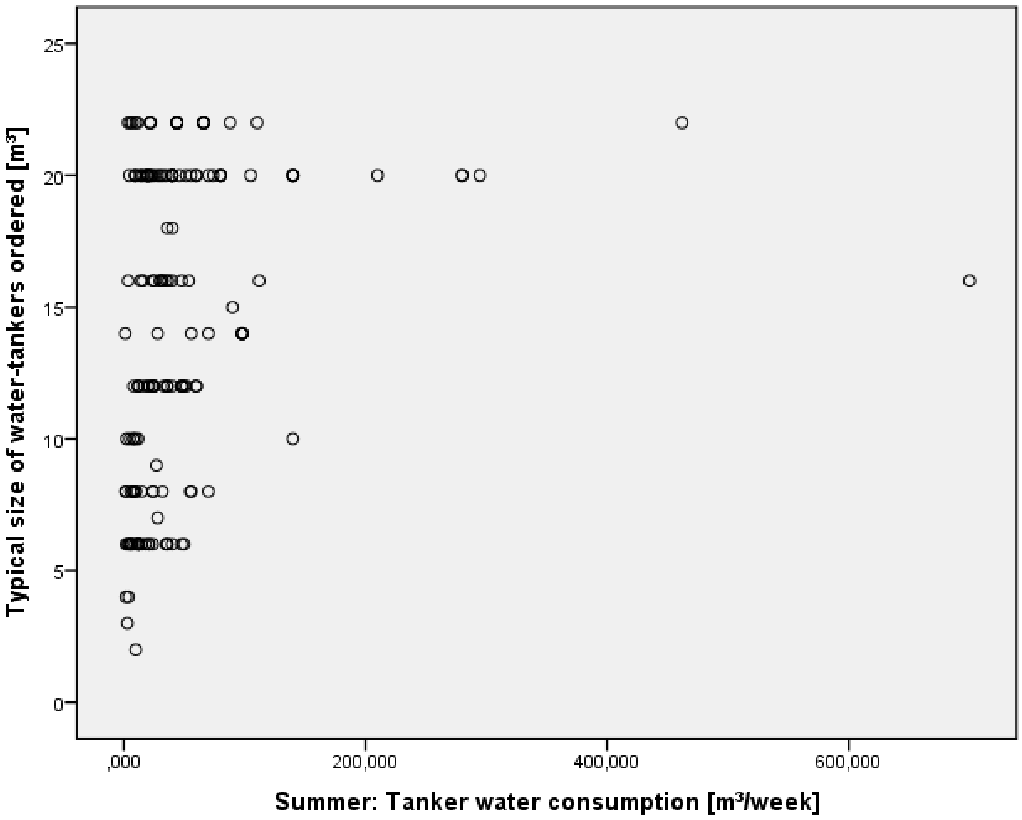

Figure 4.17: Relationship between water-tanker size and quantity of tanker water consumed (Source: Own commercials survey).

d) Consumer-owned private water-tankers

The private tanker water sector in Amman also comprises water-tankers that are owned by commercial establishments (cf. section 4.2.1.3). This has the advantage that water can be purchased directly from private wells at a reduced rate. Within the *commercials survey*, 6 establishments were identified as possessing their own water-tankers, thereof 3 car washes, 1 gas station, 1 hotel and 1 restaurant. One of the car washes owned 3 trucks. The identified consumer-owned trucks are sized differently with a range from 3 to 22 cubic meters. Of the 6 establishments with their own water-tankers, 3 buy additional water from private tanker water suppliers.

e) Crisis situations

Being asked whether they face crisis situations with regard to bulk water supply, only a few interviewed establishments (8.3 %) responded in the affirmative (n = 242). The most common crisis situation is a delay in water supply. This is applicable to both piped water from Miyahuna as well as tanker water, for example when tankers cannot be filled at a well due to electricity breakdowns. Some respondents reported that if they face water shortages they order an additional tanker, others buy bottled water. Problems can also occur in storage, for instance through broken pumps or pipes or storage mismanagement. According to one interviewee, a water vendor, tanker water quality is problematic in winter because of increased loads of salt and sediment. Several respondents referred to problems in making a good contractual "deal" with Miyahuna.

4.2.1.7 *Conclusions*

The demand and water use patterns of commercial establishments in Amman as assessed on the basis of empirical findings clearly show that there is a very high use of tanker water: More than half (56 %) of surveyed commercials use tanker water as sole, i.e. alternative bulk water source, and not an insignificant number (21 %) use it as an additional bulk water source. In total, tanker water is used by more than three quarters (77 %) of surveyed establishments. The second figure (21 %) corresponds very well with the results of a survey conducted by Theodory (2000) in 1999 with 401 non-residential WAJ-customers using piped water in Greater Amman. According to this survey, 27 % of the interviewees used tanker water as an additional water source (p. 97).

Establishments with high water disconnection rates and therefore a very high reliance on tanker water are not those that show the highest bulk water consumption levels – establishments of category H (hotels, hostels, hospitals) according to the survey – but those that consume rather less bulk water, i.e. establishments of the categories S (retail stores, service establishments, sports facilities, supermarkets) and R (restaurants). The reason is probably that low volume consumers suffer most from intermittency. As revealed by the survey, establishments with high bulk water consumption levels sometimes have special contracts with Miyahuna that include extended supply durations even up to continuous supply. Furthermore, some may also have own wells to supply themselves with additional water (cf. chapter 2.2.2).

A special situation could be identified for establishments of categories C (construction sector) and V (water vendors): The former completely rely on tanker water as construction sites in Jordan generally are not connected to the network. The latter are forced by a WAJ regulation to treat and sell only tanker water. Therefore, tanker water is not only an essential bulk water source that significantly contributes to the welfare of a multiplicity of commercial establishments, but indirectly also an important prerequisite for the supply of drinking water of recognised quality in the form of treated water.

Bulk water and tanker water demand of commercial establishments exhibit significant seasonal patterns. In summer, the surveyed entities consume 1.61 times as much tanker water than in winter. Thus, the selling market of private tanker water is a strongly demand-oriented market. The share of tanker water in total bulk water consumption, however, remains largely the same throughout the whole year (between 62 % and 67 %). This indicates that private tanker water markets in Amman are not only a summer phenomenon, like for example in Lebanon (Constantine *et al.* 2017).

The presented results show that the two bulk water supply sources provided in Amman are not perceived as perfect substitutes by buyers. In other words, commercial consumers perceive the two economic goods, piped water and tanker water, not as perfectly comparable or similar but as heterogeneous. Thus, their purchase decisions are not only price-driven. The key determinants of bulk water demand of commercial establishments as carved out by the survey are: available supply quantities, temporal availability of water, water quality, and quality or reliability of service and management. Beyond that, the survey reveals that commercial consumers also perceive different sources of tanker water as non-substitutional, even if supply is quite similar. The origin of the groundwater, i.e. its quality, and the reliability of service are important criteria for commercial establishments to select a private tanker water supplier. In general, drinking water markets are characterised by high uncertainties in terms of water quality because consumers can evaluate the quality of the water only after purchase and consumption and only partly (e.g., color, purity, taste, potability, suitability for purpose of use). Economically speaking, water is a *good of trust* or, if one assumes that the quality is revealed through its ongoing use, a *good of experience* (cf. chapter 2.2.1). Against this background, consumer confidence and supplier reputation are important determining factors for market performance. This explains why nearly all of the surveyed commercial consumers strive for a continuous relation with *one* tanker water supplier.

The service level of the two bulk water sources, piped and tanker water, is comparable. Consumers have to produce parts of the service by themselves. This so-called household production is money-consuming (e.g., costs for storage, pipes, filters), time-consuming (e.g., waiting for water pressure in the piped system or for a water-tanker, time for storing, filtering, boiling, procuring water)[37] and also space-consuming (e.g., space for storage). In terms of time expenditure, tanker water supply is advantageous as the timing of delivery can be chosen flexibly.

4.2.2 Private households

Compared to the low availability of research concerning the commercial use of water provided by tanker trucks, more information on household tanker water consumption is available. Based on data from previous studies of the Jordanian water sector, Klassert *et al.* (2015) have developed a simulation model which explores residential tanker water consumption in Amman. The main insight derived from the model and an analysis of different tariff and intermittency scenarios is that tanker water plays a significant role in balancing the shortcomings of network supply and potentially also in crisis situations.

Despite an almost universal access to the public network among residential water users (cf. Gerlach & Franceys 2009) – which stands in strong contrast to the lower connection rates among establishments that the *commercials survey* suggests – tanker water markets are nonetheless a pivotal and frequently used water source for households. Klassert *et al.* (2015) found that the distribution of tanker water is shaped by the location of consumers within the city, which determines the duration of access to water due to intermittent supply and the distribution schedule of Miyahuna. Wildman (2013) argues that this supply situation has adverse social effects because wealthier water users can afford larger storage capacities than those with lower incomes. This, in turn, enables better-off households to store more of the cheaper piped water during supply hours, while households of people with low income or refugees need to purchase more of the comparatively more expensive tanker water. Scenario analyses by Klassert *et al.* (2015), on the other hand, have shown that under baseline conditions the storage capacity was not binding for any households, which can be explained by the fact that small storages are relatively inexpensive.

Because of storage constraints, households have to coordinate their tanker deliveries with their neighbours, since most drivers require minimum sale quantities. Regardless of its high(er) price and the label "drinking water", tanker water is mostly used for washing, hygiene and irrigation because of the low trust of its quality among households (Gerlach & Franceys 2009; Rosenberg *et al.* 2008).

4.2.3 Comparison of commercial establishments' water use patters to Irbid and Ajloun

To establish a reference to compare the results of the commercials survey in Amman, two smaller survey were carried out in the cities of Irbid and Ajloun. The commercial sector in Ajloun showed a lower water consumption across all categories, except for the construction

[37] After information of a Jordanian colleague, it takes 4 hours until a storage tank of 5m³ is filled.

sector. In Irbid, the survey revealed a high share of tanker water in the commercial sector's overall consumption, when compared to Ajloun or Amman, which can be explained by the strong water rationing in place.

Table 4.14: Bulk water consumption of commercial establishments in Irbid (Source: Own commercials survey)

Categories of establishments	N	Total bulk water (mean) [m^3/week]	Piped water (mean) [m^3/week]	Tanker water (mean) [m^3/week]
S: Stores, service, sports, other	25	44.231	1.752	42.479
R: Restaurants	4	56.483	6.973	49.51
H: Hotels, hostels, hospitals	9	271.978	43.364	228.613
C: Construction sector	7	31.286	0.000	31.286
V: Water vendors	5	150.800	0.000	150.800

Table 4.15 Bulk water consumption of commercial establishments in Ajloun (Source: Own commercials survey)

Categories of establishments	N	Total bulk water (mean) [m^3/week]	Piped water (mean) [m^3/week]	Tanker water (mean) [m^3/week]
S: Stores, service, sports, other	26	15.148	5.852	9.296
R: Restaurants	8	23.750	5.106	18.644
H: Hotels, hostels, hospitals	2	55.000	11.000	44.000
C: Construction sector	1	84.000	0.000	84.000
V: Water vendors	12	73.000	0.000	73.000

4.3 The buying market of private tanker water

The private tanker water sector in Amman comprises two core submarkets, a buying market and a selling market (cf. chapter 2.2.2). The terms "buying market" and "selling market" are derived from the perspective of private tanker water operators who are the key market actors in this sector: The buying market is the market where they act as buyers by purchasing groundwater from private well operators (cf. Figure 4.18). The selling market is the market where they act as sellers by selling tanker water to different consumers. Both markets are highly interrelated and are defined such that the buying market always precedes the selling market.

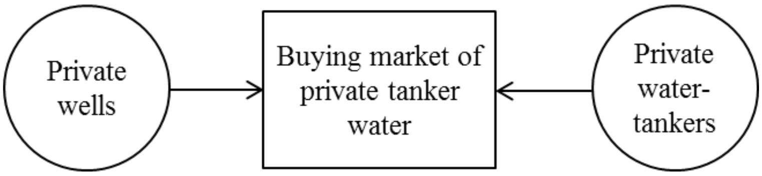

Figure 4.18: The buying market of private tanker water

In this section the buying market of private tanker water, i.e. the marketplace where private tanker water operators and private well operators interact, is analysed from a microeconomic market perspective, based on two empirical surveys, the *well operators survey* and the *tanker drivers survey* (cf. chapters 3.3.1 and 3.3.2). The section is structured according to the so-called structure-conduct-performance paradigm (cf. chapter 2.3), starting with a description of the basic conditions of groundwater supply services.[38] Afterwards, market structure, market conduct and market performance are investigated further, including consideration of both market actors: sellers (private well operators) and buyers (private tanker water operators).

