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Supplying rural Kazakhstan with safe water and sanitation



# Supplying rural Kazakhstan with safe water and sanitation

Kamshat Tussupova



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DOCTORAL DISSERTATION

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<b>Title:</b> Supplying rural Kazakhstan with safe water and sanitation		
<b>Abstract</b> <p>Access to safe drinking water and sanitation is essential for both individual and population health as well as for quality of life and dignity. The UN Sustainable Development Goals (SDGs) require nations to ensure adequate water supply and sanitation for all. For Kazakhstan, this means that rural areas will need a much stronger attention as they have been rather neglected in efforts to comply with the previous UN Millenium Development Goals (MDGs). A new massive drinking water program in Kazakhstan has the aim to cover 80% of the rural people with access to tap water from a centralized piped system by 2020. This study aimed at establishing a foundation for a management system to better supply rural Kazakhstan with safe access to water and sanitation. The data collection included interviews with households in 37 villages in the Pavlodar area, Kazakhstan. The results can be seen as guidelines that can help to illuminate some of the uncounted challenges in future effort to meet the SDG targets in Kazakhstan as well as other similar areas in Central Asia.</p> <p>The study examined the current access to drinking water and sanitation services and willingness of people to pay to maintain the access to piped water in rural areas in Northern Kazakhstan, in order to establish a foundation for a water and sanitation management systems. The results show that there are several types of raw water sources and the most common one is private boreholes. Despite the efforts to provide people with potable water during the recently completed national water supply program there is still lack of access to tap water from the piped water supply system as well as access to a safe sanitation. And this can be explained by a lack of baseline data on access to water and sanitation. The baseline data reflecting the real situation in terms of water supply and sanitation are needed for targeting and designing the improvements. Another reason for failure of previous water supply programs is that interventions so far have been top-down. Furthermore, the responsible authorities need to appreciate that national drinking water programs need to be based on surveys of existing water and sanitation service as well as a shift to more bottom-up and Water, Sanitation and Hygiene oriented planning approaches. Results show that a majority of water source users want to connect to and pay for the maintenance of the piped water system and enjoy tap water at home. The study determined important determinants for the willingness to connect and pay; however, they are specific to each water user. Thus, integration of local water users is crucially important, since they are the beneficiaries of any water intervention program. This will show the actual need for any drinking water intervention and willingness to use and pay for the water supply systems.</p> <p>It will not be possible for Kazakhstan to reach 80% coverage of tap water from a centralized piped system to the rural people by 2020 according to the national water program whereas the safe access to WASH for rural people is the most important. In any case, considerable progress can only be made by carefully managing the existing water supply and sanitation system in joint collaboration with the local users. Hence, we see the present results as important first step in this direction.</p>		
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# Supplying rural Kazakhstan with safe water and sanitation

Kamshat Tussupova



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# Popular summary

Access to safe drinking water and sanitation is essential for both individual and population health as well as for quality of life and dignity. Improvement in water supply, sanitation, and hygiene has shown substantial influence on reduced water borne diseases such as diarrhoea. However, in 2015, 663 million people worldwide still lacked improved drinking water sources. The UN Millennium Development Goals (MDGs) for drinking water were achieved in 2010 on a global scale. However, several developing regions including Caucasus and Central Asia did not reach the MDG target. Moreover, with 2.4 billion still lacking improved sanitation facilities and 946 million practicing open defecation, the sanitation target was missed by almost 700 million people. Especially, there is a strong disparity between urban and rural populations. Eight out of ten people still without improved drinking water sources live in rural areas. The MDG progress report showed that the Kazakhstani urban population is by 90% covered by piped water on premises, while only 28% of the rural people have access to piped water. About 20% of the rural population in Kazakhstan have actually the same level of piped water coverage as sub-Saharan Africa.

The SDGs require nations to ensure adequate water supply and sanitation for all. For Kazakhstan, this means that rural areas will need a much stronger attention as they have been rather neglected in efforts to comply with the previous MDGs. A new massive drinking water program in Kazakhstan has the aim to cover 80% of the rural people with access to tap water from a centralized piped system by 2020. This study aimed at establishing a foundation for a management system to better supply rural Kazakhstan with safe access to water and sanitation. The data collection included interviews with households in 37 villages in the Pavlodar area, Kazakhstan. The results can be seen as guidelines that can help to illuminate some of the uncounted challenges in future effort to meet the Sustainable Development Goal targets in Kazakhstan as well as other similar areas in Central Asia.

The results show that there are several types of raw water sources and the most common one is private boreholes. Despite the efforts to provide people with potable water during the recently completed national water supply program there is still lack of access to tap water from the piped water supply system as well as access to a safe

sanitation. And this can be explained by a lack of baseline data on access to water and sanitation. The baseline data reflecting the real situation in terms of water supply and sanitation are needed for targeting and designing the improvements. Another reason for failure of previous water supply programs is that interventions so far have been top-down. Furthermore, the responsible authorities need to appreciate that national drinking water programs need to be based on surveys of existing water and sanitation service as well as a shift to more bottom-up and WASH oriented planning approaches. Results show that a majority of water source users want to connect to and pay for maintenance of the piped water system and enjoy tap water at home. The study determined important determinants for the willingness to connect and pay. However, these are specific to each water user. Thus, integration of local water users is crucially important, since they are the beneficiaries of any water intervention program. This shows the actual need for any drinking water intervention and willingness to use and pay for the water supply systems.

The study shows that it will not be possible for Kazakhstan to reach 80% coverage of tap water from a centralized piped system to the rural people by 2020 according to the national water program. Even so, the safe access to WASH for rural people is the most important. In any case, considerable progress can only be made by carefully managing the existing water supply and sanitation system in joint collaboration with the local users. Hence, we see the present results as important first step in this direction.

# Abstract

Access to safe drinking water and sanitation is essential for both individual and population health as well as for quality of life and dignity. The UN Sustainable Development Goals (SDGs) require nations to ensure adequate water supply and sanitation for all. For Kazakhstan, this means that rural areas will need a much stronger attention as they have been rather neglected in efforts to comply with the previous UN Millennium Development Goals (MDGs). A new massive drinking water program in Kazakhstan has the aim to cover 80% of the rural people with access to tap water from a centralized piped system by 2020. This study aimed at establishing a foundation for a management system to better supply rural Kazakhstan with safe access to water and sanitation. The data collection included interviews with households in 37 villages in the Pavlodar area, Kazakhstan. The results can be seen as guidelines that can help to illuminate some of the uncounted challenges in future effort to meet the SDG targets in Kazakhstan as well as other similar areas in Central Asia.

The study examined the current access to drinking water and sanitation services and willingness of people to pay to maintain the access to piped water in rural areas in Northern Kazakhstan, in order to establish a foundation for a water and sanitation management systems. The results show that there are several types of raw water sources and the most common one is private boreholes. Despite the efforts to provide people with potable water during the recently completed national water supply program there is still lack of access to tap water from the piped water supply system as well as access to a safe sanitation. And this can be explained by a lack of baseline data on access to water and sanitation. The baseline data reflecting the real situation in terms of water supply and sanitation are needed for targeting and designing the improvements. Another reason for failure of previous water supply programs is that interventions so far have been top-down. Furthermore, the responsible authorities need to appreciate that national drinking water programs need to be based on surveys of existing water and sanitation service as well as a shift to more bottom-up and Water, Sanitation and Hygiene oriented planning approaches. Results show that a majority of water source users want to connect to and pay for the maintenance of the piped water system and enjoy tap water at home. The study determined important determinants for the willingness to connect and pay; however, they are specific to each water user. Thus, integration of local water

users is crucially important, since they are the beneficiaries of any water intervention program. This will show the actual need for any drinking water intervention and willingness to use and pay for the water supply systems.

It will not be possible for Kazakhstan to reach 80% coverage of tap water from a centralized piped system to the rural people by 2020 according to the national water program whereas the safe access to WASH for rural people is the most important. In any case, considerable progress can only be made by carefully managing the existing water supply and sanitation system in joint collaboration with the local users. Hence, we see the present results as important first step in this direction.

# Thesis content

This doctoral thesis consists of a summary and five papers. The papers are referred to as Papers I to V in the summary text and are appended at the end of the thesis:

**Paper I:** Bekturganov, Z., **K. Tussupova**, R. Berndtsson, N. Sharapatova, K. Aryngazin, and M. Zhanasova, (2016), **Water related health problems in Central Asia - a review**, *Water*, 8, 219; doi:10.3390/w8060219.

**Paper II** Tussupova, K., P. Hjorth, and R. Berndtsson, (2016), **Access to drinking water and sanitation in rural Kazakhstan**, *International Journal of Environmental Research and Public Health*, 13(11), 1115; doi:10.3390/ijerph13111115

**Paper III:** Tussupova, K., and P. Hjorth. **Enabling full access to safe drinking water and sanitation in rural Kazakhstan: A Major SDG challenge**, submitted to *Journal of Water and Health*.

**Paper IV:** Tussupova, K., R. Berndtsson, T. Bramryd, and R. Beisenova (2015), **Investigating willingness to pay to improve water supply services: application of contingent valuation method**, *Water*, 7, 3024-3039; DOI:10.3390/w7063024.

**Paper V:** Tussupova, K., **Determinants of willingness to pay for improved water supply services in rural Kazakhstan**, manuscript.

The co-authorship of the papers reflects the collaborative nature of the underlying research. Kamshat Tussupova (KT) designed and executed the survey by creating, distributing and collecting the questionnaire, analysed the initial results, and wrote the first draft of the papers II, III, IV and V. Co-authors contributed by adding comments and writing parts of the final paper. In paper I, KT planned and wrote the first version of the paper.

## Other related publications

### Conference abstracts:

1. **K. Tussupova**, R. Berndtsson, and T. Bramryd., June 2014, International Association of Hydrological Sciences conference: “Evolving Water Resources Systems – Understanding, Predicting, and Managing Water-Society Interactions”, Bologna, Italy, *Indicators for consumers’ willingness to pay to improve water supply services in Kazakhstan* ([http://distart119.ing.unibo.it/bo2014/Book\\_Abstract.pdf](http://distart119.ing.unibo.it/bo2014/Book_Abstract.pdf)).
2. **K. Tussupova**, R. Berndtsson, and T. Bramryd, June 2015, 9<sup>th</sup> World Congress on “Water Resources Management in a Changing World: Challenges and Opportunities”, organized by European Water Resources Association, Istanbul, Turkey, *Willingness to pay to improve water supply services in rural Kazakhstan: application of Contingent Valuation Method*.
3. **K. Tussupova**, August 2015, Final Colloquium, Young Scientists Summer Program, IIASA, Laxenburg, Austria, *Consumers’ willingness to pay to improve water supply services in rural Kazakhstan*

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# 1. Introduction

Access to safe drinking water and sanitation is essential for both individual and population health as well as for quality of life and dignity. Improvement in water supply, sanitation, and hygiene has shown substantial influence on reduced water borne diseases such as diarrhea (Bartram and Cairncross, 2010). However, in 2015, 663 million people worldwide still lacked improved drinking water sources (UN, 2015; WHO, 2015). The UN Millennium Development Goals (MDGs) for drinking water were achieved in 2010 on a global scale. However, several developing regions including Caucasus and Central Asia did not reach the MDG target. Moreover, with 2.4 billion still lacking improved sanitation facilities and 946 million practicing open defecation, the sanitation target was missed by almost 700 million people. Especially, there is a strong disparity between urban and rural populations. Eight out of ten people still without improved drinking water sources live in rural areas. The MDG progress report showed that the Kazakhstani urban population is by 90% covered by piped water on premises, while only 28% of the rural people have access to piped water. About 20% of the rural population in Kazakhstan have actually the same level of piped water coverage as sub-Saharan Africa (UN, 2015; WHO, 2015).