4.3.1 Basic conditions of groundwater supply services

4.3.1.1 Physical, technical and economic conditions

In the following, the basic physical, technical and economic conditions for groundwater supply services are carved out, including hydrogeology, groundwater production, physical quantity constraints and operational costs.

a) Hydrogeology

The installation and operation of groundwater wells highly depend on hydrogeological and physical conditions. This is relevant, for example, for identifying maximal abstraction which ensure sustainable groundwater use. Additionally, the productivity of groundwater wells may vary across the seasons or years due to hydrogeologic or climate conditions.

In terms of the surveyed wells, seasonal fluctuations in physical productivity seem not to be an issue. Only 2 out of 11 interviewed well operators stated that well productivity is higher in winter than in summer. The current depth of the surveyed wells is between 67 and 250 meters (mean: 154; n = 10). 5 respondents stated that the well has been re-drilled (deepened) within the last 10 years to improve well capacity.

b) Groundwater production

The general process for groundwater production at wells delivering water to water-tankers includes the abstraction of groundwater using submersible pumps, its treatment, storage and then distribution to water-tanker by means of pipes. Usually multiple water-tankers can be filled at the same time at one filling station.

The surveyed wells store the water in storage tanks sized between 40 and 400 cubic meters (mean: 185; n = 11). The general mode of treatment is chlorination. Only one of the surveyed wells operators holding a license for agriculture does not treat the water. Given that the mean size of surveyed water-tankers is 11.3 cubic meters (cf. section 4.4.3.2) the storage volume of the surveyed wells allows for 16.4 water-tankers to be filled on average. Assuming that the

[38] The basic conditions of tanker water supply services are described in the context of the selling market of private tanker water (cf. section 4.4.1).

surveyed wells sell an average of 163,565 cubic meters of water per year to water-tankers (cf. section 4.3.2.2), one well serves about 40 water-tankers per day on average (in case of 365 working days per year) which corresponds to an average of 2.4 storage-tank loads. The low buffering capacities of the supply system in the form of storage implies that the groundwater pumps are working steadily to maintain a secure tanker water supply.

c) Physical quantity constraints

Private well operators cannot easily increase the total amount of water sold to water-tankers not only because there is a extraction license that confines the annually allowed pumping quantity (cf. section 4.3.1.2) but also because of physical constraints arising from the production and distribution process. According to the *tanker drivers survey,* the majority of drivers (67.3 %) confirmed that, on occasion, the water availability at a well falls short of the volumes they intended to purchase (n = 300). The most frequent reason stated for this is "electricity breakdown" at the well which could result from overloading the pumps by overabstraction. Another bottleneck can be waiting times that exceed the opening hours of a well. Some respondents also mentioned water shortages during summer which could be a hint that some wells are overabstracted or rather operated closely to the physical limit of productivity.

d) Operational costs

No information could be found in the literature regarding the total cost for operating a groundwater well in Jordan or Amman. The *well operators survey* gives an idea about the main cost categories private well operators are confronted with in consideration of their relative dimensions and magnitudes. However, the data has to be handled with care because the sample size is small and the interviewees responded to all questions from memory. The reported variable and fixed costs for operating a groundwater well, as reported by the interviewees, are summarised in the following table.[39]

Table 4.16: Operational costs of private groundwater wells (Source: Own well operators survey)

Operational costs	N	Minimum (JD/year)	Maximum (JD/year)	Mean (JD/year)
Electricity costs	9	7,680	120,000	48,920
Wage for staff	8	7,200	24,000	11,775
Well maintenance costs	8	500	10,000	2,938
Chlorination costs	8	500	3,600	1,488
Extraction license costs[40]	8	200	1,200	638
Water quality monitoring costs	10	50	1,150	534

The data reveals that electricity costs are by far the highest costs for operating a groundwater well. Compared to that, the well license cost as a central regulatory price instrument carries hardly any weight. Even chlorination seems to be more cost-intensive than licensing. Beyond

[39] As not all respondents specified the abstracted volumes of their well the costs are not expressed per unit volume.

[40] Extraction license costs are fixed costs depending on the type of well.

these surveyed cost categories well operators have to pay service charges and water prices for the extraction of water depending on the type of well (cf. section 4.3.1.2).

4.3.1.2 Supply regulations

Below, the formal regulatory framework of relevance for the supply side of the tanker water buying market is carved out. This includes market access restrictions, quantity regulations, price regulations, quality regulations and groundwater protection regulations. The section is mostly based on the results of chapter 4.1.2.

a) Market access restrictions

In both laws, the *WAJ Law* (Art. 52a) and the *Groundwater By-Law* (Art. 3), it is stated that all water resources, surface and ground waters, are owned and controlled by the state. If a land holder wants to extract and use groundwater, he needs a license issued under the *Groundwater By-Law* prescribing the usage, the extraction quantity and any other conditions (Art. 8).

The well depth is fixed in the license and there is an additional license for the deepening, cleaning or maintenance of an existing well (Art. 28). If the licensee violates any of the conditions in the drilling and extraction licenses, WAJ is allowed to cancel the licenses and to shut down the well (Art. 17). The license for water extraction contains several conditions the licensee should comply with (Art. 29), including the responsibility to install and maintain a water-meter, the obligation to pay so-called water prices (a form of water tax) to WAJ for the extracted water, and to keep a register with all data relating to the well which might be inspected by WAJ.

Most groundwater wells in Jordan are used for irrigation. The *Groundwater By-Law* prohibits "to irrigate any land other than that specified in the water extraction license or to sell this water for irrigation purposes" (Art. 11 A.). Thus, groundwater trading among farmers is not allowed. If wells are selling water "[to] water-tankers for drinking purposes or any other purpose" they need to have a written approval (Art. 11 B.). This is the only passage where water-tankers are explicitly mentioned in the *Groundwater By-Law*.

According to the *Groundwater By-Law,* the drilling of wells is only permitted in designated areas (Art. 6 A). However, in the case where "ministries, governmental departments, official institutes, universities, and industry and tourism sector find it impossible to secure their water needs from the public water supply network the Board [Authorities Board of Directors] may grant any of them a license to drill wells in the prohibited areas pursuant to the provisions of this By-Law" (Art. 6 B). The water extracted from these wells can only be used for licensed purposes (Art. 24). As a consequence, water from these "type B wells" is not considered part of the private tanker water sector (cf. chapter 2.2.2).

None of the analysed policies and laws (cf. section 4.1) stipulate that the licensing of existing or new private wells for drinking purposes is prohibited. Only the well licensing for agricultural purposes seems to be forbidden. This is expressed in the *Groundwater Sustainability Policy* (MWI 2016a, Nr. 33), which specifies that the prohibition of well licensing for agricultural purposes "shall be sustained". According to Rosenberg *et al.* (2008, p. 498) well permits are no longer issued by the government for households or small farmers.

b) Quantity regulations

The *Groundwater By-Law* stipulates that everybody needs to have a license for drilling a well and for extracting groundwater (Art. 8). The extraction license of a well shall be based on a pumping test determining the production capacity, the water quality, the permitted depth and the annually allowed pumping quantity (Art. 9 A, Art. 21 C). Thus, operators of groundwater wells selling water to water-tankers cannot easily increase the volume of extraction and the quantities supplied even if the physical productivity of the well would allow this.

c) Price regulations

Beyond license fees and service charges, the *Groundwater By-Law* stipulates that well operators have to pay so-called water prices for the extraction of water, i.e., a form of water tax, to WAJ with different prices for different types of wells. The water tax for private wells is 250 fils per cubic meter (potable water) and 100 fils per cubic meter (non potable water). The value of 250 fils corresponds with statements in the *well operators survey* and is also quoted by Gerlach and Franceys (2009, p. 437) for licensed wells in Amman.

In addition, the surveys revealed that there seems to be a legal maximum on the sale price of (potable) water from private wells of 0.750 JD per cubic meter (cf. section 4.3.3.3). The goal of this price ceiling might be to protect low-income water users by making tanker water more affordable. The analysed regulatory frameworks, however, do not contain any information about the sales prices of potable water from private wells sold to water-tankers. The *WAJ Law* states that the selling and transporting of water needs to be approved by WAJ and that it is bound by contracts and agreements (cf. Art. 25 C). Maybe these associated documents contain provisions about well water sales prices and a legislated maximum.

d) Quality regulations

The standards for drinking water quality are the same for both piped water and tanker water. Both entities, WAJ and MoH, are responsible for the monitoring of drinking water quality by sampling and laboratory analysis (UN 2014, p. 9; WHO & UNICEF 2010, p. 3) but the MoE also has a mandate to control drinking water quality. Within the *Water Protection Regulation* of 2005 it is stated that any project to produce drinking water, mineral water or bottled water requires a license from MoE (Art. 9).

Drinking water quality standards are controlled by the MoH "regardless of its source". According to the *2016 strategy* drinking water quality shall be protected by safety and risk management approaches including the whole supply chain "from source to tap", i.e. including "treatment, transmission, distribution, and storage of drinking water" (cf. Art. 38, *Public Health Law).*

According to the *Drinking Water Quality Standard* of 2001, quality control is within the responsibility of the owner of a "water enterprise". This could mean that even the operators of a private groundwater well selling drinking water to water-tankers are obliged to conduct quality testing. Similarly, the quality of bottled water has to be controlled by the factory or store producing such water (cf. *Standard for Bottled Drinking Water* of 2004).

Only a few of the regulations relating to drinking water quality are tailored to the sourcing of tanker water, like the "written approval" private wells need to have to sell water to water-tankers or the "physical and technical requirements" and "inspection requirements" recommended by MWI for water-tankers (cf. chapter 4.1.2.2).

e) Groundwater protection regulations

According to the *WAJ Law* (Art. 30 A 3.) and the *Groundwater By-Law* (Art. 10), water pollution or depletion is strictly prohibited and WAJ has a mandate to penalize the pollution of any water resource. The regulations for groundwater protection and management with relevance for private wells are quite comprehensive. In addition to provisions for installing a new well (e.g., drilling license, permitted well depth, extraction license, water-meter provision, approval for selling water etc.) there are also provisions for maintaining and operating an existing well (e.g., annually allowed abstraction rate, permitted deepening, cleaning and data registering provisions, etc.).

The major concern of groundwater policy in Jordan is to prevent groundwater sources from depletion and salinization. This is mostly targeted by the extraction license together with the abstraction permit which determines the maximal amount of water allowed to be extracted from a well within a fixed period of time. The abstraction rate has to be measured and controlled through metering. Nonetheless, illegal abstraction in excess of the licensed rates is a serious problem in Jordan because of the lack of and manipulation of water- meters, and absence of controls (cf. MWI 2009, p. 3-1).

4.3.2 Market structure

4.3.2.1 General market characteristics

a) Number of sellers and buyers

No official data could be identified regarding the total number of sellers, i.e. private well operators selling (parts of their) water to private tanker water operators. According to oral communication with staff from WAJ the total number is about 27 (15 within the administrative area of Greater Amman Municipality, 12 out of town). In terms of the buyers, i.e. private tanker water operators, data from the Jordanian *Department of Motorvehicles and Licensing* suggests that the total number in the Governorate of Amman is 1469 (data from 2015-2016).

b) Heterogeneous oligopoly

The buying market of private tanker water in Amman is a competitive market as each tanker water operator can choose between several wells and each well operator is aware that the good offered – groundwater supply service – is similar to that offered by other wells. As the market is dominated by a rather small number of well operators (sellers) and the good on offer is heterogeneous (see below), the market form can be characterised as a heterogeneous oligopoly. Another core characteristic of the market is that it is predominantly private because all sellers (well operators) and nearly all buyers (tanker water operators) are private entities.[41]

c) Heterogeneity of groundwater supply services

From the perspective of the buyers, the offered goods – groundwater supply services – are not identical, i.e. heterogeneous. Important competition parameters as identified by the surveys are (in decreasing importance): Water quality, geographical location of the wells, quality of service provision (e.g., waiting time at well, opening hours of well, payment schemes) and prices. Prices do not seem to play a crucial role because well water sales prices are determined by law (at least in the sense of a maximum price).

d) Spatial aspects

The marketplace of the buying market of private tanker water is generally situated at the private wells. Here, sellers (well operators) and buyers (private tanker water operators) meet. Transport costs are completely covered by the drivers. Advantages of location matter as not

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[41] As outlined in chapter 2.2.2, there is a small float of public water-tankers used by Miyahuna for emergency cases. These public water-tankers can buy water from private well operators.

all wells are located at the same distance from the customers. Drivers prefer wells that are located close to the customers and close to their own residence (cf. section 4.3.3.1). Thus, the buying market does not bear the characteristics of a spot market.

According to Map 3.1 (cf. section 3.2), which depicts the locations of 18 surveyed private wells, Amman's tanker water buying market can be divided into 4 well areas or supply zones: one in the northwest, one in the northeast, one in the south and one within the municipal area of Greater Amman Municipality (Marka and Quasabet). It can be assumed that the strong spatial zoning of the wells has an impact on the competitive conduct of the well operators. The existence of a regional monopoly, however, cannot be derived from the map.

4.3.2.2 Degree of supplier concentration

Private tanker water operators delivering water to Amman can choose between several competing private suppliers of groundwater. As mentioned above, it can be assumed that the total number of private well operators that sell (parts of their) water to private water-tanker operators is about 27. To resolve the relative market share, data on amounts of water sold to water-tankers for each well would be required. The surveyed wells sell between 47,450 and 438,005 cubic meters per year on average to water-tankers (mean: 163,565; n = 9). The wide variability in this data indicates that the market share of individual wells differs substantially.

4.3.2.3 Degree of product differentiation

The groundwater offered by private wells for drinking must conform to drinking water quality standards (cf. section 4.3.1.2). There is no empirical evidence that private well operators undertake measures to modify well water quality beyond the prescribed hygiene measures, such as chlorination. Differences in water quality that result from the specific hydrogeologic conditions cannot be assessed easily. Thus, from the supplier's perspective, there is no significant product differentiation or product policy. However, a special dimension of product differentiation does exist through the different licenses that private wells can be licensed for (e.g., drinking, agricultural, industry) which was observed for the surveyed private wells.

4.3.2.4 Barriers to the entry of new suppliers

As already mentioned above, private well operators that want to legally sell water to water-tankers need to have an extraction license. Beyond such legal constraints, potential suppliers of groundwater may face further barriers to market access, for example possible competitive advantages of existing suppliers (e.g., location of the well) or constrained financial or non-financial resources (e.g., personal competencies). The investment costs to install a new well provide an indication of the financial market access barriers. According to literature the installation of a new well costs up to 60 JD per meter (Rosenberg *et al.* 2008, p. 498) plus a unique licensing cost of 1,750 JD (Bonn 2013, p. 126). Assuming that a groundwater well within the Amman-Zarqa basin is 154 meters deep on average (cf. section 4.3.1.1) the corresponding total well installation costs can be estimated at 10,990 JD. The surveyed well operators were asked about the costs for a farmer or landowner to set up a water-tanker service (e.g., well drilling or improvement, tanker delivery pipes, tanks, road paving or hardstanding etc.). Some interviewees approximated these costs to be between 24,000 and 300,000 JD (n = 4). All in all the market barriers for new groundwater suppliers can be characterised as being rather high, facilitating imperfect competition.

4.3.3 Market conduct

4.3.3.1 Purchasing behaviour of private tanker water operators

In this section, the purchasing behaviour of the consumers of the tanker water buying market is investigated further, based on results of the *tanker drivers survey*. Firstly, the survey reveals that the drivers generally head for one preferred well, namely the well where the interview took place (n = 255).[42] 30 drivers referred to up to 3 different wells where they usually get their water, 9 answered that they are frequenting multiple wells.

Tanker water that originates from different wells and/or providers is valued differently by most of the drivers. The valuation depends not only on the perceived quality of the economic good – tanker water – but also on the whole service provision process. The following figure indicates what the interviewees answered on the openly-formulated question "how do you decide which well to drive to?" (coded answers, multiple answers possible, n = 298).

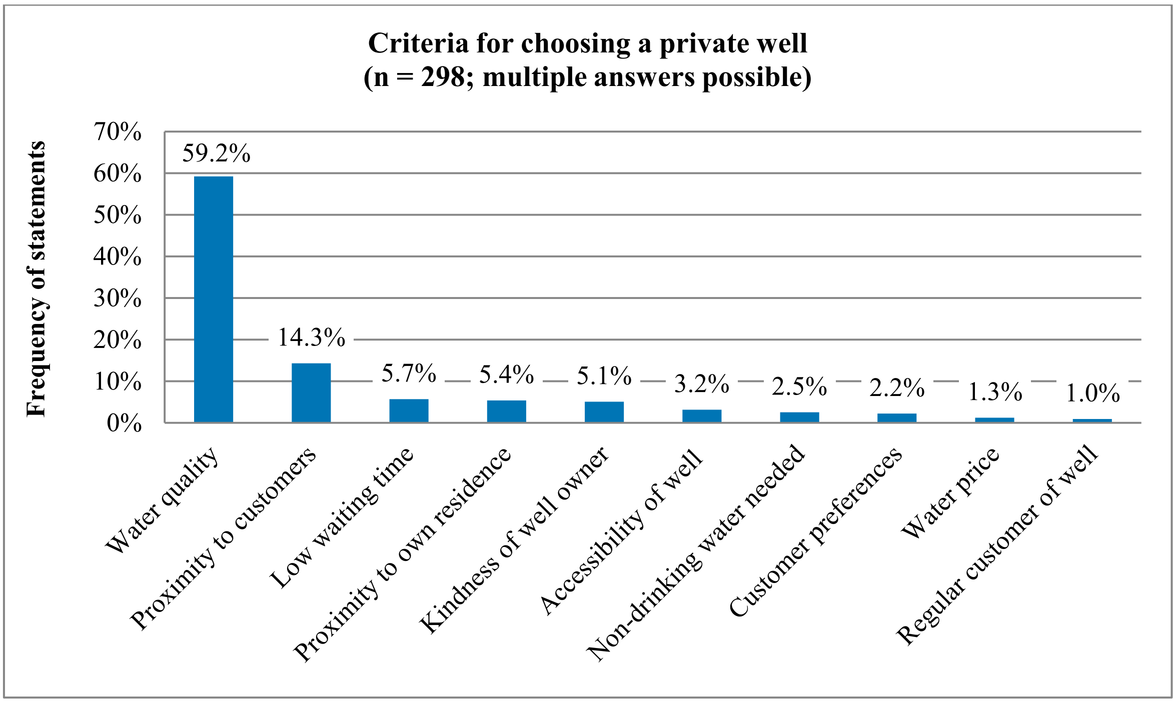


Figure 4.19: Criteria used by water-tanker operators to choose a private well (Source: Own tanker drivers survey)

- **Water quality:** The by far most commonly stated criteria for selecting a private well, expressed in the majority of the statements (59.2 %), is water quality which indicates clearly that drivers perceive differences in water quality between wells. According to nearly all respondents (95.3 %) well water quality does not fluctuate significantly over time (n = 300). Within the survey the interviewees were also directly asked if their customers, i.e. commercials and private households, care about water quality or not. The vast majority (84.3 %) confirmed (n = 300). Of the interviewees who said that their customers cared about water quality, the majority (97.6 %) stated that their customers care more about wa-

[42] Sample size is only 255 (and not 300) because 33 driver's interviews took place at waiting stations and not at wells. Beyond that, 12 wells referred to by the drivers could not be clearly identified.

ter quality than about water price.[43] These findings are consistent with results from the *commercials survey,* which indicate that commercial establishments select private tanker water providers primarily according to perceived water quality, followed by the reliability of service and finally the water price (cf. section 4.2.1.6).

- **Geographical location of the well:** Some respondents (in total: 22.9 %) mentioned criteria that are related to the well location and traffic conditions (*proximity to customers*, *proximity to own residence, accessibility of well*). The underlying interest of the drivers in this regard is, of course, to reduce transportation time and cost.
- **Quality of service provision:** For some interviewees (in total: 10.8 %), the quality of service provision in form of *low waiting time* at the well and *kindness of well owner* are decision-relevant. As described later, the mean waiting times at the surveyed private wells vary significantly (cf. section 4.3.3.3).
- **Water price:** Evidently, the purchase price of well water is only crucial for very few (1.3 %) respondents. The reason presumably is that only a few private wells sell water at less than the governmental target sales price of 0.750 JD per cubic meter (cf. section 4.3.3.3). Thus, the location of the supplier and the associated transport cost, mostly in the form of fuel cost, carry much more economic weight for the drivers than differences in the well water purchase prices.

In addition, the following criteria were also mentioned by respondents (not shown in the figure): (i) the owner of the truck prescribes the well, (ii) the well owner accepts payment delay, (iii) long opening hours of the well, (iv) high water production at the well and (v) suitable parking conditions.

4.3.3.2 General market strategy of private well operators

All surveyed private wells are selling water to water-tankers who deliver water to Amman.[44] Out of the 11 surveyed private wells, 9 always intended to sell water to tankers, 2 were originally farmer‘s wells. A total of 8 were selling water to private water-tankers exclusively. Out of the remaining 3 wells, 1 is selling 5 % of the water to public trucks, 1 is selling 66 % of the water to other farmers and 1 is giving 10 % of the water away for free. The 11 surveyed private wells were installed between 1960 and 1980, 7 within the 1970s. The stated number of operating years is between 6 and 56 (mean: 36; n = 10). This indicates that the water sold through water-tankers in Amman mostly originates from increased abstraction of existing wells and/or increased ratios of water sold from agricultural wells and less from the installation of new wells.

Out of the 11 surveyed wells, 7 are licensed for drinking, 9 for agriculture and 4 for industrial purposes. 5 wells hold 2 licenses; only 2 wells hold all 3 licenses. The 4 wells without a drinking license are either licensed for agriculture (3 wells) or for industry (1 well).

The surveyed well operators sell between 18 % and 100 % of the abstracted water to water-tankers (mean: 66 %; n = 7). 5 out of 11 well operators are also working as farmers. All of these wells have a license for agriculture purposes. The water used for agriculture is between 10 % and 80 % (mean: 58 %). As stated by the interviewees, all of the remaining water is sold

[43] This corresponds with findings from Gerlach and Franceys (2009, p. 437), according to which tanker water quality and not price seems to be the main concern of households in Amman.

[44] This was a criterion for the selection of wells in the *well operators survey*.

to water-tankers. Water for agriculture, however, is always given first priority. 2 respondents stated that the choice to sell water to tankers affects crop selection.

The most pressing business challenges reported by the interviewed well operators are the increase of electricity prices, more strict governmental regulations, pollution of groundwater, decline of groundwater levels and low sales quantities during winter. One well operator stated that he does not like it when piped water supply or rather public wells experience an outage, because he then has to increase staff levels to serve increased tanker water demand. At the same time he cannot increase his profit as the abstraction rate of his well is limited.

4.3.3.3 Sales strategy of private well operators

To maximise profit, private well operators have an interest to increase the quantities of supply. However, due to existing supply regulations and physical limits of groundwater production (cf. sections 4.3.1.1 and 4.3.1.2), their scope for (legal) action is limited in this regard. Well operators that are also farmers may strategically decide on the water quantities sold to water-tankers depending on crop yield. But as the well water sales price for tanker water seems to be capped at 0.750 JD per cubic meter and potable water is taxed higher than non-potable water (250 fils per cubic meter versus 100 fils per cubic meter), this competitive strategy is limited as well. Sales policy measures of private well operators that could be verified empirically were: price differentiation in the form of price cutting (mostly in winter), extension of opening hours of the well and the offer of payment schemes for drivers. Marketing and advertising strategies never came up in the interviews. In the following, the identified well operators‘ sales policy measures are described in detail.

a) Price differentiation

The actual sales and purchase prices of water from private wells in and around Amman were investigated from two angles: Through the *well operators survey* and the *tanker drivers survey*. In the following, the results of both surveys are presented.

Within the *well operator interviews,* 7 out of 11 operators stated that they fixed their sales according to the governmental legal maximum. The data on the charged prices for summer and winter is summarised in the following table.

Table 4.17: Water sales prices at private wells (Source: Own well operator interviews).

Well No.	Sales price: Summer (JD/m^3)	Sales price: Winter (JD/m^3)
1	0.750	0.500
3	0.750	0.750
4	0.750	0.750
6	0.750	0.750
9	0.500	0.450
12	0.500	0.500
13	0.750	0.750
14	0.500	0.350
15	0.500	0.500
16	0.700	0.700

17	0.750	0.700
Mean	**0.655**	**0.609**

The surveyed water sales prices are between 0.500 and 0.750 JD per cubic meter in summer (mean: 0.655; n = 11) and 0.350 and 0.750 JD per cubic meter in winter (mean: 0.609; n = 11). The legislated maximum sales price is supposed to be 0.750 JD per cubic meter. 7 wells charge less, at least during winter. One possible reason for cheaper prices being offered by some wells is that they hold different licenses. A total of 4 out of 11 surveyed wells, for example, are not licensed for drinking. 7 wells show the same sales prices for summer and winter whereas the data from 3 wells indicates that there are seasonal price differences, with higher prices in summer. 3 respondents stated that their sales price was customer-specific, 3 others reported giving a discount for higher sale quantities. All in all, the results provide evidence that there is price competition between private well operators, notably in winter.