The UN MDGs have now developed into the UN Sustainable Development Goals (SDGs) (UN, 2016). The SDGs present a continuation of the MDGs and a road map for how to ensure sustainable social and economic progress worldwide. Thus, the SDGs seek not only to eradicate extreme poverty but also to integrate the three dimensions of sustainable development. An important difference between the MDGs and the SDGs is the change from a top-down to a bottom-up approach and full coverage with water providing WASH (water, sanitation, and hygiene) for all by 2030, (UN, 2016; Sachs, 2012) Thus, the SDGs emphasize the gender goals, people's participation, and as well local governance as a way to reach sustainable development. The well-established links between poor sanitation and poor health mean that water supply must be viewed in connection with sanitation, and hygiene promotion as a coherent whole (WASH) (Allen et al., 2006; Paper IV)

Kazakhstan is a former Soviet Republic that is transitioning from state planned to market economy. This transition is changing patterns of basic services such as water and sanitation. The Soviet Union sought to tackle the desperate living conditions that the major part of the population suffered from in the early twentieth century by expanding access to essential services such as piped water. However, when the

Soviet Union broke apart in 1991, many people, especially in rural areas that historically have been disadvantaged, still had limited access to drinking water. Since then, the situation has not improved much. Important elements of the state apparatus have been dismantled, leading to shortages of basic goods and services while the economic crisis has reduced funds that could otherwise have been used to invest in basic infrastructure for water and sanitation. During the transition from a state planned to a market economy, existing water supply systems have deteriorated due to lack of maintenance (McKee et al., 2006; OECD EAP, 2006).

Information on access to drinking water and sanitation is based on official Kazakhstani statistics, data from the Joint Monitoring Program, and case-studies provided by different researchers. According to McKee et al. (2006), 17.3% of the rural Kazakhstani population had access to piped water at home and 50.3% used water from public standpipes in 2001. The same survey showed that 92.2% of rural people had toilets outside the home, 7.5% inside the home, and 0.3% did not have access to toilet. According to UNDP (UNDP, 2006), the rural share of population corresponds to 43% and only 36% of them have access to centralized water supply, 57.3% use groundwater (wells and boreholes), 2.6% use water from surface sources, and 4% drink delivered water. Previous studies have shown that only 2.8% of rural houses are connected to the sewage system. About 5% have in-house toilets, including 1.7% with toilets connected to local sewage systems, mostly wet pits (UNDP, 2006). This shows that the sanitation level in rural Kazakhstan is low.

Recent research has shown that there have been no significant changes in patterns of access to piped water during the period from 2001 to 2010 in neither rural nor urban areas in Kazakhstan (Roberts et al., 2012). In rural areas, the access to piped water remains about 29%. This situation is surprising because a massive governmental drinking water program for the rural areas was launched from 2002 to 2010 (Drinking Water Program, 2002). In any case, there is an urgent need to improve the water supply and sanitation conditions for rural areas in Kazakhstan. In addition, if rural water projects are to be both sustainable and replicable, an improved planning methodology is required that includes peoples' desire to use different levels of services (Whittington et al., 1990). In particular, the people's participation is crucially important.

A new massive drinking water program in Kazakhstan has the aim to cover 80% of the rural people with access to tap water from a centralized piped system by 2020 (Water Program, 2011). Before executing such large-scale water supply projects, it is important to assess the current situation on the access to drinking water and sanitation services as well as whether people are willing to accept the new system or not (Whittington et al., 1990). For this purpose, it is important to establish a comprehensive base line data on current access to drinking water and sanitation before any major water intervention. In view of this, the present study examines and

quantifies the current access to drinking water and sanitation services and willingness of people to pay to access to piped water in rural areas of the Pavlodar region, Northern Kazakhstan. The objectives of the study were:

A) What is the actual access to drinking water sources and sanitation services in situ? To what extent does it differ from the official statistics?

B) What are the indicators and to what extent do they influence rural peoples' willingness to pay (WTP) to improve drinking water services, particularly regarding access to piped water?

C) What are the drinking water and sanitation management solutions that can be used to provide water, sanitation, and hygiene (WASH) for all?

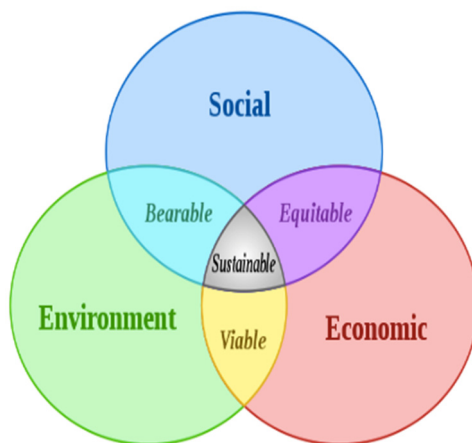
The appended thesis papers address the above objectives. Paper I (part 4 and 5, part of discussion, and conclusion in the paper) gives a literature review, assessing the background problems of water supply systems and some water related health problems in Central Asia that are also relevant for the investigated area. Paper II and III contribute to objective A), showing the access to drinking water and sanitation in situ, discrepancies in official statistics, and the real situation based on questionnaires. Paper II, IV and V investigate indicators and assess the WTP for piped water and contribute to objective B). Paper III and V contribute to objective C), offering possible solutions to improve the access to drinking water and sanitation, providing WASH for all.

The results are important since they can be used to predict the willingness to connect to public water supply and sanitation systems. Consequently, the results in this thesis are important for the planning, policy development, as well as the management of new drinking water and sanitation programs in order to include local users in this important process.

## 2. Methodology

### 2.1. Conceptual framework

The conceptual approach used in the present study is based on the sustainable development model. Several definitions exist for the term sustainable development. An important landmark in this direction are the ideas put forward in the Brundtland Commission Report (BCR, 1987). According to BCR, "...Sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations". This definition is quite broad and somewhat vague. It is best stated by Solow: "- sustainability is an essentially vague concept and it would be wrong to think of it as being precise, or even capable of being made precise" (Solow, 2000). Sustainability is intimately connected to the quality of life in a community. This means the economic, social, and environmental systems that constitute the community and provide a healthy, productive, meaningful life for all present and future community residents (Fig. 1)



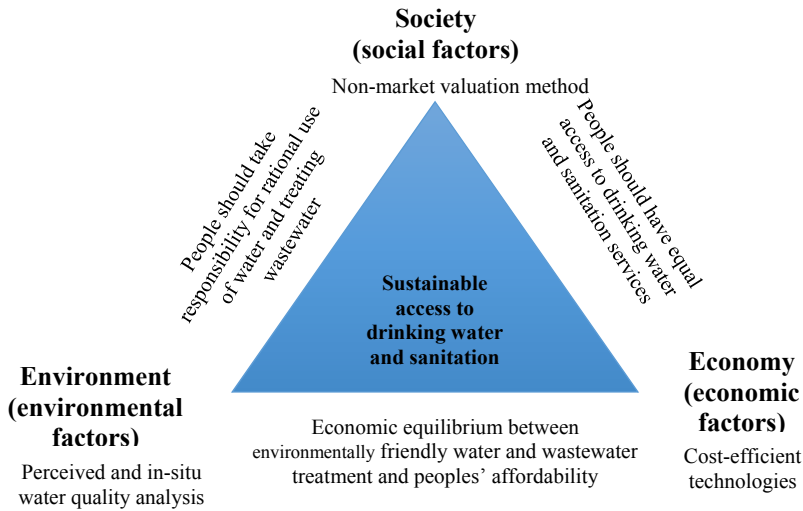
**Figure 1.** Relationships between the main systems of a sustainable development model.

According to the above, the research framework used in the present thesis is visualized in Fig. 2. The figure shows the relationship between society, environment, and economy and principles implied in order to provide the sustainable access to drinking water and sanitation services. The theoretical framework considers investigating water resources from an environmental perspective namely, availability, accessibility, and quality in situ. The investigation of social aspects includes people's involvement, their actual access to drinking water and sanitation services, satisfaction with the existing water source, and willingness to improve the access. The investigation of economic factors helps to find the appropriate management and technology choice to provide water and sanitation services for all based on the societal choices and available water options. Thus, the theoretical background included the following steps of analyses:

- Access to drinking water supply and sanitation services
- In situ and perceived water quality
- Societal preferences in terms of water supply and sanitation based on the WTP for connection to tap water
- Technological choices for water and sanitation provision based on peoples' preferences and availability of water sources

Due to practical constraints, the study focused on social aspects and to some extent, economic aspects.

Sustainable water supply and sanitation mean that everybody has access to acceptable and affordable services. It also implies that the various actors have well-defined and well-coordinated responsibilities for the operation and maintenance of the systems. The management system should be transparent and accountable in this respect.



**Figure 2.** The sustainable drinking water supply research framework used in the present thesis with relationships between the environmental, social, and economic systems.

## 2.2. Data collection methodology

An initial literature review was done to investigate the current problems with water supply and water related health problems. Further literature surveys focused on interview design and included the following steps of data and information collection:

- *Focus group discussions (FGD) with professionals in the field and interviews of two village mayors.* FGD with professionals who maintain water supply and sanitation systems showed the main benefits for them as workers and for people using different water supply methods. The discussions indicated what are the disadvantages/advantages or obstacles using the present systems of water supply and sanitation. Local mayors shared information regarding the payment and monitoring systems for water supply. This knowledge helped to develop the pilot study questionnaire on WTP.

- *Pilot study - contingent valuation (CV) survey on WTP for improved water services.* This was an open interview with village people on their opinion and the level of satisfaction on water supply and sanitation services that they are provided with. The survey helped to define possible determinants of WTP for piped water and testing the CV survey.
- *Survey of WTP for piped water. Interviewing village people regarding their satisfaction with the present water and sanitation supply systems.* The survey displayed the actual access to and the level of satisfaction with drinking water and sanitation services. In a later stage, results were compared to official statistics, and defined the main determinants of WTP.

Focus group discussions and visits to local mayors took place in September 2010. All interview surveys were performed between October 2011 and August 2013.

#### *Data collection for the pilot study*

The pilot study survey was performed between October 2011 and January 2012 in eleven randomly selected villages of the Pavlodar region, where 10 villages were from the investigated area and one village from a neighboring region, Maiskiy. In total, 168 questionnaires were completed and included in the survey analysis. Since the villages are of different size, each household was chosen randomly so that at least half of the respondents would live in four different directions outside of the central part of the village.

Face-to-face interviews with the heads of households were conducted in the respondents' homes. Standardized questions regarding socio-economic and demographic characteristics, existing drinking water sources and their characteristics, trust regarding water source types, and direct open-ended and bids questions on WTP were used.

The question asked was: *How much is your household willing to pay monthly for the maintenance of a private connection and 24 hour a day access to potable water?*

The contingent valuation (CV) method was used to identify WTP for individual water connection and public standpipe. (Table 1). Across the questionnaire, two types of questions were asked. The first, open-ended, directly asked about the maximum amount(s) (s)he would be willing to pay for the proposed water supply improvement. The second was a bidding game, when households were asked different prices until settling at a maximum offered price. The reason for having these two question formats was to see whether respondents react similar regardless of type of asked question.



Table 1. CV scenario and the choice of elicitation procedure.		
Type of elicitation procedure	CV scenario for public standpipe	CV scenario for private connection
Open-ended maximum WTP	If water is provided for your village with public standpipes on each street and unlimited potable water supply at any time of the day, how much would your household be willing to pay each month?	Besides the use of water from the public standpipe you can have private connection, that is, the water will be in your house. You will not be able to sell water or use it for watering the garden. If you do not pay a monthly fee, your private connection will be disconnected. How much would your household be willing to pay monthly for the maintenance of a private connection and 24 hour access to potable water?
Closed end bidding game	How much would your household be willing to pay 100, 200, 500, 700 or 1,000 KZT* a month for maintaining the standpipe in your district?	Suppose your household pays for the installation of individual connection (taps at home) and there are already public standpipes so that everyone will have at their disposal good drinking water. Would your household be willing to pay 300, 500, 1,000, 1,500 or 2,000 KZT* each month to have a private connection and 24 hour access to potable water?

\*150 KZT = 1 US\$ (as of January 2012)

The split-sample experiment was incorporated in the research design; three different bidding games with different starting points were randomly assigned to the respondents in the study. All three bidding games were evenly distributed among the respondents in the survey. The purpose of the split-sample experiment was to test whether respondents' WTP would be influenced by the magnitude of the first price that they received and the sequence of follow-up questions.

The enumerators were specially trained students, following the principle that good enumerators make respondents feel comfortable and at ease. Therefore, the enumerator was not supposed to influence or convince the respondent's WTP by remaining quite neutral about answers. The enumerators were explained what the study was about, so that in case they would be able to explain what the maximum WTP is as well as to read slowly and clearly the questions. The detailed data methodology is explained in Paper II.

#### *Data collection for the main study*

The data from the pilot study helped to develop the main questionnaires on the WTP that were used in the main study. The interview survey for the main study was performed in the rural area around Pavlodar City. The area covers 5,578 km<sup>2</sup> and 37 rural villages. In total 27 rural villages of different size, were investigated in the survey conducted during July-August 2013. Thus, due to the participation of the 10 first villages in the pilot study, these were not included in the main survey.

Through the close collaboration with the local municipalities, a questionnaire was designed, distributed to all households in the 27 villages and consequently collected by the village mayors. Due to the local rules for performing interviews, this was a necessary manner to collect interviews. Depending on village, the households had from several days to a few weeks to answer the questionnaires. Interviews represent households and not individuals. Interviews were performed with the heads of the households. The answer rate was about 42% and ranging from 4% to 100% in each village. Altogether, 2,570 questionnaires covering 8,493 persons in the area were collected.

The questionnaire had three parts describing socio-economic characteristics of the household, access to drinking water and its perceived quality access to sanitation, and willingness to connect and pay to maintain the access to tap water at home (the questionnaire is shown in Paper V). The CV method was used to identify the WTP. The WTP questions were constructed in the form of payment cards, when the range of price options had been offered.

The objective of the data collection was to get an overall picture of the access to water supply and sanitation in a larger representative area, possible discrepancies between official statistics and the actual access, and to identify the determinants of WTP. The detailed data collection methodology is described in Paper III and V.

## 2.3. Data analysis

### *Pilot study analysis*

The data from the pilot study was analyzed to identify WTP to connect and maintain the access to piped water and its possible determinants. Mean WTP was calculated according to:

$$E[WTP] = \Pr_{(Zero)} \cdot 0 + E(WTP_{WTP>0}) \cdot \Pr_{(Positive)} \quad (1)$$

where

$\Pr_{(Zero)}$  is the probability that a respondent has zero WTP

$\Pr_{(Positive)} = 1 - \Pr_{(Zero)}$  is the probability that a respondent has a positive WTP

$E(WTP_{WTP>0})$  is the mean WTP for the positive WTPs

Binary logistic regression commands in the SPSS software were used to find the maximum likelihood estimation of the independent variables (determinants) as regards lower and higher bids (lower and higher WTP) according to:

$$\ln(WTP) = \ln\left[\frac{Pr}{(1 - Pr)}\right] = a + bX \quad (2)$$

where

$a$  and  $b$  are constants and  $bX$  is consumer index.

### *Main study analysis*

Descriptive statistics and regression were used to analyze data from the main study. For this purpose, the SPSS software was used to get an overview of the access to drinking water and sanitation services, their perceived characteristics as well as to describe the socio-economic and demographic characteristics of the households in the area.

During initial data analyses, one of the villages was removed from further analysis. The excluded village used to have access to piped water in the past. However, currently people use different water sources and almost no one in the village wants to pay for and use tap water at home. A sensitivity analysis showed that this village significantly affected the overall regression analysis.

Binary logistic regression in the SPSS software was used to find the maximum likelihood estimation of the independent variables (determinants) as regards willingness to connect and pay and not to pay according to Eqn. (2).

In order to estimate the WTP all respondents among different water users were split in to three categories: those who will not pay, those who will pay little amount (below 600 KZT), and those who will pay higher amount (above 600 KZT). Ordered regression in the STATA software was used to estimate the WTP among different water users according to:

$$y^* = \mathbf{x}'\beta + \varepsilon = \begin{cases} 0 & \text{if } y^* \leq 0 \\ 1 & \text{if } 0 \leq y^* \leq 600 \\ 2 & \text{if } 600 \leq y^* \end{cases} \quad (3)$$

where  $\mathbf{x}'\beta$  is consumer index.

# 3. Experimental area

## 3.1. Overview of water in Kazakhstan

The Republic of Kazakhstan, a former member of the Union of Soviet Socialist Republic, became independent on December 21 1991. Kazakhstan is the 9<sup>th</sup> largest country in the world with a wide variety of climate and physiographical features. The about 17 million people country borders Russia to the north, China to the east, Kyrgyzstan and Uzbekistan to the south, and Turkmenistan and the Caspian Sea to the west and is one of the Central Asian states (Severskiy, 2004) (Fig. 3). For administrative purposes, Kazakhstan is divided into 14 provinces (oblasts) namely, Akmola, Aktobe, Almaty, Atyrau, West Kazakhstan, Jambyl, Karagandy, Kostanai, Kyzylorda, Mangystau, South Kazakhstan, Pavlodar, North Kazakhstan, East Kazakhstan, and three cities (qalalar), namely Almaty, Astana, and Baykonyr. The largest part of the country is constituted by flat lowlands that are less than 500 m amsl. Deserts and steppes account for more than 80% of the total area (Tussupova et al.,2015). The climate is mainly continental with cold winters and hot summers. Average annual precipitation is only about 250 mm with 315 mm in the northern areas and about 150 mm in the central parts. In mountainous areas, it can reach up to about 880 mm per year (Cowan, 2007; Siegfried et al., 2012; Dukhovny, 2002). In total, 70–85% of annual precipitation occur between October and April.

After its independence in 1991, Kazakhstan experienced a transition from state planned to market economy resulting in changing patterns of basic services such as water supply (Kamalov, 2002). The Kazakhstan economy is developing under increasing water deficiency (Ryabtsev and Akhmetov, 2002; Lack, 1999; Adany et al., 2011; McKee et al., 1995; Adeyi et al., 1997). About 70% of developmental problems in the region are caused by freshwater shortage (Kipshakbayev and Sokolov, 2002). Totally renewable water resources (surface and groundwater) of Kazakhstan have been estimated at 100-117 km<sup>3</sup>/year (Kulzhanov and Rechel, 2007; Islamov et al., 2009; O'Hara, 2000). Out of this total, water resources originating from the outside of Kazakhstan correspond to 34-44 km<sup>3</sup>/year. Thus, the totally renewable water volume per capita and year is about 6,490 m<sup>3</sup>. Kazakhstan is, consequently, not water scarce in terms of total water supply per capita (O'Hara, 2000). But the uneven distribution in space and time in combination with excessive and often uncontrolled withdrawal for irrigation, however, create water scarcity

especially in areas to the south. Figures are in any case uncertain due to great inter-annual variability and a general lack of long-term spatially distributed hydrological observation stations over a sparsely inhabited arid expanse. In general, groundwater resources are stated to constitute about 10-15% of surface water resources (FAO, 2013).



Figure 3. Kazakhstan in Central Asia.

## 3.2. The Pavlodar area

The Pavlodar region, one of 14 regions in Kazakhstan, is situated in the northeast of the country in the Irtysh River Basin (Fig. 4). The climate is continental, characterized by long, cold winters (5.5 months), and short, hot summers (3 months). It is dry with constant winds and a low level of precipitation. The temperature is from -40-45 to +35+42°C during the year. The landscape consists of plains, steppes, forest-steppes, pine forests, mountains and numerous lakes. The steppe comprises the greatest portion of the region. Available water resources in the region are mainly the Irtysh River and groundwater (Shaimerdenov, 2002)

Pavlodar is one of the main industrial regions of Kazakhstan. The territory of the region is 127,500 square km with 747,203 people (Taldau, 2012). It has 3 cities and 10 districts with 412 rural settlements. Each rural settlement has a population less than 5,000 people.

As of January 2010, the 412 rural settlements had a population of 268,700 people. Among these:

- 67 rural areas with the population of about 100,750 people have access to centralized water supply system (public standpipes or/and individual pipe connection),
- 335 rural areas with the population of about 166,980 people take water from decentralized sources, such as boreholes or wells, and
- 8 rural areas with the population of about 970 people use delivered water.

The experimental area of this study has 37 villages situated in a rural area with the population ranging between 50 and 2,416 persons per village with an average of 712 persons per village.



**Figure 4.** The experimental rural area around Pavlodar City in Kazakhstan.

### 3.3. Water supply sources and wastewater management

The governmental decree on “Sanitarian-epidemiological requirements for water resources, drinking water sources, locations of cultural-domestic water use, and safety of water” regulates the water supply and drinking water sources in

Kazakhstan (Order of Minister of Health, 2010). Accordingly, main water supply systems are classified as centralized or decentralized (Table 2). The main difference between them is that the centralized water supply has a distribution system to provide water from the raw water source with or without treatment. The decentralized water supply system uses water directly from a local raw water source with or without treatment. Consequently, centralized water supply means water provided through pipes to households (tap water) or public standpipes according to Table 2. Protected boreholes and wells are considered decentralized water supply sources. To be classified as having access to drinking water, water supply connected to a household piped water, public standpipe, protected borehole and protected well, should be accessible within 100 m distance from the household (UNDP, 2006). The water quality should also meet the Sanitarian regulations and norms regulating the quality of drinking water (Regulation, USSR, 1989; SanPIN, 1996). Both groundwater and surface water are sources for the centralized system. However, groundwater is the most common raw water source for rural centralized systems in the region. Official statistics also accounts for water users using delivered water by truck. Delivered water is regarded as an unsustainable water supply source and perceived as a temporary solution. Complex Block Module (CBM) is water for sale. It is typically constituted by treated groundwater that is sold by private vendors at a kiosk in gallons. This type of water is used for drinking water purposes in villages where a public water source is not available.

The Soviet State tried to provide rural people with drinking water and build systems that needed low capital investment and small cost for process equipment but considerably high operational costs (Global Water Partnership, 2009; Bekturganov et al., 2016). The majority of these water supply systems was constructed during the period 1950–1980. After dissolving the Soviet Union the new government had little accountability and in some cases no financial capacity to maintain the water distribution systems. This led to a rapid deterioration. Although, a national rural water program was put in place during 2002-2010 the poor management of the program was a major problem that resulted in virtually no progress. Even though the water supply systems are in a deteriorated state, not maintained, and officially recognized as not being used, rural people may still use these systems. The major problem of today is thus often to supply rural areas with safe water in a degraded pipe system.