The results of the *tanker drivers survey* confirm that there seems to be a price ceiling at 0.750 JD per cubic meter because most of the drivers (71.5 % in summer, 63.1 % in winter) pay this purchase price for water from private wells (cf. Table 4.18). Only in some cases water is purchased for a higher price (1.000 JD per cubic meter). The high price range with a minimum price of 0.450 JD per cubic meter reveals that price undercutting is used by well operators as a measure to increase sales quantity. Within the interviews the drivers explicitly complained about fluctuating well water sales prices (cf. section 4.4.3.1). This also indicates that the well operators face price competition.

In general, prices in summer (mean: 0.731 JD per cubic meter) are slightly higher than compared to winter (mean: 0.700 JD per cubic meter) which is an indication for a demand-oriented prices policy and increased competition in winter.

Table 4.18: Purchase prices of water from private wells (Source: Tanker drivers survey)

	Purchase prices summer [JD per m^3]				Purchase prices winter [JD per m^3]			
	Price	Frequency	Percent	Valid Percent	Price	Frequency	Percent	Valid Percent
Valid	0.450	5	1.7	1.7	0.450	5	1.7	1.7
	0.500	22	7.3	7.4	0.500	52	17.3	17.4
	0.550	10	3.3	3.4	0.550	21	7.0	7.0
	0.600	9	3.0	3.0	0.600	1	0.3	0.3
	0.700	17	5.7	5.7	0.700	17	5.7	5.7
	0.750	213	71.0	71.5	0.750	188	62.7	63.1
	1.000	22	7.3	7.4	1.000	14	4.7	4.7
	Total	298	99.3	100.0		298	99.3	100.0
Missing	no response	2	0.7			2	0.7	
Total		**300**	**100**			**300**	**100**	

b) Opening hours of wells

Another measure well operators can adopt to increase their sales quantity is to modify their opening hours. Expanded and demand-oriented well opening hours can reduce the driver's waiting time to get bulk water which is an important advantage for drivers (cf. Figure 4.19, section 4.3.3.1). The opening hours of the surveyed wells vary between 8 and 24 hours per day with a mean of 16.3 hours in summer and 14.9 hours in winter (n = 10) (cf. Table 4.19). 4 wells offer 24 hours service in summer and in winter. 3 wells show slightly increased opening hours in summer compared to winter which may be an indication that they react to increased tanker water demand in summer.

Table 4.19: Opening hours of private wells (Source: Own well operators survey).

Well No.	Opening hours: Summer	Opening hours: Winter
1	*no data*	*no data*
3	24	24
4	12	8
6	9	9
9	8	8
12	24	24
13	24	24
14	8	8
15	24	24
16	14	10
17	16	10
Mean	**16.3**	**14.9**

The data of the *tanker drivers survey* indicates that waiting times at wells are slightly negative correlated with the well opening hours with a Pearson correlation of –0.24. As reported by the interviewed truck drivers the waiting time at the wells is between 0.50 and 6.00 hours in summer (mean: 2.77; n = 298) and 0.00 and 2.00 hours in winter (mean: 0.54; n = 297). Thus, there is a very high seasonality factor of 5.13 which speaks for an increased tanker water demand in summer. In the following figure the mean waiting times are shown for the 18 wells where the interviewed drivers usually get their water. At all surveyed wells, the waiting time is significantly higher in summer compared to winter.

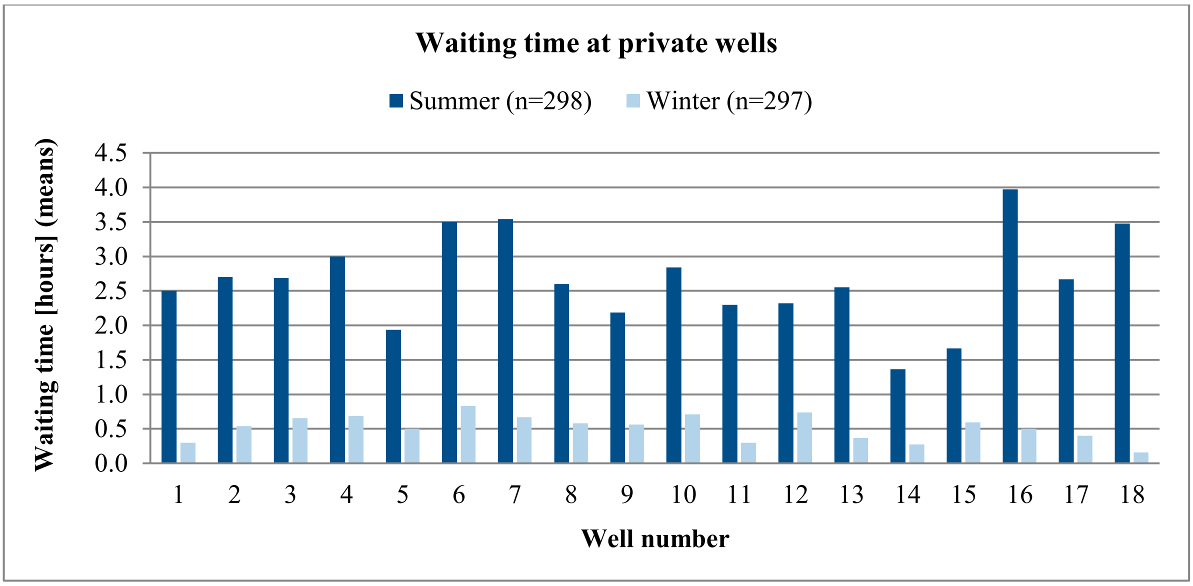


Figure 4.20: Waiting time at private wells (Source: Own tanker drivers survey)

c) Payment schemes

In terms of payment schemes, the *tanker drivers survey* reveals that there are different modes of payment between well operators and water-tanker drivers: cash and non-cash as well as payments within distinct periods (cf. Table 4.20). Most commonly the drivers pay their bill monthly in cash (56.7 %) or immediately in cash (33.9 %). The different terms of payment offered by the well operators can be interpreted as a form of financial service to increase competitiveness.

Table 4.20: Modes of payment between water-tanker drivers and well operators (Source: Own tanker drivers survey)

	Answers coded	Frequency	Percent	Valid Percent
Valid	Cash monthly	169	56.3	56.7
	Cash immediately	101	33.7	33.9
	Monthly payment	17	5.7	5.7
	Cash weekly	7	2.3	2.3
	Other	4	1.3	1.3
	Total	298	99.3	100
Missing	no response	2	0,7	
Total		**300**	**100**	

4.3.3.4 Cooperation among private well operators

The *well operator interviews* gave no evidence that well operators cooperate or make price-fixing agreements. Instead, a total of 8 respondents emphasised that they were in active competition with other well operators (n = 11). According to one interviewee, competition is higher in winter than in summer. Nevertheless, it cannot be ruled out that well operators informally coordinate their pricing.

4.3.4 Market performance

The performance of the buying market of private tanker water is constrained by a number of factors, most notably the combination of price and quantity constraints resulting from regulation. The quantity of water, which a well operator can sell, is limited by his extraction license. Sales prices, on the other hand, are constrained by a lower and upper boundary: the water tax on abstracted volumes as the lower boundary, and the price ceiling of 0.750 JD per cubic meter as the upper boundary.

The price cap for drinking water implies, in combination with the lower taxes on water for agricultural purposes, that well operators cannot increase the profitability of tanker water supply beyond a fixed level and are therefore hesitant to re-direct (more) water to the private tanker water market. Along with the licensed extraction quantity, the price cap therefore constrains the available water volumes for tanker operations. While no broad evidence for a shortage of tanker water was found in the surveys, the intensive use of existing wells, exemplified by waiting time and long opening hours, implies a high-demand pressure. This is further substantiated by the presence of groundwater overabstraction and the existence of illegal wells.

The price cap seems to stem from a WAJ-regulation rather than from price collusion among well operators, at least no evidence was produced in the surveys which suggested otherwise. On the contrary, the different wells claim to be in competition, and increasingly so in the winter months, during which the demand for tanker water is lower. In winter, price competition between well operators intensifies and several begin to set their prices considerably below the price cap.

The effect of decreasing sales prices, however, seems to be of limited importance because water *quality* is the dominating criterion that tanker drivers use to determine their well of choice. In addition to that, the location of a well, i.e. its proximity to the driver’s residence or customers, and the quality of service – for instance the waiting time – are the most relevant factors. While water-tankers can choose from a variety of competing wells, it seems questionable whether full competition can be assumed, due to the barriers of entry that obstruct the drilling of new wells, most notably regulatory and economic burdens.

4.4 The selling market of private tanker water

In accordance with what has been outlined for the tanker water buying market (cf. section 4.3), the selling market is the market where private tanker water operators act as sellers by selling tanker water to different consumers (cf. Figure 4.21).

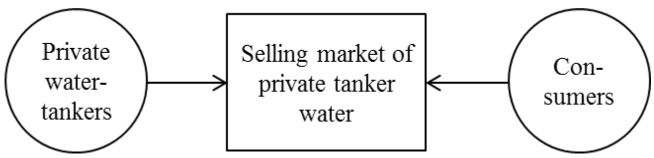


Figure 4.21: The selling market of private tanker water

The demand behaviour of the key consumers of tanker water, private households and commercial establishments, were the subject of section 4.2. These demand-side related market characteristics will feed into the following analyses on market structure, market conduct and market performance as well as the empirical results of the *tanker drivers survey* (cf. chapter 3.3.2). First, though, the basic conditions of tanker water supply services will be carved out.

4.4.1 Basic conditions of tanker water supply services

4.4.1.1 Physical, technical, and economic conditions

Below, the basic conditions for tanker water supply services in the form of physical, technical and economic conditions are carved out, including truck sizes, water losses and operational costs.

a) Truck sizes and water losses

For reasons of transport safety, water-tankers should be completely full or empty when driving. This implies that, at least for technical and safety reasons, drivers have an interest in selling the full load of water at once. The *tanker drivers survey* shows that the capacity of the truck generally corresponds to the average amount of water sold per customer. In winter there are slightly more cases in which drivers sell water quantities that are smaller than the capacity of their truck. The maximum size of the trucks is limited by the traffic conditions in Amman and the size of the streets.

According to the interviewed drivers the amount of water which is usually lost is between 0 and 200 liters per ride (mean: 18.3; n = 300), independent of tanker size. Assuming that the mean tanker size is 11.3 cubic meter, water losses are in the range of 0.1 %.

b) Operational costs

Fuel costs are by far the most relevant operational costs for carrying out a water-tanker business. According to the interviewed drivers fuel costs are between 0.100 and 1.667 JD per kilometer (mean: 0.523; n = 297). In relation to truck size, the fuel costs range from 0.011 and 0.250 JD per kilometer and cubic meter (mean: 0.061; n = 297). Other variable and fixed operational costs as reported by the drivers are summarised in Table 4.21.

Table 4.21: Operational costs of private water-tankers (Source: Tanker drivers survey)[45]

Operational costs	N	Minimum (JD/year)	Maximum (JD/year)	Mean (JD/year)
Tanker maintenance costs	225	144	8,104	1,729
Costs for tires	251	120	14,400	1,008
Oil change costs	288	48	3,600	1,008
Traffic violation costs	148	24	3,000	419
Tanker cleaning costs	173	12	2,760	328
Costs for hoses	245	12	600	152
Transport license costs (fixed)[46]	285	12	300	124

[45] Beyond these operational costs, some drivers employ an assistant which results in labor costs.

[46] Probably increasing with truck size.

Business license costs (fixed)	285			35
Health license costs (fixed)	284			16

The compiled operational cost data has to be handled with care. The values are highly variable which in part could be a result of not all interviewees being able to enumerate all cost categories from memory. Nevertheless, the data suggests that license costs, for example, hardly carry weight when compared to the other cost categories.