As mentioned above, the Soviet State provided the water supply system. The wastewater collection and treatment system was, however, the responsibility of the villagers. Thus, the rural wastewater collection differs from village to village. Usually, however, rural houses have an outside pit latrine as a toilet. Greywater is often collected in a septic tank. Sometimes the water distribution system is complemented with sewage collection pipes where greywater goes untreated to

local cesspools or wetlands. At present, however, there is no reliable information on how the wastewater is managed in the different villages.

**Table 2.** Drinking water sources in northeast rural Kazakhstan.

<i>Drinking water sources</i>								
<b>centralized</b>		<b>decentralized</b>					<b>other</b>	
<i>tap water</i>	<i>standpipe</i>	<i>borehole</i>		<i>well</i>		<i>CBM</i>	<i>open source</i>	<i>other</i>
		<i>private</i>	<i>public</i>	<i>private</i>	<i>public</i>			



# 4. Results

## 4.1. Literature review (Paper I)

The literature review in Paper I, exposed some of the problems related to water supply and sanitation. It showed that there is a general lack of data regarding access to drinking water and water related health problems in the region. The general problems as regards water supply systems are the low level of access to drinking water in rural areas, rapid degradation of the water supply infrastructure (in some cases 80–100%) leading to frequent interruption of water supply and inadequate accessibility to safe water supply especially for rural areas, unclear relationships between WTP for water supply service, and instalment of meters in relation to perceived gains. Low tariffs in combination with absent metering and low collection rates for water fees mean that operation and maintenance costs for basic services of water supply and sanitation are not covered. The human resource base for the water supply and sanitation systems needs to be better trained and capacity building is needed for the governance. Large distances between remote and sparsely populated villages in rural areas mean that alternative systems may be needed.

## 4.2. Access to drinking water and sanitation (Paper II)

The literature review showed a general lack of basic data and underpinned the necessity to take care of the wastewater and have safe excreta disposal. In this sense, Paper II presents the actual access to drinking water and sanitation and gives an overview of the household socio-economic and demographic situation in the area.

**Table 3.** Overview of the household socio-economic and demographic situation in the area.

Description	Per cent	Mean
<i>Respondent characteristics</i>		
Sex of respondent: 1 = female, 0 = male		0.64
Age of respondent (min.= 17, max.= 90)		47 (SD 4.6)
<i>Socio-economic characteristics of the household</i>		
Living time for the household in the area:		
<i>Less than 5 years</i>	7%	
<i>Between 5 and 10 years</i>	14%	
<i>More than 10 years</i>	79%	
<i>Number of people in household (min.=1 and max. =12)</i>		3.45 (SD 1.6)
<i>90% of households contain up to 5 persons</i>		
Family with children up to 18 years old: 1 = yes, 0 = no		0.51
Household monthly income in KZT* (min.=1,000, max.=650,000, Median=40,000)		52,057 (SD 36,091)
Household income perception		
<i>Very good</i>	2%	
<i>Good</i>	19%	
<i>Satisfactory</i>	70%	
<i>Bad</i>	8%	
<i>Very bad</i>	1%	

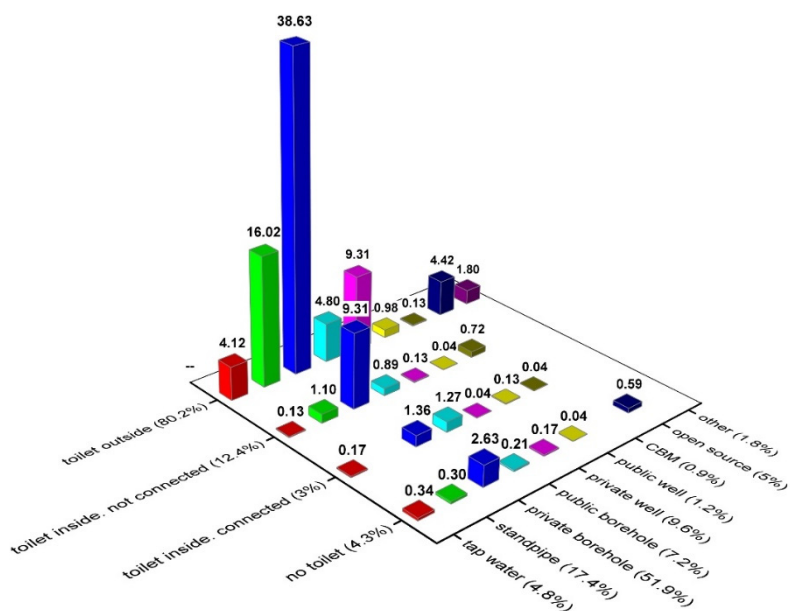
It is important to establish the general socioeconomic and demographic characteristics of the households since safe access to water and sanitation to a major extent is a question of socioeconomic conditions (Table 3). Most of the respondents were women (64%). This perhaps visualizes that women perceive water quality and sanitation as more important as compared to men. The span of age distribution was large among the respondents. The migration in the area is quite small and most households have lived in the area for more than 5 years. The most common household structure is two adults and two children with an average of about 3.5 persons per household. A total of 96% of households does not include more than 6 persons.

The average monthly household income was 52,057 KZT with a standard deviation of 36,091 KZT (150 KZT = 1 US\$ as of January 2012). Probably, the notion of household income perception is a better description of household income. This displays how much the household can afford for a certain income. There is tendency in Kazakhstan to perceive the income better than before. This indicates that the economic situation of the households is improving.

The most common water source, used by more than half of the investigated households, is groundwater through a private borehole (Fig. 5). Boreholes are

generally 8 to 50 m deep with a diameter of 10-30 cm. Water is usually pumped by electricity and in rare cases by hand. Boreholes are usually covered with a plastic top. Some of the households have connected the standpipe to their homes and have tap water from the borehole. All villages except one use water from boreholes.

### *Household access to drinking water and sanitation*



**Figure 5.** Overview of the rural users' water supply and sanitation systems.

The second most common water source is standpipe water (17%). Standpipe water is groundwater distributed through pipes and obtained from a standpipe at street crossings. In some cases, the standpipes may not be controlled and officially closed for usage. In many cases, however, people continue obtaining water from them. Only villages that historically have had or at present have access to pipelines may use standpipe water.

Private wells are used by about 10% of the households. Wells are usually about 10 m deep with a diameter of 0.5-1.5 m. In most cases, wells are covered with a wooden top. Public boreholes are used by 7% of the households. All households in a village can use standpipes connected to public boreholes. Often, piped water supply is constituted by groundwater from public boreholes. In some cases, people still use water from public standpipes created during the Soviet era.

The number of households that use open source water or have access to tap water at home coming from a central water supply system are almost the same, about 5% in each category. Groundwater is the main source of water for the central water supply. Mainly four villages represent households that use open water sources (5%). Open source water is taken from the Irtysh River either directly by the households or delivered from the source by payment. These villages, either in the past or currently, have had access to piped water supply system. It is common for piped consumers to return to open sources when the system fails to deliver. This shows that there is an obvious problem in these villages to access safe water and a non-functioning public water supply. Households in few villages only, use water from a public well. Several households may share the well. The basic construction is similar to a private well.

Very few households use delivered water. A special tanker delivers this water usually for a fee. According to the law in Kazakhstan, the government is responsible to provide people with potable water. The local municipality usually provides delivered water to the households that do not have access to potable water. This is not a sustainable solution, however, must be used when there is no other way to provide potable water. In some cases, households themselves order delivered water and pay extra for this.

The CBM is an abbreviation for Complex Block Module that treats groundwater in a so-called local treatment plant. People collect it using their own containers. The cost for this water ranges between 20 to 40 KZT per 20 litres. Bottled water is water that households buy only for drinking purposes. A small number of households uses other sources of water for drinking purposes.

Three questions were posed regarding access to sanitation, namely: 1) no private toilet, 2) private toilet outside home, and 3) toilet at home either connected to the sewer system or locally collected to a septic tank (Fig. 5). The majority (80%) have their toilets outside in the yard in the form of a pit latrine and they are not connected to a sewage system. This is usually up to a few meter deep hole in the ground that is covered by a concrete slab. Only about 15.3% have their toilet inside the house. Moreover, those who have toilets at home mostly use septic tanks for the sewerage. No toilet means no access to private toilet, and the household most probably use a shared toilet outside with no charge.

#### *Perceived characteristics of water source*

Three criteria were used to assess perceived characteristics of the water source, namely: 1) satisfaction with the water quality (such as turbidity, odor, and taste), 2) perceived reliability of water, and 3) time spent to collect water (Table 4).

**Table 4.** Perceived characteristics of the water source.

water source	water satisfaction			reliability of water source			time spent to collect water			
	good	not bad	bad	safe	not often	not safe	much	not much	little	nothing
tap water	23%	69%	8%	36%	56%	8%	3%	18%	42%	38%
standpipe	13%	79%	8%	19%	59%	21%	17%	30%	47%	6%
private borehole	33%	57%	10%	36%	48%	16%	8%	20%	40%	32%
public borehole	15%	56%	28%	20%	44%	36%	32%	28%	14%	27%
private well	34%	62%	4%	61%	34%	5%	18%	23%	46%	13%
public well	4%	79%	18%	14%	64%	21%	43%	14%	14%	29%
CBM	86%	14%	0%	100%	0%	0%	0%	10%	85%	5%
delivered water	4%	69%	27%	15%	42%	42%	39%	39%	19%	4%
open source	4%	38%	58%	13%	39%	48%	41%	35%	13%	11%
other	8%	54%	39%	7%	43%	50%	57%	14%	21%	7%
<b>total</b>	<b>26%</b>	<b>61%</b>	<b>13%</b>	<b>33%</b>	<b>48%</b>	<b>19%</b>	<b>15%</b>	<b>23%</b>	<b>38%</b>	<b>24%</b>

The perceived water quality assessed the colour, smell, and taste of water. Most households (87%) perceived the quality of water as good or not bad and only a small portion was not satisfied with the quality (13%; Table 4). Although the satisfaction with the quality of water appears relatively good, still for specific water users the satisfaction rate varies. The most unsatisfied are those who take water from the open and other sources (39-58%), which is obvious. The most satisfied water users are those who buy water from CBM, although the portion of these water users is quite small. The next most satisfied are those who have a private water source such as private borehole and private well (33-34%). Even standpipe users and public well users perceive the water quality as good or not bad (83-92%).

Those who use tap water from the central water supply perceive the water as good (23%) or not bad (69%). 8% of the tap water users perceived the water quality as bad. The water from pipes often have a slight brownish colour and may appear with some smell because of either old or not properly maintained pipes or contains a high mineral content from the groundwater.

In terms of reliability regarding the water source the majority of households thought that the water source was not safe or not often safe (67%; Table 4). This term is quite ambiguous because it can both be interpreted as whether you are sure this water is safe to drink and whether you can obtain water from this source continuously regardless of season and other factors. In most cases, users with private water source find their water relatively safe 36-61%). Excluding the CBM water users, the majority of private well water users think their water source is reliable (61%). It is interesting to note that more than half of the standpipe and tap water users think that the water is not often safe, while one third of tap water users believe it is a safe and reliable source (36%). Only a small number of households think the tap water is not reliable (8%). This might be due to that the water supply is given only on a pre-determined time basis and that people may be ill informed about this.

The question regarding time spent to collect water may not have felt relevant to all water users. However, this is an important aspect of water access. Those who use

tap water may still have problem with temporal disruptions of the system. A majority of households did not spend any time or if spending time this was very little. Those who use public source water generally spend much time to collect water (>32%). Those who use private borehole and centralized tap water spend less time than others do. For private borehole water users this might be due to connection problems to the house. Some borehole water users may not spend any time because water is connected to the home and used as tap water. A somewhat surprising result is that CBM water users spend little time. This may be due to that the CBM plant is close to their house. This study did not adopt the distance to the source or exact time indicator. The pilot study showed that even some water users that have water at home could spend time for collecting water and the value of time can differ from person to person. In addition, we find it more relevant to investigate to what extent people value their time to obtain the water.

**Table 5.** Household water treatment (percentage of households giving each response).

	N	<i>no</i>	<i>filter</i>	<i>boiling</i>	<i>settling</i>	<i>other</i>
<i>Tap water</i>	111	58.6	5.4	30.6	4.5	0.9
<i>Standpipe</i>	361	21.9	5.0	67.0	5.5	0.6
<i>Private borehole</i>	1155	51.8	14.2	27.4	6.5	0.2
<i>Public borehole</i>	153	37.9	6.5	47.1	8.5	0.0
<i>Private well</i>	219	50.7	5.9	33.3	9.6	0.5
<i>Public well</i>	26	34.6	0.0	65.4	0.0	0.0
<i>CBM</i>	22	13.6	77.3	9.1	0.0	0.0
<i>Delivered water</i>	25	52.0	8.0	32.0	8.0	0.0
<i>Open source</i>	89	42.7	5.6	48.3	3.4	0.0
<i>Other</i>	18	50.0	0.0	44.4	0.0	5.6
Total	2179	45.1	10.8	37.4	6.4	0.3

The question whether households apply water treatment was meant to decipher whether water users feel a potential risk to use water directly from the source without treatment or not. As seen from Table 5, overall 45% of consumers generally do not treat the water in any way. About 37% boil the water before drinking. Only a small portion of respondents stated that they either let the water settle or use a filter. Again those who use private water sources such as boreholes, well or tap water use water directly without treatment. A majority of tap water users (59%) do not treat the water before use. Also, those who use delivered water mostly use water directly without pretreatment.

Table 6 shows that a majority of households feel that water supply is important for the family. One may interpret this as the household considers that either there is an issue with the water supply or that the household generally thinks the water supply

is important. In the questionnaire, we tried to make sure that the respondent understood the question as whether the household has an issue with the water supply and cares about its continuous improvement. In any case, in total 72% think that the water supply is important.

**Table 6.** Importance of the water supply issue to the household.

Absolutely not important	10%
Not important	10%
Between important and not important	8%
Important	38%
Very important	34%

The willingness to connect to a piped water supply system may depend on water source type. As seen from Fig. 6, a majority (65%) are willing to connect and pay for the water. About 28% of the households do not want to connect to piped water and about 7% would use it only if there is no fee. Among those who would not use piped water, the majority are private borehole users (20%). It should be noted though that this group is mixed. About 27% of private borehole users say that they are willing to connect to the piped water supply. One missing but interesting question to borehole water users is if water is connected from the borehole to the home. From the pilot study, it was seen that those who have connected water to the home and have a water boiler at home regardless of income have low or no willingness to connect to the piped tap water. Thus, if the households already have installed a convenient system using borehole water they are unwilling to use anything else.

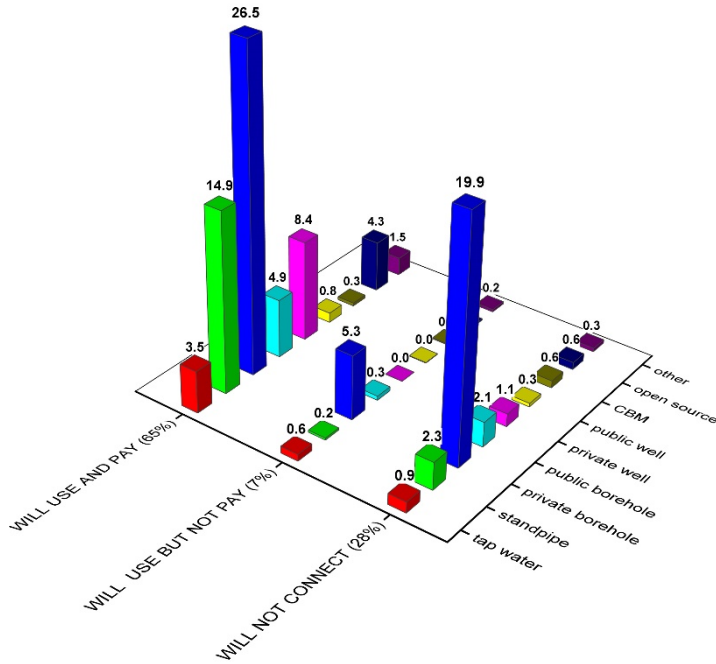
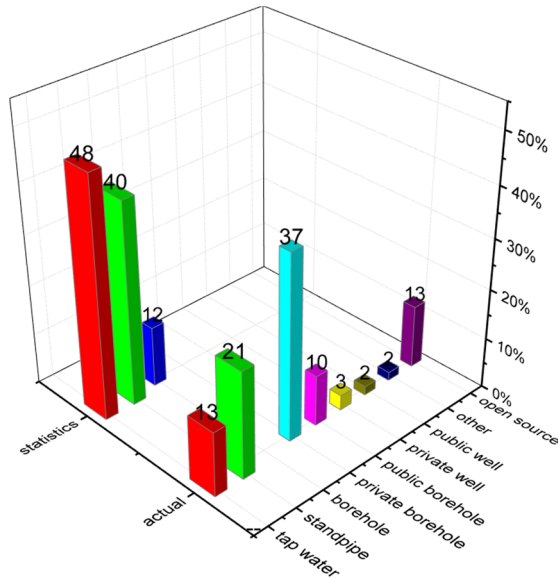


Figure 6. Willingness to connect to the piped water supply system depending on water user type.

### 4.3. Access to drinking water and sanitation services in villages with piped water (Paper III)

Despite the governmental efforts to provide people with piped water there is still a low level of access to piped water. Therefore, to evaluate the efforts regarding the access to piped water, Paper III presents a comparative analysis on usage of water from the piped systems. For this purpose, official statistics and the actual situation in the rural villages regarding water and sanitation was investigated (Fig. 7). This survey included only villages with access to piped water.

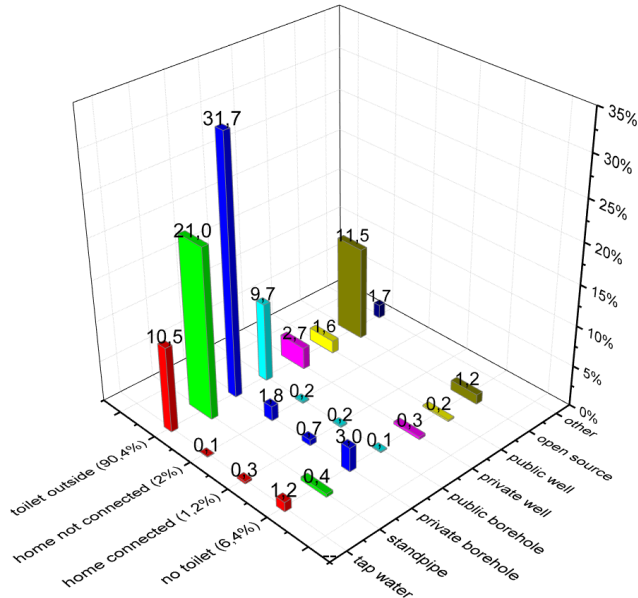




**Figure 7.** Comparison between official statistics and actual usage of water from the piped systems.

Official statistics in these villages include three types of water supply users only, namely tap water, standpipe, and borehole. As piped systems have a mandatory requirement to provide standpipes at regular intervals, 100 % village users, by definition, have access to safe water supply. The major water supply type according to official statistics is tap water with 48%. According to the survey results tap water users are only 13%. A second major difference is the standpipe users. Official statistics state 40% standpipe users while survey results only give 21%. About 12% of all users have boreholes in the official statistics while the survey indicates about 47% (Fig. 7). The survey also lists users such as open source (13%), public and private wells (5%), and other (2%). These categories are completely absent in the official statistics. Overall, while official statistics state a 100% access to safe water supply, the survey indicates a mere 85%.

The official statistics do not distinguish between private and public boreholes as water source. This is an important aspect of water access that should be defined since it has implications for the practical management of the water supply.



**Figure 8.** Access to drinking water sources depending on sanitation situation.

Figure 8 shows access to drinking water source depending on sanitation situation. From the figure it is seen that a majority of people have their toilets outside of the house (90%). About 32% of households with outside toilet combine this with private boreholes for water supply. Private boreholes and private wells represent 34% of those who have outside toilets. If toilets discharge into pit latrines and this is combined with wells and boreholes within the same yard area, a concrete risk may be fecal contamination of the water supply.

About 12% of all villagers have tap water but still use a toilet outside or no toilet. Similarly, about 12% of the open source users have toilet outside. Those who have tap water at home could have access either to a sewer system or to a septic tank or other in-household wastewater treatment technique. In all these cases, there might be a possibility to use flush toilets. As seen from Fig. 8, some of the private borehole water users have flush toilets at home. This means that they have access to piped water and some sewer collection system or septic tank but only use the sewer system without paying for it. Payment for the sewer system is done through using the drinking water from the piped system.

#### 4.4. Willingness to pay to maintain access to piped water (Paper IV)

Water supply is an important issue to the households. Even so, there are people who have access to piped water but still use other water sources. Since the national water program aims at covering 80% of rural people with access to piped water by 2020, it is important to look at the WTP for improved water sources. Paper IV is based on the pilot study and investigated the WTP for maintenance of the piped water system using the CV method with open-ended and bids format questions (as shown in Table 1, type of elicitation procedure).

The results showed that bids format questions give higher response rate as compared to the open-ended format questions. This is due to the fact that offered prices give some navigation. Therefore, those who wanted to pay but did not know how much in the open-ended questions could choose one of the offered amounts in the bidding game (Fig. 9).

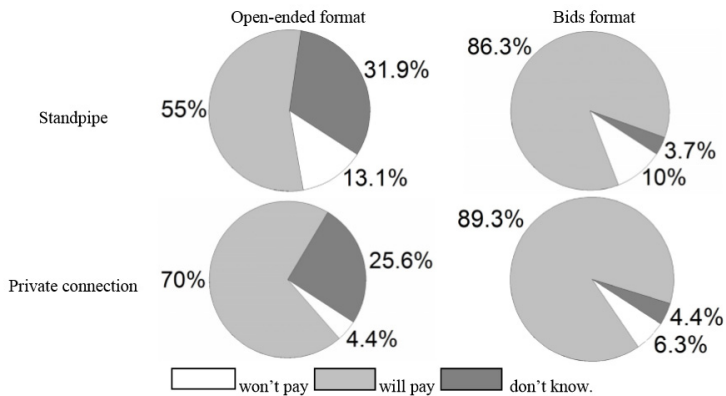
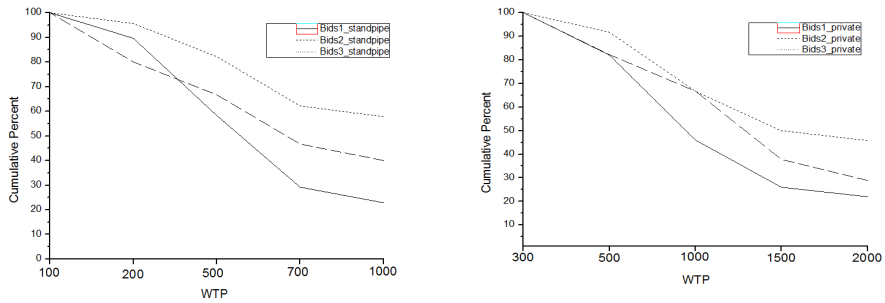


Figure 9. Comparison of open-ended and bids format results.