4.4.1.2 Supply regulations

In the following, the formal regulatory framework of relevance for the supply side of the tanker water selling market is carved out, including market access restrictions, operating regulations, price regulations and quality regulations. The section is mostly based on the results of chapter 4.1.2.

a) Market access restrictions

Only one regulation could be identified which specifically targets water-tankers, namely the *Transportation Costs and Conditions of Water Tankers* document issued by MWI in 2008 (cf. section 4.1.2.2). However, its liability seems to be rather vague as it has the status of "recommendations". According to this *MWI 2008* document, water-tanker operators have to pay a nonrecurring tanker truck registration fee of 1,830 JD when they start their business. There is no evidence that there is a hard upper-limit on the total amount of water-tankers that can be licensed in Amman or Jordan. Another provision being relevant for water-tankers is within the *WAJ Law* (Art. 25c), stating that anyone wishing to sell or transport water needs to obtain WAJ's "written approval". Thus, water-tankers driving through Amman are reliant on a transport license. All in all, the market access restrictions seem to be rather low, i.e. private tanker water operators can enter the market without major problems.

b) Operating regulations

The *MWI 2008 document* also contains specific provisions in terms of tariffs and transportation costs, physical and technical requirements of water-tankers and inspection requirements. The physical and technical requirements specified in the *MWI 2008 document* are "to ensure public health protection and safety" and "to protect the quality of drinking water". They include the water-tanker body (4.1), the water drain pipes (4.2), the exterior shape of the water-tanker truck (4.3), the paintings and writings (4.4) and additional equipment (4.5). Amongst other things it is stated that water-tankers transporting drinking water shall be painted in green and the words "potable water" shall be written on both sides and on the back of the water tank in suitable sized letters in white color. Non-potable water shall be transported in tanker trucks painted in blue. Furthermore, every water-tanker truck shall be equipped with a valid water counter credited with a certificate from the Standards and Meteorology Department.

Furthermore, the *MWI 2008 document* recommends conducting routine inspections of water sources "for filling water tanks and tanker trucks" by liaison officers from each of the relevant Ministries, to ensure compliance with existing standards, instructions and requirements, and to adopt deterrent measures against violations and irregularities (5.3, 5.4). Then, each tanker driver shall have a "statement of facts" from the drinking water sources indicating the water source, the water counter number, and the quantity loaded in cubic meters (4.10, 5.5).

c) Price regulations

The *MWI 2008 document* also contains recommendations for private tanker water providers for setting water tariffs. Thus, the water tariff should be based on mean transportation costs, the water price at the private well and an assumed net profit of 10 % of transportation costs.

Gerlach and Franceys (2009. p. 437), however, state that there is a regulated target sales price for water sold via private water-tankers in Amman set by WAJ of 2.00 JD per cubic meter in summer and 1.75 JD per cubic meter in winter. According to the authors, though, this price regulation is not enforced. As there are no distinct procedures to monitor and control prices, tanker drivers do not risk any penalties if they sell their water at higher prices (p. 439). The data of the *tanker drivers survey* indicate that there is a regulated tanker water target sales price of 2.50 JD per cubic meter which it is not strongly enforced (cf. section 4.4.3.2).

d) Quality regulations

There are only a few rather vague regulations in terms of drinking water quality that are tailored to the specific conditions of tanker water. In terms of water-tankers, the "physical and technical requirements" and "inspection requirements" recommended by the *MWI 2008 document* might be of relevance here. As stated by Gerlach & Franceys (2009, p. 28), tanker operators require a valid water quality license from MoH and must produce these upon request in random inspections if they want to avoid penalties or loss of license.

4.4.2 Market structure

4.4.2.1 General market characteristics

a) Number of sellers and buyers

Amman's selling market of private tanker water is characterised by a large number of sellers. As pointed out earlier, data from the Jordanian *Department of Motorvehicles and Licensing* suggests that the total number of licensed water-tankers in the Governorate of Amman is 1469 (data from 2015-2016). The number of customers of tanker water in Amman is large as well. As discussed earlier, many households in Amman augment their water supply needs by buying tanker water from private suppliers, mostly during the summer season (cf. section 4.2.2). More than half (56 %) of surveyed commercial establishments use tanker water as sole, i.e. alternative bulk water source (cf. section 4.2.1).

b) Monopolistic competition

The selling market of private tanker water in Amman fulfills the three attributes of a type of imperfectly competitive market called monopolistic competition: (i) There are many sellers of tanker water, i.e. private tanker water operators, competing for the same customers; (ii) the good offered by one provider – tanker water supply services – is similar but not identical to that of other providers, i.e. it is heterogeneous (see below); (iii) sellers can enter or exit the market without substantial restrictions (cf. section 4.4.1.2). Thus, a monopolistically competitive market is monopolistic in some ways (differentiated goods) and competitive in others (many sellers, free market entry). The product differentiation leads private tanker water suppliers to maximise profits by attracting more buyers to their particular good.

c) Heterogeneity of tanker water supply services

From the perspective of the consumers, the offered goods – tanker water supply services – are not identical, i.e. heterogeneous. As already pointed out, consumers care a lot about the quality of tanker water and also the quality of service provision. Commercial establishments, for example, select their tanker water supplier first and foremost according to the criteria water quality, followed by reliability of service and water price (cf. section 4.2.1.6). As a consequence, tanker water suppliers have an interest to offer water from a high quality well (cf. section 4.3.3.1) and to perform well in terms of service provision. Important competition parameters beyond water quality as identified by the *tanker drivers survey* are: delivery times, truck sizes, types of customers, sales quantities, price differentiation, and payment schemes (cf. section 4.4.3.2).

d) Spatial aspects

The typical physical marketplace of the selling market of private tanker water is the place of residence of the customers. After receiving customer request, generally via phone call, the private providers deliver the water directly to the customer's home. Similar to the buying market, transport costs are completely covered by the drivers. A special selling concept of tanker water in Amman is linked to so-called *waiting stations*. These are centrally located parking places where filled water-tankers wait for customers. Customers come either in person to the waiting station or call a truck via phone. By using waiting stations, drivers can reduce delivery times and bridge periods of time in the absence of customer requests. Some interviewed drivers pointed out that the appearance of mobile phones significantly reduced the importance of waiting stations as a physical marketplace. As is the case with the buying market of private tanker water, advantages of location (e.g., location of well, location of driver's residence, location of customers, location of waiting station) matter in terms of delivery times, transport costs and pricing. Thus, also the selling market does not bear the characteristics of a spot market.

The distances travelled by water-tanker operators to transport water from the well to the point of delivery provide an insight into the geographic expansion and demarcation of Amman's private tanker water markets and help to answer the question wheather market sub-segments exist or not. Firstly, the *tanker drivers survey* reveals travelling distances of between 1 and 45 kilometres (mean: 14.5; n = 300). As the drivers generally head for one preferred well, namely the well where the interview took place (cf. section 4.3.3.1), the distances travelled by every driver can be related to the surveyed wells. The following figure shows for every surveyed well, how many kilometres the water-tankers transport the water from this well to the point of delivery on average (one way).

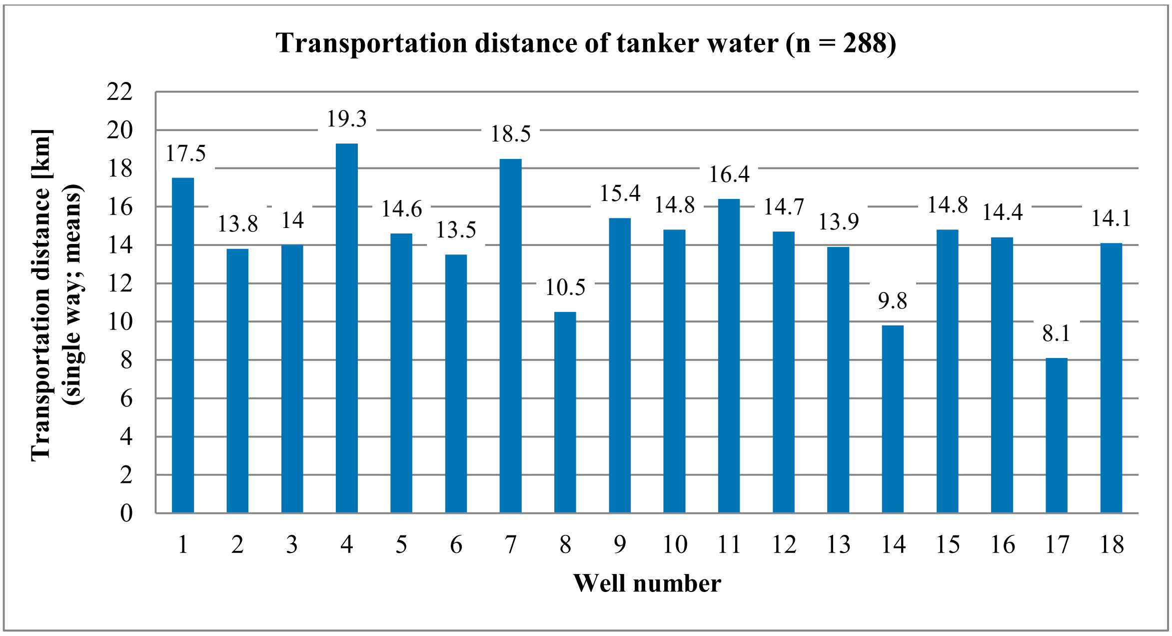
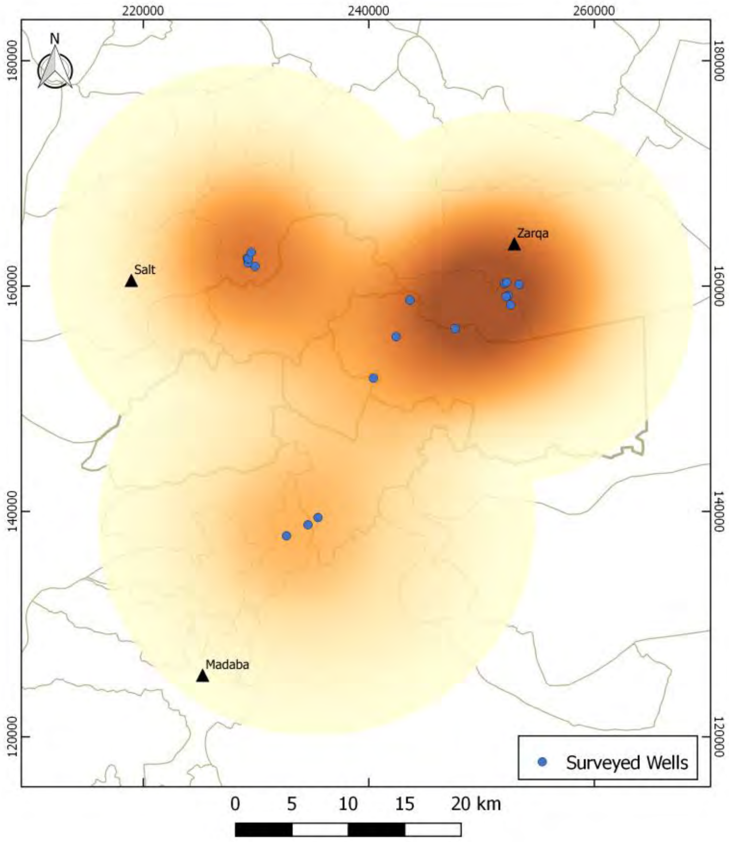


Figure 4.22: Distance travelled by water-tankers from private well to point of delivery (single way) (Source: Own tanker drivers survey)

Some wells show comparatively short mean transportation distances for water-tankers (wells No. 8, 14, 17), whereas others are rather longer (wells No. 1, 4, 7). These differences cannot be easily explained by the differing locations of these wells (cf. Map 3.1, chapter 3.2).

The following map provides a visual representation of the density of tanker water supply in Amman based on the data presented above. For each of the 18 surveyed wells (marked in the map by blue points) the tanker water supply area is delineated in form of a yellow circle, using the surveyed well-specific average distances (means) travelled by water-tankers from the well to point of delivery (cf. Figure 4.22) as radius. The graphical representation indicates the extent of overlapping of water supply areas by the level of shading, with darker shades of orange indicating greater overlap. First of all, it becomes obvious that each of the five main sub-districts of Greater Amman Municipality (cf. Map 2.1, chapter 2.2.3) is covered by tanker water supply originating from the surveyed wells. Consumers located in the north-eastern sub-districts (Al Jameh, Marka) can choose between a larger number of suppliers and wells than those of other sub-districts. The three distinct tanker water supply areas appearing in dark orange indicate that there are 3 market sub-segments. The map also illustrates clearly that Amman's tanker water markets are highly interrelated with those of other large cities like Zarqa and Salt (marked on the map by black triangles).



Map 4.1: Density of tanker water supply in Amman (Source: Own tanker drivers survey).

4.4.2.2 Ownership structure and form of organisation

Most of the interviewed truck drivers (68.7 %) are owners of the truck(s), the remaining (31.3 %) are non-owners or employees (n = 300). The survey also reveals that out of the interviewed drivers who own their vehicle, the vast majority (90.8 %) had only one truck (cf. Table 4.22). This might indicate that the truck drivers that are employees work for an individual employer who typically owns only one or very few trucks.