**Figure 10 a-b.** Cumulative distribution of maximum WTP (KZT) for standpipe and private connection.

Using bids with different starting points can be influential (Fig. 10). If respondents have not paid to obtain water and have no real idea how much they should pay, then the first price is interpreted as a reference price. Private borehole and private well water users as well as open source water users were partially navigated by the first price, although the magnitude of the first price was not high. In contrast, if users are already charged and/or have to spend some time to obtain water, such as delivered water and standpipe water users, their bids with different starting point do not have significant influence.

Half of the respondents were ready to pay the fee of 20,000 KZT for the individual connection. The mean WTP for the maintenance of the individual piped water system was about 1,120 KZT per month per household in the bids format and about 1,590 KZT per month per household in the open-ended format question. For public standpipe, the mean WTP was about 950 KZT per month per household in the open-ended category answers, and about 610 KZT per month per household in the bids format. When open-ended answers are adjusted up to the maximum amount in bids format, the difference of mean values is insignificant (Table 7).

The most important explanatory variables for private connection appeared to be the existing water source, family with children, and the connection fee (Table 8). The pilot study predefined the main explanatory variables for the WTP that were included in the main study.

**Table 7.** Comparing means for open-ended and bids format standardized from 100 to 2000 KZT.

	Public Standpipe		Private Connection	
	Open-Ended	Bids	Open-Ended	Bids
Mean	607	588	1110	1089
SD	329	354	637	667
t-statistics	0.5 *		0.3 *	
DF	65		88	
Prob.	0.6		0.8	

Note: \* At the level 0.05 the difference of population means is not significantly different.

Variables	B	Sig.	Exp(B)
Sex: 0=woman, 1=man	0.447	0.245	1.563
Family with children: 0=no, 1=yes	0.828	0.036	2.289
Water source: 0=private, 1=public	0.806	0.043	2.238
Water quality: 0=bad, 1=satisfactory	0.599	0.148	1.820
Connection fee: 0=no, 1=yes	1.160	0.007	3.189
Constant	-2.874	0.000	0.056

Cases selected = 142      Nagelkerke R square = 0.191      Significance = 0.005

## 4.5. Determinants of willingness to pay to maintain access to piped water (Paper V)

Paper V investigated the determinants of WTP for the data collected in the main study. The questionnaire for this study was based on the CV method.

The results were used for a binary regression analysis (Eqn. (2)) for the willingness to connect to and pay for maintenance of the piped water supply. As seen from Table 9, the most statistically significant variables were present water source, perceived quality, perceived reliability of the source, time-spent to collect water, additional household treatment of drinking water, household size, and current expenses for drinking water.

Compared to tap water users individual borehole water users have lower willingness to connect and pay for tap water from the piped system. The water quality variable shows that the change in perceived water quality from good to bad increases the willingness to connect and pay for piped water supply.

The reliability of the water source can be interpreted as if water from the source can provide constant access and give the same quality and quantity of water. The change in perceived reliability from reliable to not reliable increases the WTP.

The time spent variable shows that if you spend less time to collect water the less you are willing to pay for the piped water (and consequently, if spending more time you are more willing to pay).

The additional household treatment of drinking water variable shows that those who do not use the water directly from the source and use additional treatment have higher WTP for piped water.

The variable for water expenses shows that if the current water users at present spend money to obtain drinking water they are willing to pay for the piped water supply.

Access to sanitation and perception of the household financial situation do not show a significant influence on the willingness to connect to the piped water system. As seen from the above, it is obvious that a water supply source can be described from many different viewpoints and various perceived characteristics. As well, the socioeconomic situation of the user influences how water is perceived and the WTP to be connected. Thus, it is important to involve the user in the decision process to understand and quantify factors that determine the WTP. Different water users may have different drivers for the WTP.

<b>Table 9.</b> Results for the binary regression analysis (Eqn. (2)) for the WTP for connection and maintenance of the piped water supply.				
Variable in Eqn. (2)		b	Significance	Exp(b)
<b>Water source</b>	<i>tap water</i>		<b>0.000</b>	
	<i>open source</i>	-0.457	0.368	0.633
	<i>individual borehole</i>	-1.005	<b>0.003</b>	0.366
	<i>public borehole</i>	0.346	0.536	1.413
	<i>individual well</i>	0.810	<b>0.060</b>	2.248
	<i>standpipe water</i>	0.546	0.188	1.726
<b>Water quality</b>	<i>from good to bad</i>	0.510	<b>0.002</b>	1.666
<b>Reliability</b>	<i>from reliable to not reliable</i>	0.705	<b>0.000</b>	2.024
<b>Time spent</b>	<i>from much time to less time</i>	-0.459	<b>0.001</b>	0.632
<b>Household treatment</b>	<i>no treatment</i>		<b>0.000</b>	
	<i>settling</i>	0.405	<b>0.014</b>	1.499
	<i>other</i>	1.662	<b>0.001</b>	5.269
<b>Household size</b>		0.152	<b>0.002</b>	1.164
<b>Income perception</b>		-0.025	0.532	0.976
<b>Water expenses</b>		0.347	<b>0.015</b>	1.415
<b>Sanitation</b>	<i>at home</i>		0.440	
	<i>no toilet</i>	-0.382	0.220	0.683
	<i>outside toilet</i>	-0.459	0.264	0.632
<b>Constant</b>		-0.196	0.788	0.822
<b>Number of observations: 1,408</b>		<b>R square: 0.345</b>	<b>Sign.: 0.0</b>	

Ordered regression according to Eqn. (3) was used to determine the WTP for piped water supply depending on different water user type according to Table 10. The perceived water quality was the variable that all water users found relevant. Obviously, if you are not satisfied with the water quality you are willing to pay more for a better quality water.

Perceived reliability of the water source indicates whether the consumers believe that the water service access is reliable or if water uptake from the source is secure. If your current water source is not reliable you are willing to pay more for the piped water. The only exception is the current tap water users that had a negative relationship. Consumers who believe that the water source is not reliable (e.g., water service given hourly or water having a brownish color) would like to pay less. This indicates that there are problems with the current trust towards tap water from the piped system.

For the time spent to collect water there is a positive trend for all water users except for the current tap water users. This means that the more time they spend to collect water the less they want to pay for a similar system with 24 hour access to potable water.

The variable for additional household treatment is less clear since sub-variables were merged into one group corresponding to no treatment. Settling represented a small proportion, and all other types of treatment that were merged into the second largest group. Individual borehole water users would be willing to pay more if they use additional household treatment before water intake.

**Table 10.** Results for ordered regression according to Eqn. (3) to determine the WTP for piped water supply depending on different water user type.

WTP ordered	Tap water	Standpipe	Ind.borehole	Public borehole	Ind.well	Open source
Water quality bad	4,11 **	-1,32 *	0,65 *	1,64	0,22	4,18 ***
Water quality OK	3,69 ***	-0,55	0,62 ***	2,11 **	0,68 *	2,65 *
Water quality good	0	0	0	0	0	0
Not reliable	-4,85 **	1,88 ***	1,61 ***	-0,18	-1,94	-0,43
Not often reliable	-3,11 **	1,95 ***	1,05 ***	0,99	-1,03 ***	-0,54
Reliable	0	0	0	0	0	0
Much time spent	-2,61	0,59	1,09 ***	0,86	0,48	0,69
Less time spent	-2,24 ***	1,79 ***	0,57 ***	0,10	1,27 ***	2,05
No time spent	0	0	0	0	0	0
Other treatment	-0,84	0,98 **	0,56 ***	0,71	-0,22	-1,31 **
Settling down	0,98	0,26	0,76 ***	0,91	-0,11	-0,87
No treatment	0	0	0	0	0	0
Income perception good	-1,39	-0,20	0,81 ***	0,009	0,64	2,95 ***
Income perception satisfied	-3,02 **	0,43	0,45 *	0,66	1,30	0,25
Income perception bad	0	0	0	0	0	0
Household size	0,10	-0,014	-0,023	0,21	0,019	0,28
Water expenses	0,0005	0,0002	0,00007 *	-0,0003	0,001	0,0002
number of observations	93	291	838	88	179	82
significance	0	0	0	0	0	0
r square	0,29	0,16	0,15	0,18	0,09	0,24
/cut1	-4,47	0,57	2,00	1,74	-0,30	2,96
/cut2	4,79	4,65	5,58	7,04	2,92	6,41

The variable income perception was chosen due to the fact that this might better reflect the purchasing ability. Recent research has shown that those who perceive that they have a good income would likely pay more. As seen from the table, particularly open source and individual borehole water users would like to pay more if they perceive their income as good. There is a negative trend for tap water users. The better they perceive their economic situation, the less WTP for improved water system.

The two variables household size and water expenses are in general not statistically significant.

As seen from the table, different water users value different factors that influence the WTP for piped water. For the current tap water users, it appears that they have lost some trust in the current water source. The time spent to collect water and income perception are other main factors affecting the WTP. Improved trust in the



piped water system may increase the WTP for piped water. One interesting variable that is significant is the perceived household financial situation. With improved financial situation there is a less WTP but it can be also associated with perceived bad quality of the water.

For open source water users, the income perception is one of the most influential variables for WTP. In general, if consumers can afford they are willing to pay. Water treatment variables have a negative relationship meaning that if the household has installed some treatment technique then they are less willing to pay.

For individual borehole water users, variables indicate logical relationships. The worse the quality of water, less reliable, much time spent, using additional household treatment, higher income perception, higher current water expenses, the more they want to pay for the piped water. There is a similar situation for the public borehole water users.

Standpipe water users are more or less similar to borehole water users with only a difference in the perception of water quality.

We may conclude that although some of the variables, especially perceived water quality, are common for all the different water users, there are still differences in their relationship in regards to WTP.

## 5. Discussion

In the following, the results and their implications are synthesized and discussed in relation to the three main thesis objectives.

**Objective A:** To investigate the *actual access* to drinking water and sanitation services on ground and to compare with official statistics (Paper II and III).

Paper II showed that there is a variety of water sources used and unclear information about sanitation services. A majority of households (52%) use groundwater from private boreholes and out of these 96% believe that the water is of good or not bad quality. About 17% of all households take water from the public standpipes. Standpipes can usually be found at every street-crossing in the rural villages. Only 5% of all households enjoy in-house tap water. Mainly four villages represent households that use open water sources (5%). All of these are relatively close to Irtysh River. These villages, either in the past or currently, have had access to piped water supply system. This leads to the conclusion that there is a problem with the water supply situation in these villages.

The majority (80%) have their toilets outside in the yard in the form of a pit latrine and they are not connected to a sewage system. The pit latrine is a usually up to a few meter deep hole in the ground that is covered by a concrete slab. Only about 15% have their toilet inside the house. Moreover, those who have toilets at home mostly use septic tanks for the sewerage. Some people have no access to private toilet, and the household most probably use a shared toilet outside with no charge.

Paper III showed large discrepancies between official statistics and the actual access in villages with access to piped water. The discrepancy between official and actual individual water supply types is even larger. In our survey we found that this difference could be more than 300%.

The official policy regarding provision of safe drinking water to rural Kazakhstan appears to be a centralized pipeline network system. Official statistics counts every household as being covered with piped water if there are stand pipes at a maximum distance of 100 m from the household. Once the household has notified the authorities that it has tap water at home and is connected to the piped system, this is put in the official records unless the household cancels the connection. It may happen that when the household starts using other types of water sources they do not notify the appropriate authority. Official statistics also appear to lump together

a few major water supply sources. These lack the detail and diversity of actual conditions. Some water supply types such as open water sources are completely absent in the official statistics. As well, there is no discrimination between public and private boreholes and wells.

The lack of reliable statistics and data misdirect the efforts made by various agencies in terms of water supply programs. The reality shows that people use different water sources and sanitation services, which are not monitored and regulated. In the investigated rural area in Kazakhstan, there is virtually no reliable information on how the wastewater is collected and treated. As well, there is no information on access to sanitation facilities and how they are managed. An unsafe management of the wastewater and excreta disposal are likely to increase the risks for contamination of the drinking water supply.

Good water service delivery requires reliable data that seem currently to be lacking for rural Kazakhstan. Data and statistics that may exist have not been sufficiently analyzed or shared. Achieving SDGs will require investment in data collection as well as more selective and innovative ways to understand, share, and audit the data.

The study only covered a small area of rural Kazakhstan. However, if similar principles are used nationwide, great uncertainties may be found in the national statistics.

**Objective B:** To assess and identify the *indicators* of WTP to connect to piped water.

Paper II concludes that in each category of water users a majority would like to connect to the piped tap water at home and pay monthly maintenance costs for the system. Regardless of perceived low quality of piped water, piped water users (tap and standpipe) still have high willingness to connect. Particularly open source water users, as mentioned above, come from villages where they either used to have or still have access to piped water, and would like to connect and pay for the usage of tap water. This means that currently there is a problem with the water supply system, but people still have strong willingness to use piped water. One may assume that although there is a low satisfaction with the current tap water quality still a well-functioning system in terms of water quality and absence of interruptions in the system seem attractive.

A majority think that water supply is an important issue for the household and 65% would like to connect and pay for the piped water system. The fact that so many want to connect but still lack access to piped water, indicates that there have been serious problems affecting the 2002-2010 drinking water supply campaign. The main water users that are reluctant to connect to a central water supply are those that have private boreholes (20%).

In order to have a water program working we need reliable data on current access to drinking water as it is defined by Objective A. In order to have successful implementation of the program we need to know whether local water users want the water interventions planned by the government and how they assess different levels of services. In this sense, Paper IV and V used the CV method for data collection and determinants of WTP to maintain the access to piped water.

Paper IV showed that the CV method using different question formats can be used in the area and provide reliable data on WTP if constructed properly, particularly where people use different water sources.

The main influencing factors for high or low WTP were the existing water source and the payment of fee for the private connection. Private water users with borehole and well water do not have charges and perceive their water to be of good quality. Thus, they were willing to pay less. Those who use public sources such as open source and standpipe water were ready to pay more every month to get access to piped water, which is more convenient compared to the existing sources, as they have to travel, as well as sometimes pay, to obtain water. They perceived the water quality as not good. The readiness to pay the connection fee for private access to water as a possible indicator of the household wealth showed that those who are ready to pay the connection fee of 20,000 KZT were much more frequent in the higher bids category. The connection fee might be an implicit indicator of the household having savings and the ability to pay. However, the household wealth indicator should be well constructed in future surveys.

Paper V used the CV method with payment cards and defined the main determinants of WTP among different water users. It showed that existing water source and its perceived characteristics such as perceived quality, reliability of the source and the time-spent to collect water, household water treatment, as well as household size and current water expenses are the main determinants of WTP ( $p$  below 0.05). Sanitation and income perception showed no significance for the WTP. It should be noted that local villagers use water from different sources and a majority of the respondents are willing to connect and use water from the piped water supply. However, generally defined determinants for WTP should be carefully considered as regards each particular water user. Thus, the survey established determinants of the WTP among the different water users.

Perceived water quality is a variable that is relevant for all water users. The less people are satisfied with the current water source the more they are willing to pay. Other variables are also significant but differently correlated with the WTP among different water users. These are perceived reliability and the time-spent to collect water from the source, in-household treatment of water, and income perception. The variable water expenses is significant only for the private borehole water users.

Current tap water users behave somewhat differently as compared to other groups. When the other groups perceive the water source as less reliable and spend more time to collect water than they have greater WTP for the piped water. The same relationship for the current tap water users is a smaller WTP. As regards the current tap water users, it is important to improve the trust to the system, since those who had lower reliability to the system, less satisfaction with the water quality, and spent time to collect water for various reasons can still use this water if it is properly managed.

As regards the current tap water users, it is important to improve the trust to the system, since those who had lower reliability to the system, less satisfaction with the water quality, and spent time to collect water for various reasons can still use this water if it is properly managed. In this case, the wastewater system should be well functioning offering either local in-household treatment such as septic tank, safe pit-latrines or a proper sewage collection system. Obviously, open source water users need to have an access to safe water. Thus, the water provided to them should be affordable in price and of a decent quality.

**Objective C:** To define possible drinking water and sanitation *management solutions* to provide WASH for all. This was discussed in Paper III and V.

The UN SDGs promote WASH for all. Its agenda is full coverage with access to safe drinking water and safe management of excreta disposal. These goals do not discriminate between the different water sources and sanitation services unless the access is safe and the excreta is disposed. Thus, the management of drinking water supply and wastewater, and safe management of excreta disposal are crucial.

In the investigated region in Kazakhstan, a majority of users appears to combine private boreholes and wells with pit latrines in their yard. A sustainable solution to this problem needs to consider both water supply and sanitation.

It is important that a management system is developed that can provide a safe sanitation for the rural areas. The SDG target 6.2 suggests to support and strengthen the participation of local communities for improving water and sanitation management. Thus, a key aspect of this management system is to build on local participation and needs. The sanitation system of today to a major extent separates toilet waste and greywater. Building on local solutions that preserve the advantages such as possibilities to re-use the greywater would decrease needs for large-scale and expensive public treatment plants. Thus, careful planning and management are needed for the next step in the sanitation development. The SDGs go beyond the access to basic facility and address the safe management of faecal waste along the sanitation chain. The SDG indicator “percentage of population using safely managed sanitation services” means the proportion of the population using different types of basic sanitation facilities such as flush toilet and pit latrines which are not

shared and safely disposed in situ or transported and treated off-site. The emphasis is not whether a flush toilet is connected to a sewer system or septic tank or if pit latrines are used but instead on a safe disposal of the excreta in order not to pollute the environment. Thus, a more economically feasible alternative for a sustainable sanitation system may be to concentrate on a safe excreta disposal for those who use pit latrines rather than building a new large-scale wastewater system. Proper management includes a monitoring system as well as a hygiene behavior promotion and a main responsibility from the water user side.

The perceived responsibility for the piped water system is the government according to a majority of users. This, however, differs among different water users. While the majority of non-piped water users believe that it should be the responsibility of the local municipality, the majority of current pipe-water users believe it is either water users' responsibility or another private organization. It might give us a thought that the environmental awareness among piped water users is increasing and people do not perceive the maintenance only as a responsibility of the government, but also ready to be partly responsible for the maintenance of the systems. In any case, the proper water supply and sanitation management should require both the provider and the consumer to have clearly defined responsibilities under the consideration of WASH.

Although water on premises is a safe access type to drinking water, still certain water users would not like to connect to the piped system. There are different drivers for them not to connect and one of the major drivers is satisfaction with the current water source, which should not be neglected. If the private borehole water user is satisfied with the present water source it should be properly managed. Consequently, the wastewater should be treated and the excreta disposed in a safe way. This system will require a proper management and monitoring as well as involvement of local water users and their responsibility for the well-functioning water and wastewater system and excreta disposal. The hygiene promotion is a must in such cases.

Proper management for the drinking water and wastewater and safe management of the excreta disposal should be supplied. This can also mean to supply in-household treatment of greywater using septic tanks or other eco-friendly treatment techniques and eco-friendly pit latrines with safe excreta disposal. Local systems, however, mean a greater responsibility from the water user side and consequently their environmental awareness and improved hygienic behavior.

# 6. Conclusions and suggestions for future studies

## 6.1. Conclusions

The current study investigated the access to drinking water and sanitation services as well as assessed households' willingness to connect to the piped water system in 37 rural villages of the Pavlodar region. The results are important since they can be used to guide more efficient efforts to provide sustainable water supply and sanitation services to all and to predict the willingness to connect to public water supply and sanitation and at what potential cost. Especially, they are important for the planning of the national drinking water program that aims to provide all rural people with safe water and thereby fulfilment of the UN SDGs in Kazakhstan concerning safe water and sanitation.

The main results are as follows:

1. Despite the efforts to provide people with potable water during the recently completed national water supply program there is still a lack of access to tap water from the piped water supply system as well as access to a safe sanitation. This may largely be explained by the severe lack of baseline data that are needed for targeting and designing the improvements. Therefore, there is a need for more ambitious data collection, as well as more selective and innovative ways to understand, share, and audit the data.
2. A reason for failure of previous water supply programs is that interventions so far have been top-down. Furthermore, the responsible authorities need to appreciate that sustainable drinking water programs need to be based on better knowledge about local conditions as well as a shift to more bottom-up and WASH oriented planning approaches.

The integration of local water users is crucially important, since they are the beneficiaries of any water intervention program. This will show the actual need for any drinking water intervention and create a better understanding of their willingness to use and pay for the water supply systems. The integration of people in this process should also increase the responsibility

from their side and increase the hygiene behavior, which are both sustainability components.

3. National drinking water programs need to include concerns about the wastewater collection systems and treatment. Thus, regardless of the type of basic sanitation, the safe management of faecal disposal is a key component in a sustainable WASH system.
4. The results show that there are several types of raw water sources and the most common one is private boreholes. A majority of private water source users want to connect to the public tap water system. This thesis quantified the willingness to connect to public water supply and at what cost for the different users. Further, the results determined important determinants for the willingness to connect.

The overall results show that it will not be possible for Kazakhstan to reach 80% coverage of tap water from a centralized piped system to the rural people by 2020. The Kazakhstani national water program states this as a general goal. However, safe access to WASH for rural people should be the most important aspect of any water program. Furthermore, it seems that the Kazakhstani government has not yet fully appreciated the role of proper sanitation in achieving the health benefits of a safe water supply. There is clearly a need to develop the WASH effort. In any case, considerable progress can only be made by carefully managing the existing water supply and sanitation system in joint collaboration with the local users. Hence, we see the results presented in this study as important first step in this direction.

## 6.2. Future studies

Future studies need to focus on establishing a nation-wide data base regarding present water access, sanitation needs, and existing raw water quality. It is also crucial to develop means and systems to better include the end user in the process of finding local solutions for safe access to water and sanitation. Future studies should try to find alternative and locally-adapted water supply and sanitation systems that put the user in center.