Table 4.22: Ownership of water-tanker trucks (Source: Own tanker drivers survey)

	Number of trucks owned	Frequency	Percent	Valid Percent
Valid	1	187	62.3	90.8
	2	15	5	7.3
	3	2	0.7	1
	6	1	0.3	0.5
	7	1	0.3	0.5
	Total	206	68.7	100
Missing	not applicable	94	31.3	
Total		**300**	**100**	

One interviewed driver reported that his truck is owned by the consumer (a restaurant) and that he is just transporting the water from the private well to the consumer. This provides evidence that there are commercial establishments that directly buy tanker water from the buying market by means of their own trucks. Within the *commercials survey*, 6 establishments of this type were identified.

The filling of the customer's storage facilities is part of the water tanker's service provision. Nevertheless, only few of the surveyed drivers (13.3 %) are working with an assistant (n = 300).

4.4.2.3 Degree of supplier concentration

As already pointed out, the total number of competing private tanker water suppliers in the governorate of Amman is high; the Jordanian *Department of Motorvehicles and Licensing* registered 1469 private water-tanker trucks in 2015-2016 (cf. chapter 3.3.2.1). As there seem to be no larger companies or associations of private tanker water operators (cf. section 4.4.2.2), it can be assumed that there is an atomistic market with numerous small suppliers and that the individual market shares are distributed rather equally.

4.4.2.4 Barriers to the entry of new suppliers

Beyond the legal market access restrictions such as truck registration or transport license (cf. section 4.4.1.2), potential suppliers of tanker water may have to overcome financial barriers if they want to enter the market such as investment costs for a truck. According to the *tanker drivers survey*, the investment cost for a second-hand water truck is estimated to range between 4,000 JD and 67,500 JD (mean: 21,769; n = 297), depending on tanker size. The cost for a second-hand water truck with a capacity of 6 cubic meters, for example, is projected to be between 4,500 and 27,000 JD (mean: 11,648; n = 54). All in all, the market barriers for new tanker water suppliers can be characterised as being rather low, favouring a high degree of competition.

4.4.3 Market conduct

4.4.3.1 General market strategy of private tanker water operators

The *tanker drivers survey* was intended to include both green (drinking) and blue (non-drinking) trucks. In fact, nearly all interviewed drivers (97.0 %) were operating a green truck and very few (3.0 %) a blue one (n = 300). A total of 7 (out of 9) surveyed blue trucks supply the construction sector, with 2 supplying farmers. This suggests that the possibility to differentiate the tanker water by its quality (drinking, non-drinking) and the price at which it is supplied, is not of major importance in practice.

The drivers were asked if, beyond seasonality, there are any factors which influence their business in a good or bad way. The majority of drivers (68.0 %) answered in the affirmative. The following figure summarises the stated negative business factors as perceived by the interviewees (coded answers, multiple answers possible, n = 204).

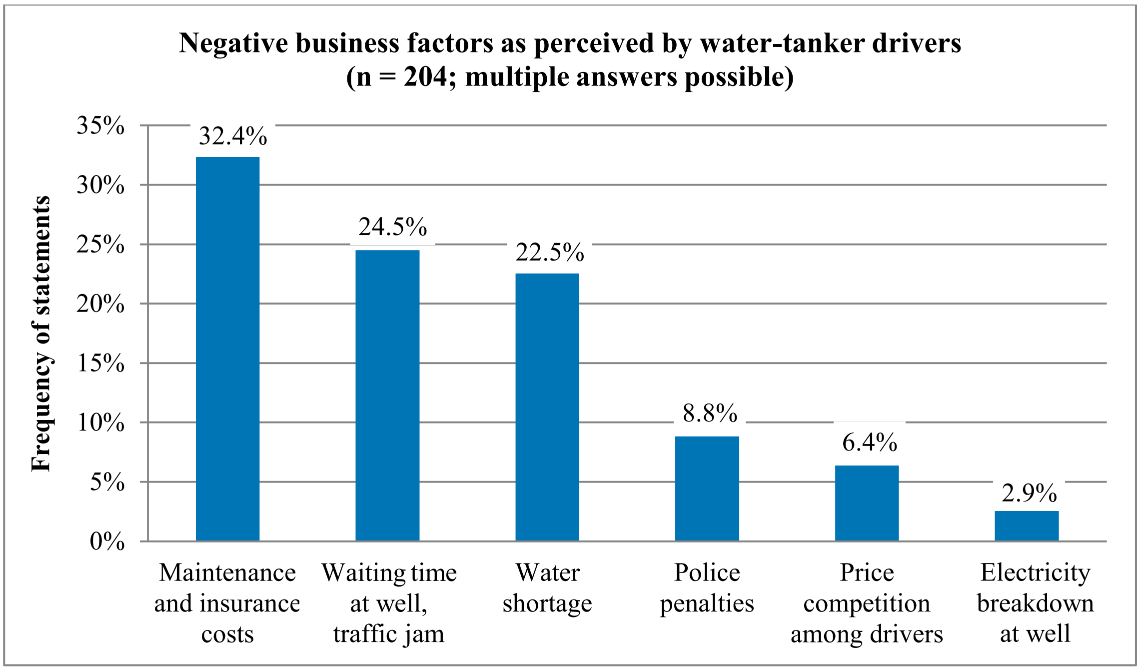


Figure 4.23: Negative business factors as perceived by water-tanker drivers (Source: Own tanker drivers survey)

Interestingly, in terms of cost burdens, many drivers (32.4 %) referred to truck maintenance and insurance costs and not to (fluctuating or increasing) fuel costs. Also the waiting and queue time at the well is perceived as an important burden for a number of drivers (24.5 %), which corresponds with the results of the survey question addressing criteria important for water-tanker operators in selecting their preferred private well (cf. section 4.3.3.1). The fact that interviewees also refer to water shortages underlines what has been already carved out under the heading “physical quantity constraints” of the tanker water buying market (cf. section 4.3.1.1): There are indications that the buying market is characterised by excess demand. Also the problem of electricity breakdowns, mentioned by a few drivers (2.9 %), could be interpreted in that sense. Several drivers also complained about police penalties (8.8 %) and price competition among drivers (6.4 %).

Other negative business factors perceived by the interviewed drivers and not depicted in the figure are: Decreased tanker water demand during winter or within some years, business setback after Disi water conveyance[47], differences with the well owner, difficulties to park the truck close to the customers, penalties of rangers, illegal price increases by private wells during summer and fluctuating selling prices of well water. The latter confirms that there is price competition among private wells (cf. section 4.3.3.3) and a legal maximum on the sales price of (potable) water from private wells (cf. section 4.3.1.2).

Being asked about the most pressing business challenges, some drivers complained that they do not have a social and health insurance, that some customers delay their payment, and that there is no professional association for drivers.

[47] Water supply project in Jordan completed in 2013. 100 MCM of water is pumped per year from the Disi aquifer in southern Jordan and northwestern Saudi Arabia to Amman and other cities in the north of Jordan to cover increased water demand (cf. https://en.wikipedia.org/wiki/Disi_Water_Conveyance, accessed 11 April 2017).

According to the interviewed drivers, the tanker water business developed as follows over the last years: The number of private wells, the number of water-tankers, the size of the water-tankers, the competition between drivers and the waiting time at the wells increased. The appearance of mobile phones significantly changed the business in the sense that customers no longer come in person to inner-city waiting stations but instead call water-tankers on the phone.

The majority of interviewed drivers (85.7 %) stated that the business negatively changed after the Disi water conveyance (n = 300) because tanker water demand decreased. One respondent pointed out that this negative effect on the business only lasted for three years. After that, the situation changed to become more positive again.

4.4.3.2 Sales policy of private tanker water operators

To increase competitiveness and to maximise profit private tanker water operators have strong incentives to deliver water of high quality (cf. section 4.3.3.1) and to perform well in terms of service provision. Important competition parameters and sales policy measures (beyond water quality) as identified by the *tanker drivers survey* are: reduction of delivery times, coordination of types of customers, truck sizes and sales quantities, price differentiation and offer of payment schemes. These will be described in detail in the following. The empirical results of the survey gave no evidence that the drivers use advertising and marketing strategies.

a) Delivery times

Water-tanker drivers aim to reduce delivery times by choosing wells that are close to customers, close to their own residence and easy to access (cf. section 4.3.3.1). According to the *tanker drivers survey*, customers have to wait between 0.25 and 7.00 hours from request to delivery in summer (mean: 1.95; n = 296) and between 0.17 and 3.00 hours (mean: 1.10; n = 298) in winter. Another sales policy measure to react very quickly to unexpected customer requests is to fill the tanker at the well and to park the tanker truck temporarily at so-called waiting stations within the city (cf. section 4.4.2.1).

b) Types of customers

The survey reveals that the drivers serve five different types of customers (with decreasing frequency): Commercial establishments, construction sector, private households, agriculture sector and public sector. The most common customers of tanker water are commercial establishments and the construction sector (cf. Figure 4.24).

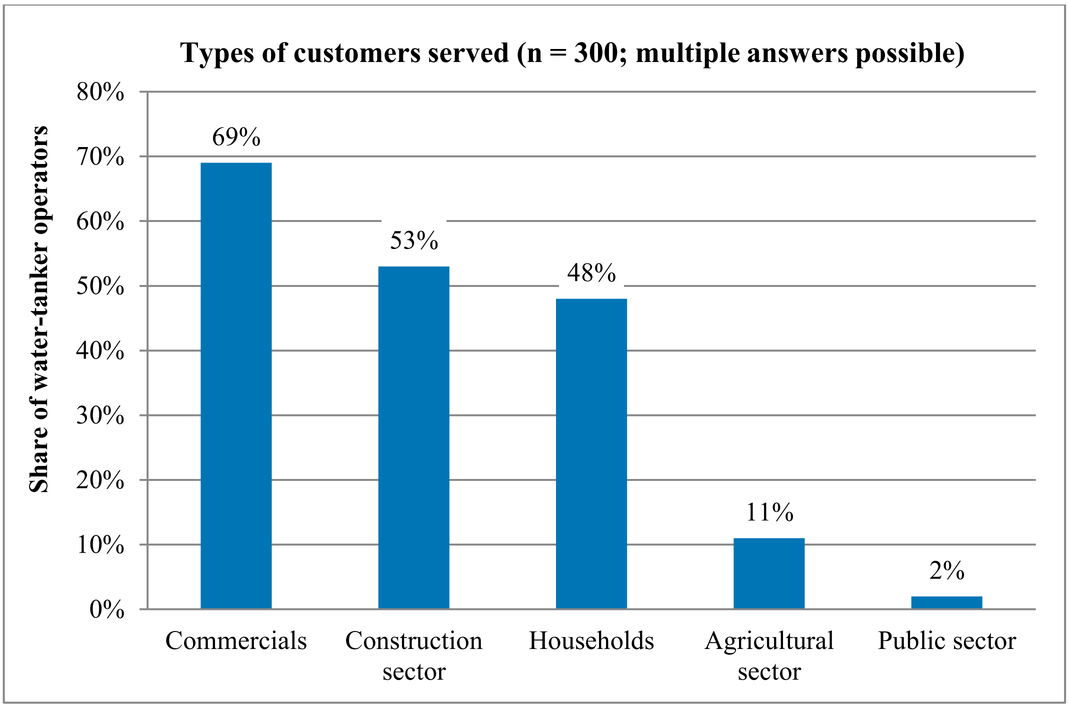


Figure 4.24: Types of customers served by private water-tanker operators (Source: Own tanker drivers survey)

In the majority of cases (47.7 %) the drivers serve two different types of customers (cf. Table 4.23).

Table 4.23: Number of types of customers served (Source: Own tanker drivers survey)

	Number of types of customers served	Frequency	Percent
Valid	1	107	35.7
	2	143	47.7
	3	45	15
	4	4	1.3
	5	1	0.3
	Total	**300**	**100**

c) Truck sizes

Water-tanker operators can select between different tanker truck sizes. Within the *tanker drivers survey* a large variety of tanker truck sizes between 3 and 22 cubic meter (mean: 11.3; n = 299) were identified (cf. Figure 4.25).[48] Most common are tanker trucks with a capacity of 6 or 20 cubic meters. Tanker trucks of size 17 cubic meter could not be identified.

[48] Occasionally truck sizes were also indicated in 0.5 m^3 intervals. These values were rounded up for the frequency graph.

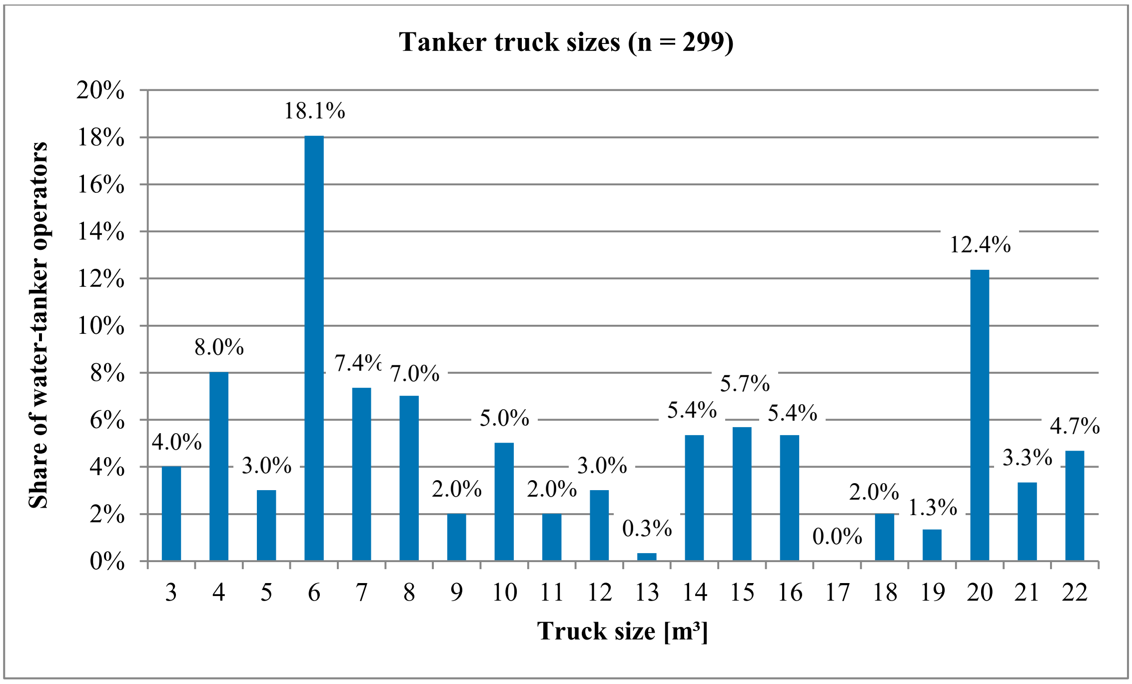


Figure 4.25: Tanker truck sizes (Source: Own tanker drivers survey)

The *tanker drivers survey* suggests that truck sizes correspond to the types of customers served. The following figure illustrates mean tanker truck sizes of drivers who are selling their water to only one type of customer (n = 105), namely households, commercials, the construction sector or the agricultural sector. Accordingly, households are supplied by smaller trucks than commercial establishments which reflects the different levels of consumer demand.

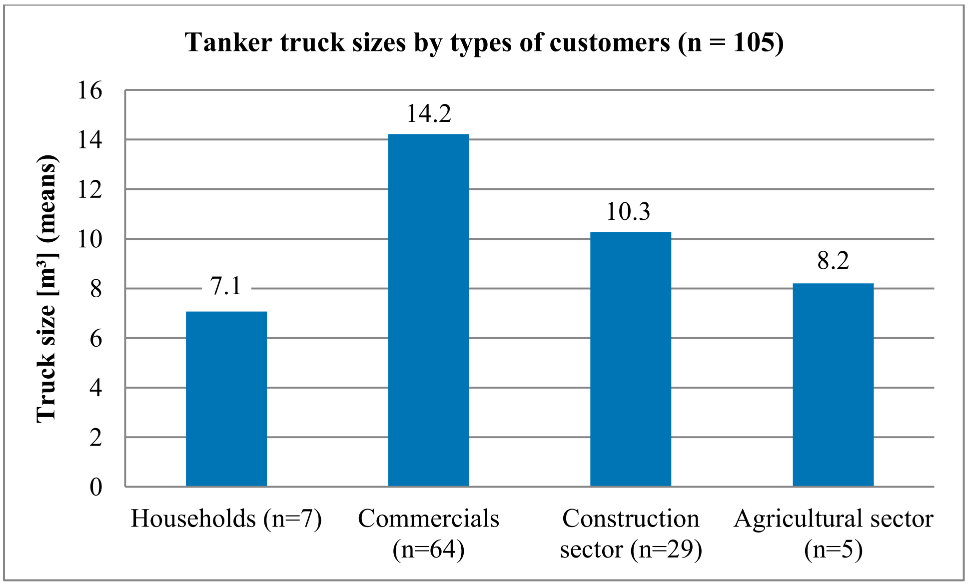


Figure 4.26: Tanker truck sizes by types of customers served (Source: Own tanker drivers survey)

d) Sales quantities

The tanker water quantities sold can be calculated from the survey data on the basis of the number of trips the drivers make per day, the capacity of the trucks and the number of working days per week. The following table shows the identified number of rides per day for summer, winter and during the busiest days. There is a large seasonal difference with a seasonality factor of 1.84 between summer and winter. During the busiest days the drivers make up to 20 rides per day or rather 5.7 rides per day on average.

Table 4.24: Rides per day (Source: Own tanker drivers survey)

Rides per day	N	Minimum	Maximum	Mean
Summer	300	1	14	4.6
Winter	300	0	11	2.5
Busiest days	299	1	20	5.7

Below, the sales quantities are calculated by multiplying the number of rides per day with the capacity of the trucks and the number of working days per week, which are assumed to be 7 for all drivers (cf. Table 4.25). According to that, the seasonal ratio of sales quantities is 1.75.

Table 4.25: Amount of tanker water sold (Source: Own tanker drivers survey)

Amount of tanker water sold [m^3/week]	N	Minimum	Maximum	Mean
Summer	299	21	2156	357.5
Winter	299	3	1694	203.3

The drivers were also asked about the quantity shares of different types of customers. The results show that 73 % of Amman‘s tanker water is delivered to commercial establishments and the construction sector and 21 % is delivered to private households (cf. Figure 4.27).

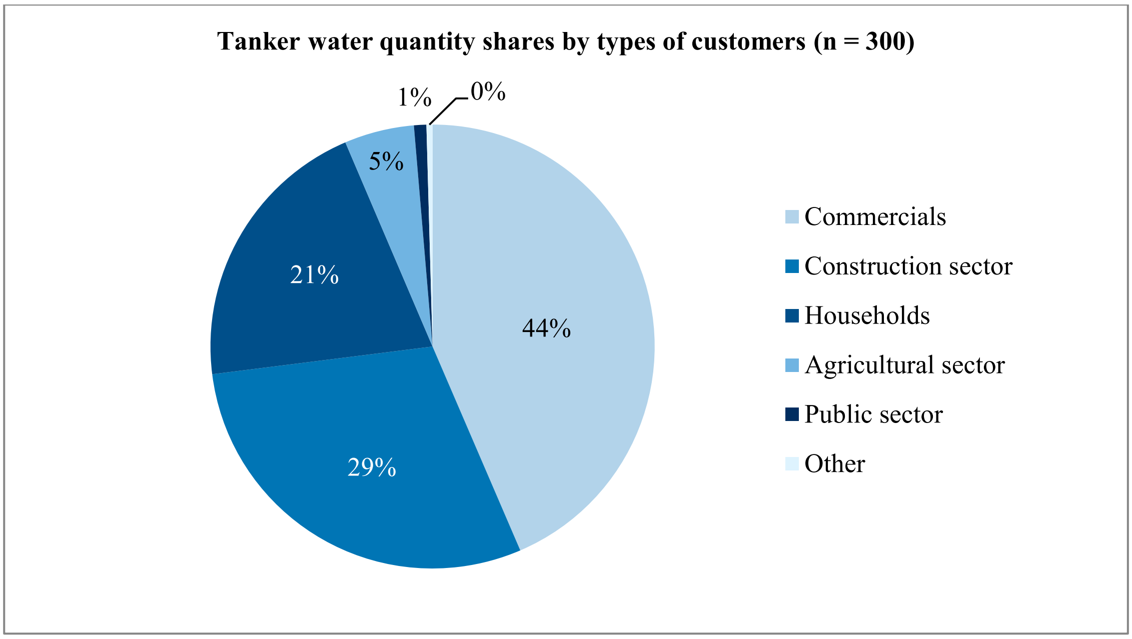


Figure 4.27: Tanker water quantity shares by types of customers (Source: Own tanker drivers survey)

e) Price differentiation

According to the *tanker drivers survey*, the sales prices of tanker water exhibits high variability with prices ranging from 1.520 to 6.250 JD per cubic meter in summer and 1.350 and 5.000 JD per cubic meter in winter (cf. Table 4.26 and Figure 4.28).

Table 4.26: Tanker water sales prices in summer and winter (Source: Own tanker drivers survey)

Tanker water sales prices [JD/m^3]	N	Minimum	Maximum	Mean	Mean (volume-weighted)
Summer	286	1.520	6.250	2.773	2.483
Winter	285	1.350	5.000	2.497	2.267

The prices determined here are slightly higher than those in the literature for Amman, although the latter are already several years old. According to Gerlach and Franceys (2009, p. 437), the price for tanker water for households is between 0.9 and 3.0 JD per cubic meter (mean: 2.065) derived from a survey. Rosenberg *et al.* (2008, p. 493) indicate prices from 1.5 to 4.3 JD per cubic meter (mean: 2.4) determined from driver interviews.

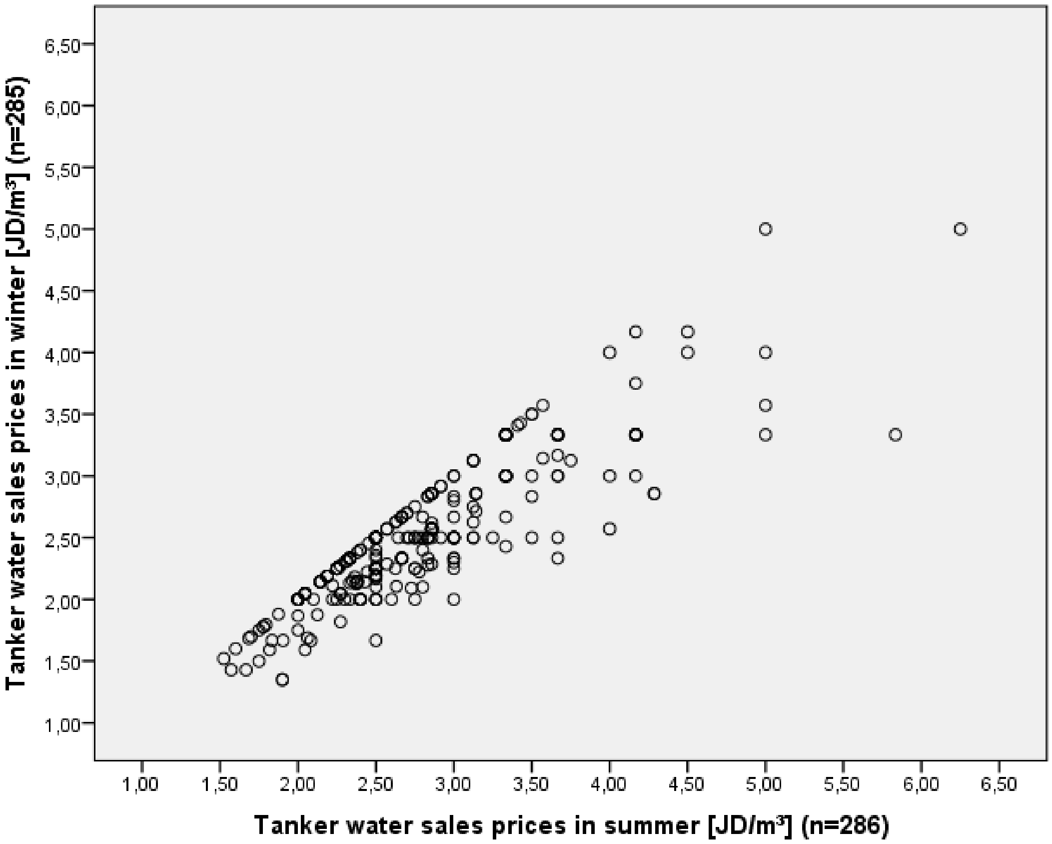


Figure 4.28: Tanker water sales prices in summer and winter (Source: Own tanker drivers survey)

The majority of drivers (62.1 %) set higher prices in summer, the remaining (37.9 %) sell the water at the same price throughout both seasons (n = 285). Accordingly, mean sales prices are slightly higher in summer than in winter. The maximal seasonal price difference as identified by the survey was 2.50 JD per cubic meter.

The fact that tanker water sales prices are higher in summer compared to winter is an indication that private tanker water operators pursue a demand-oriented prices policy. In some interviews, drivers have confirmed that they base their selling price on market prices and competition. Correlation between tanker water sales prices and well water purchase prices (cf. section 4.3.3.3) is rather low with a Pearson coefficient of 0.129 in summer and 0.188 in winter.

The frequency distributions show that several drivers (15.4 % in summer; n = 286) (15.1 % in winter; n = 285) set a tanker water sales price of 2.500 JD per cubic meter. This provides some support for the existence of a regulated tanker water target sales price of 2.500 JD per cubic meter which is not strongly enforced (cf. section 4.4.1.2).

The data also indicates that tanker water sales prices are negatively correlated with truck size, with a Pearson correlation of –0.482 in summer and –0.440 in winter. As truck sizes correspond with the types of customers served, it can be assumed that small consumers (private households) pay higher prices for tanker water than bulk consumers (commercials). This is confirmed by the following figure which shows mean tanker water sales prices of drivers serving only one type of customer (n = 105), differentiated between summer and winter.[49] Accordingly, commercials pay significantly lower prices for tanker water than households with a maximum mean price difference of 0.507 JD per cubic meter in summer. Also Gerlach and Franceys (2009, p. 437) state, based on a tanker driver survey, that tanker water drivers sell their water more cheaply to commercials than to households.

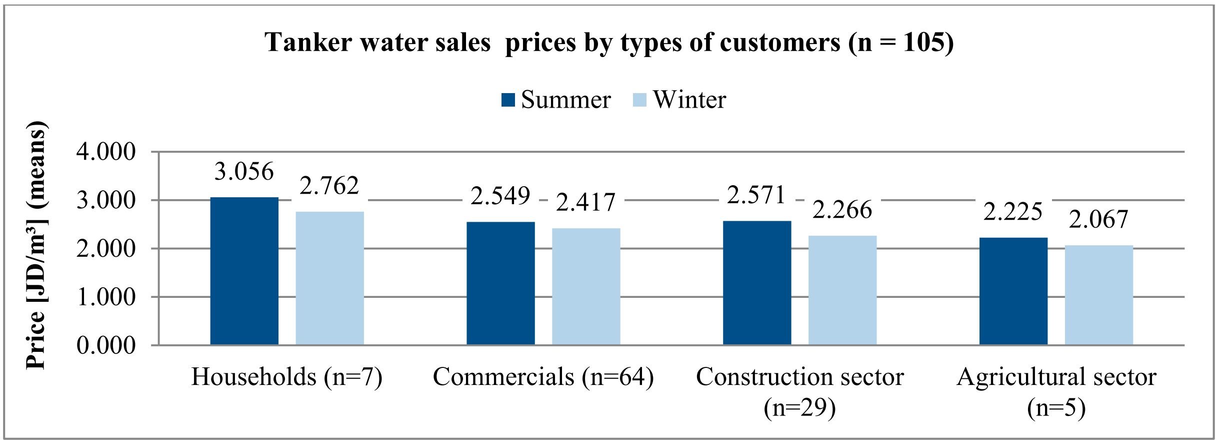


Figure 4.29: Tanker water sales prices by types of customers (Source: Own tanker drivers survey)

The mean tanker water sales prices for commercials (summer: 2.549 JD per cubic meter; winter: 2.417 JD per cubic meter, cf. Figure 4.29) are very similar to the mean purchase prices for commercial establishments according to the *commercials survey* (cf. section 4.2.1.3). For both seasons, they lie between the non-volume-weighted mean and volume-weighted mean. Unlike the *commercials survey*, the results here point to a significant price difference between summer and winter for all types of customers, however, for households much more than for commercials.

Presumably the drivers differentiate their prices not only depending on sales quantities and the usual types of customers but also on other customer-specific characteristics. For example, a vast majority of drivers (89.8 %) reported to have regular customers (n = 285). Some also explicated that prices are customer-specific and fixed (probably based on a contract) and that they give a discount for regular customers.

f) Payment schemes

According to the *tanker drivers survey*, there are different modes of payment between drivers and customers (cf. Table 4.27): cash and non-cash as well as payments within distinct periods. This can be interpreted as a financial service provided by the drivers to be more competitive. The most common payment scheme between drivers and customers is cash monthly (78.4 %), the same as between private well operators and drivers (cf. section 4.3.3.3). Other modes of payment include for example payments “every 10 days” or “every 5 rides” or “no payment scheme” because the drivers are operating a truck which is owned by a private company.

[49] In this figure the underlying data for the tanker water prices are not volume-weighted.

Table 4.27: Modes of payment between water-tanker drivers and customers (Source: Own tanker drivers survey)

	Answers coded	Frequency	Percent	Valid Percent
Valid	Cash monthly	232	77.3	78.4
	Cash immediately	27	9	9.1
	Monthly payment	22	7.3	7.4
	Other	10	3.3	3.4
	Cash weekly	5	1.7	1.7
	Total	296	98.7	100
Missing	no response	4	1.3	
Total		**300**	**100**	

4.4.3.3 Cooperation

The *tanker drivers survey* gives no evidence that there are contractual cooperation agreements or strategic alliances between drivers. The fact that the tanker water business is mostly operated by individual employers who typically own only one or very few trucks (cf. section 4.4.2.2) facilitates competition. Correspondingly, the vast majority of interviewed drivers (94.7 %) stated to be in active competition with other drivers (n = 300). In addition, most of the interviewees (89.0 %) stated to cooperate with other truck drivers (n = 300). A typical form of cooperation is that truck drivers forward customer requests to other drivers in case that they are too busy or not available. Some drivers reported that they sometimes buy/sell water from/to other drivers. This means that private tanker water operators sometimes also act as intermediaries. All in all, the survey suggests that the selling market of tanker water is predominantly competitive and without larger monopolistic structures.

4.4.4 Market performance

When compared to the buying market as described in section 4.3, the selling market of private tanker water exhibits two important differences. On the one hand, market access seems to be less restricted. On the other hand, price levels are less influenced by regulation.

The arguably largest hurdle for market entry as a seller of tanker water is the costs of a tanker truck, which vary considerably according to the load capacity of the vehicle. Other entry barriers, such as a one-time fee for starting a tanker business or the transport license seem to have little restrictive effects. This results in a market shaped by a large number of suppliers that are either self-employed truck owners or employees of a small business.

Although there are recommendations by WAJ concerning tanker water sales prices, these do not seem to be enforced. Thus, strong differences in end-user prices can be observed which include seasonal variations, as the demand for tanker-provided water increases during the summer months. Together with the aforementioned scarcity of tanker water, this results in higher summer prices when compared to the winter months. The seasonal differences indicate that the tanker pricing policy is demand-oriented. In addition, prices are negatively correlated with the size of the truck in which the water is delivered, which produces different prices among water user groups such as households, commercial establishments and construction sites. Residential water consumers, for instance, purchase water from smaller trucks – most likely due to limited storage capacities – and therefore pay on average higher prices per unit.

Together, both factors, i.e. low market entry barriers and demand-oriented pricing, result in a market in which consumers can choose between a large number of competing tanker businesses which offer water from different wells. Therefore, conditions are favorable for full competition. As has been discussed in section 4.3, however, consumers choose their tanker water primarily based on its (perceived) quality, followed by the quality of service and only then the price levels. Thus, the selling market of private tanker water also includes characteristics of monopolistic competition because tanker water from different providers is a heterogeneous good.

5 Conclusions & Outlook

This report was concerned with tanker water operations in Amman, which emerged in the form of private suppliers of bulk water in response to network intermittency and excess water demands. Motivated by a review of relevant literature and based on own empirical data, we contributed a positive market analysis and evaluated private tanker water supply from a microeconomic perspective. The analyses we conducted and the conclusions on market efficiency derived were enabled by the results of three extensive surveys, the *well operators survey*, the *tanker drivers survey* and the *commercials survey*, implemented in Amman from September 2015 to January 2016.

Up to this date, this analysis is the first of its kind and constitutes the only comprehensive assessment of tanker water markets in Jordan known to us. This report provides information on the institutional and regulatory framework of tanker water markets in Jordan as well as key characteristics of both the supply and demand side players active in these markets.

In particular, we compiled existing knowledge on residential water uses in Jordan and contributed survey-based data and analyses on tanker water use in the commercial sector, which is the largest consumer of tanker-provided water in Amman. Our commercials survey revealed that three quarters of the surveyed establishments consume tanker water, and more than half use it as their only bulk water source.

For the market analysis, tanker water markets were divided into 'buying' and 'selling' markets to distinguish between the purchase of groundwater by tanker drivers at peri-urban wells and the transactions between the tanker drivers and the consumers of tanker water. In the (formal) *buying* market, both prices and available quantities are fixed by regulation and market entry is restricted. There is, however, evidence for illegal groundwater extraction for tanker water markets, where quantity and price regulation is absent. In the *selling* market of private tanker water, on the other hand, a high number of small businesses are active, pricing is demand-oriented and barriers to entry are lower. This results in spatial and seasonal differences in tanker water prices for end consumers.

This report and the data gathered in the surveys build the foundation for a number of publications concerned with different aspects of the tanker water market in Jordan. Zozmann *et al.* (2019) have used data from the commercials and tanker drivers survey to develop a spatially and seasonally differentiated simulation model of tanker water consumption in commercial establishments in the city of Amman. In an upcoming study, Klassert *et al. (in preparation, 2021b)* will present the results of an econometric commercial water demand function estimation based on the data gathered in the commercials survey. In a further paper currently in preparation, Klassert *et al. (in preparation, 2021a)* will apply a spatial price equilibrium approach within a country-wide coupled hydro-economic model in order to analyze the growing economic value of formal and informal tanker water markets for water-stressed consumers across all of Jordan.

Future research on tanker water markets

The research agenda regarding tanker water markets in Amman and Jordan as a whole is far from exhausted. Beyond the findings of this report and subsequent works derived from the data acquired, significant knowledge gaps remain. To name a few examples: up to this point, there has been no empirical analysis of the impacts of tanker water markets on sustainable urban water supply or *access to wate*r in Amman. This is also the case for the ongoing discussion on tanker water markets in the literature: There is a variety of contentions about alleged negative effects of private tanker water markets, associating these with welfare losses (Baisa *et al.* 2010; Srinivasan *et al.* 2010b), groundwater depletion (Venkatachalam, 2014), or concerns about equity and affordability of supply (Whittington, 1991). Yet, few of them are based on sound empirical evidence. Studies that attempt to evaluate the suainability implications of tanker water markets should analyze these as elements of a larger supply system. In particular, questions about welfare, equity and afforability should be analyzed conjuntively for both supply options. The close interrelation of both systems can be demonstrated with examples from this report: First, as discussed in Section 4.2.1, demand for tanker water is partially dependent on the unequally distributed network supply, i.e. those establishments with higher degrees of access consume more piped water quantities at lower prices and thus purchase less tanker water quantities. Second, most commercial consumers do not perceive piped and tanker water as close substitutes but base their consumption on preferences about specific characteristic of each service (e.g., quality). Third, certain water users, such as the bottled water shop, have to consume tanker water because they do not have the option to connect to the public network. Therefore, specific aspects of piped supply (e.g., coverage, supply duration, characteristics of service) clearly influence how much tanker water is consumed in which locations. In a similar way, concerns about groundwater overabstraction can hardly be attributed to tanker water markets alone, given that these are part of a larger system of water supply and use. In the case of Jordan, tanker water markets are merely one of several relevant users of groundwater, including agriculture, industry and public network supply. There is thus a need for a coherent and integrated water management. Notwithstanding, as we discussed, attempts to establish such a governance system may be impeded by the informal and decentral nature of tanker water markets. Overall, the discussion in the tanker water literature would profit from systematic economic analyses and the development of sustainability indicators to address the question of impacts on sustainable water supply more comprehensively.

Another potentially interesting avenue for further research could be the careful study and delineation of evidence for *informality* and *illegality* in tanker water markets. Both terms are used frequently and frivolously, for instance in discussions on groundwater extraction, but here once more a lack of sound empirical analyses inhibits informed conclusions and policy-making. While the inherent challenge of quantifying shadow economy activities might impede attempts to implement such a study, its relevance for groundwater management in Jordan could be significant nonetheless. Since the commercial sector is the largest consumer of tanker water in Jordan, it could be worthwhile to improve the current state of knowledge on commercial water use in general and tanker water use in particular. What is the contribution of tanker water to value creation in the commercial sector? Why do certain commercial establishments opt out of the piped network and how is this related to supply intermittency? The results presented in Section 4.2.1 of this report and in Zozmann *et al.* (2019) could, for instance, be complemented by a spatial-econometric model of commercial tanker water use based on the survey data to shed further light on this issue.

Despite the persistence of the aforementioned knowledge gaps, this report and the further research efforts based on it represent a leap forward in understanding tanker water markets in Amman. As such, it could prove to be an important resource for future discussions on sustainable urban water provision under conditions of water scarcity and supply intermittency.

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