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# Paper I



Review

# Water Related Health Problems in Central Asia—A Review

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**Abstract:** The present paper provides an extensive literature review on water related health issues in Central Asia. Even though the per capita amount of available freshwater is substantial in all Central Asian states the uneven distribution in time and space creates problems for water availability. Due to this, the Central Asian economies are developing under increasing water deficiency. The degradation of water supply systems and sewage treatment plants is often severe leading to potentially high water loss rates and inadequate accessibility to safe water supply. In this context, rural areas are the most affected. Low tariffs in combination with absent metering and low collection rates for water fees mean that operation and maintenance costs for basic services of water supply and sanitation are not covered. Unsafe water supply contains both microbiological and non-microbiological contaminants. Helminthiasis and intestinal protozoa infections are of considerable public health importance in Central Asia. Agricultural and industrial pollution is especially affecting downstream areas of Amu Darya and Syr Darya rivers. In large areas copper, zinc, and chromium concentrations in water exceed maximum permissible concentration. Thus, there is an urgent need to strengthen the environmental monitoring system. Small-scale water supply and sanitation systems need to be developed in line with more efficient public spending on these.

**Keywords:** Central Asia; water supply; public health; safe drinking water; sanitation; pollution

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## 1. Introduction

Central Asia refers to the five former Soviet Union states Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyzstan [1]. Central Asia stretches from the Caspian Sea in the west to China in the east and from Afghanistan in the south to Russia in the north (Figure 1).



**Figure 1.** Outline of Central Asia and the five former Soviet Union states Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyzstan (courtesy of World Sites Atlas).

Consequently, all five Central Asian states have experienced the crumbling of the Soviet Union in 1991, the following collapse of the economic system, and the subsequent socioeconomic upheaval [2]. The transition from state planned to market economy has meant changing patterns for basic services such as water supply and sanitation [3]. At present Central Asia is home to a population of about 66 million (Kazakhstan 17.0 million, Kyrgyzstan 5.7 million, Tajikistan 8.0 million, Turkmenistan 5.2 million, and Uzbekistan 30.0 million) [4]. By 2040, the total population is expected to have increased to about 86 million. This together with countryside migration to urban areas will put an enormous stress on water and infrastructure. Water supply availability in Central Asia is complicated due to that the region's two major rivers, the Syr Darya and Amu Darya, are transboundary. Thus, continual conflicts over the region's water resources have characterized the Central Asian states since the collapse of the Soviet Union [4].

The Central Asian economies are developing under increasing water deficiency [5–9]. According to I.V. Severskiy [2], 70% of developmental problems in the region are caused by freshwater shortage. The main reasons for this are increasing political tensions and worsening ecological and socioeconomic conditions. Freshwater shortage, however, also affects the public health and providing continuous access to safe drinking water is fundamental to protecting the population from microbiological disease [10]. Before 1991, public health service mainly followed the Soviet model with priority on regulatory hygienic and sanitary control measures for combatting infectious diseases [11]. After 1991, the notion of “New Public Health” including a broader range of evidence-based scientific, technological, and management based systems for improving the health of individuals became more widely accepted [12–14]. The new approach, that also stressed chronic non-communicable diseases, health policy, health promotion, health systems management, and public health practice, eventually lead forward to the reformulation of educational programmes and legislation. At present the main challenge for Central Asian states public health sectors is in clarifying, coordinating, and streamlining the

roles and responsibilities of different agencies responsible for public health and health promotion activities [15].

In view of the above, there is a remarkable absence of basic information on water related health issues of Central Asia in the English scientific literature. The lack of information may reflect a general absence of investigation efforts during the period following the collapse of the Soviet Union. It is believed that this collapse also was followed by a breakdown in public health infrastructure. On the other hand, much of this information may be delimited to the Russian scientific literature. Relevant data and information may also be available in unpublished documents and reports. The authors are, however, not aware of any previous scientific publication trying to cover the state of art situation on water related health problems in the Central Asia. Along this line, we try to summarize all available scientific literature and publically available reports on this subject, synthesise, and draw general conclusion from the state of water and health in Central Asia. The introductory chapter is followed by a description of distribution of freshwater resources of Central Asia. The chapter after this describes threats to water quality. In the following chapter, access to safe water is outlined. The final chapter treats occurring and possible future health impacts. We close with a conclusion and a discussion on possible ways forward.

## 2. Distribution of Freshwater Resources

Central Asia is located in the centre of the Eurasian continent occupying an area of about 4 million km<sup>2</sup> [16]. The main part of the Central Asia is arid and thus, there is a general deficit of freshwater. The climate is strongly continental arid to semiarid with hot cloud-free summers and humid temperate winters in the south and cold winters in the north [17]. Average annual precipitation for Central Asia is about 273 mm. It varies from about 161 mm in Turkmenistan to 691 mm per year in Tajikistan. The by far largest country Kazakhstan receives on average about 250 mm per year. The plains and deserts receive less than 70 mm per year and the high mountains of central Tajikistan up to 2400 mm per year [18–22]. Potential evaporation similarly varies from above 2250 mm per year in the most arid region to less than 500 mm per year in the mountainous areas.

Water resources in Central Asia are constituted by surface water and groundwater. The major part of potentially usable water comes from the large rivers of the region. All these rivers, however, are transboundary. The largest, the Amu Darya and the Syr Darya, flow through more than three countries. The Amu Darya and Syr Darya account for 90% of Central Asia's river water. Especially, Turkmenistan and Uzbekistan are vulnerable due to that a major part of the water resources is generated outside of their respective territory. The Central Asian water problem is thus, complex and also involving other transboundary stakeholders such as Russia, China, Afghanistan, Iran, and Pakistan. Other large rivers are the Irtysh and Ishym located in the east parts of Central Asia, the Chu and Talas located in the south, in the west the Ural can be found, and finally the Ishim and Tobol are found in the north [2]. The by far largest withdrawal of water for irrigation is done from the large rivers of the region. However, the area also contains countless smaller river and creeks that as well contribute to irrigated agriculture. The information on this, however, is often absent.

Totally available water resources the respective country are given in Table 1 [23–25]. The groundwater resources generally constitute about 10%–15% in comparison to the surface water resources [23]. Turkmenistan, though, has reminiscent groundwater only. As seen from the table, there are substantial potentially available water resources as a whole in Central Asia. The smallest per capita amount of water is represented by Uzbekistan with 1870 m<sup>3</sup>/capita and year. In general, an amount of less than 3000 m<sup>3</sup>/capita and year may be regarded as economic water scarcity and less than 1000 m<sup>3</sup>/capita and year as physical water scarcity [26]. According to this criterion, only Uzbekistan falls below the threshold for economic water scarcity. Most part of the surface water in Table 1 can be regarded as annually renewable water. However, it must be remembered that there is a great spatial and temporal variability of surface water. Groundwater as well, especially deeper groundwater, will not be replenished as quickly as the surface water. As seen from the table, especially Uzbekistan and Turkmenistan are dependent on water sources located outside of the country borders. This makes them more vulnerable in case of political conflict and hydro-political issues.



**Table 1.** Totally renewable water resources in Central Asian countries (surface and groundwater, after [23–25]).

Country	Total Renewable Water Resources (km <sup>3</sup> /Year; within Brackets is Given Share of Outside Sources)	Total Renewable Water Resources (m <sup>3</sup> /Capita and Year)	Average Precipitation (mm/Year)	Main Agricultural Production
Kazakhstan	117 (34)	6490	250	Wheat, livestock
Kyrgyzstan	58 (0)	8480	530	Livestock
Tajikistan	99 (16)	13,500	690	Cotton, wheat
Turkmenistan	25 (23)	4090	160	Fruit, vegetables
Uzbekistan	59 (34)	1870	265	Cotton, wheat, fruit

During the last decades of the 20th century, Central Asia suffered an enormous ecological crisis. The Aral Sea, the fourth largest lake in the world, started to dry up [27]. The reason for this was the doubling of irrigated agricultural area from 4.3 to 8.2 million ha. Due to the changed ecology, several hundred thousand square kilometers with a population of several million have been damaged [28].

As seen from the above, the Central Asian states are not water scarce in terms of total water supply per capita. The uneven distribution in space and time in combination with excessive and often uncontrolled withdrawal for irrigation, however, create water scarcity especially in areas to the south. These problems can only be solved at the international level and involving integrated water resources management. This, however, requires a political will and the involvement of all stakeholders, including an environmentally aware public.

### 3. Threats to Water Quality

#### 3.1. Human Waste

Just before the Soviet Union collapse, about 70% of all cities and 20% of all villages had their own wastewater collection systems [23]. Wastewater treatment plants were usually designed with mechanical and biological treatment. When the Soviet State collapsed in 1991, the majority of wastewater treatment plants halted their operation. During the following period, lack of investment and maintenance resulted in serious degradation of the majority of sewage treatment plants. Still, most wastewater treatment plants do not operate efficiently. Their present technical standard is insufficient due to lack of equipment and spare parts, chemicals, and trained personnel [23]. Almost everywhere, biological treatment stages are not functioning efficiently. Mechanical treatment is only operating at a few city wastewater treatment plants.

According to Unicef and the MDG (Millennium Development Goals) the portion of the 2015 population who gained access to improved sanitation since 1990 for Caucasus and Central Asia was 24% [29]. All Central Asian countries except for Turkmenistan (no data) achieved 93%–100% improved sanitation. Reviews indicate that improved sanitation can reduce diarrhoeal diseases by 32%–37% [30–32]. However, improved sanitation needs to be combined with good operation and maintenance of water supply systems. Worn-out water pipe-lines are often the reason of deteriorated potable water quality and higher incidence of intestinal infections.

One gram of fresh faeces from an infected person can contain  $10^8$  viral pathogens,  $10^8$  bacterial pathogens,  $10^4$  protozoan cysts, and  $10^4$  helminth eggs [33,34]. The lack of sanitation, as well as occurrence of polluted water, cause different consequences in the health of the population [35]. Drinking water provided by old water pipes can be the cause of acute gastrointestinal illnesses such as typhoid, dysentery, and cases of viral Hepatitis A [35–37]. Diarrhoeal disease accounts for an estimated 4.1% of the total DALY (disability-adjusted life year) global burden of disease. It has been estimated that 88% of that burden are attributable to unsafe water supply, sanitation, and hygiene according to World Health Organization [28]. In the harsh climate of Central Asia, rural villagers often obtain water from shallow wells [38,39]. These wells are typically located near the house and the

outdoor toilet. The prevalence of *Helicobacter pylori* infections is inversely related to living standard and sanitary practice [40,41]. *H. pylori* infection is linked with gastritis and associated diseases such as peptic ulcer, gastric adenocarcinoma, and primary gastric lymphoma [36]. In Kazakhstan, the morbidity and mortality associated with gastrointestinal diseases are high and gastric cancer is the second largest cause of cancer death [38,42]. Results by Nurgalieva *et al.* [38] suggest that transmission of *H. pylori* can be water borne, related to poor sanitary practices, or both.

### 3.2. Agriculture

Central Asia has been one of the world's fastest growing regions since the end of the 1990s [18]. Thus, the area has shown a strong development potential. The reasons for this are natural resources such as oil, gas, and gold together with cotton and agricultural production combined with acceptable infrastructure and human capital. The added value of agriculture to the GDP is about 10% for the Central Asian region (2010) [18]. It generally ranged from 5% in Kazakhstan to about 21% in Kyrgyzstan and Tajikistan. On average, about 30% of the economically active population are engaged in farming (ranging from 14% in Kazakhstan to 29% in Turkmenistan) [18]. Cultivated area per person economically active in agriculture varies from 1.1 to 1.7 ha/person in Tajikistan and Uzbekistan respectively, 2.7 ha/person in Kyrgyzstan and Turkmenistan to almost 20 ha/person in Kazakhstan [18]. This gives an average for the region of 3.3 ha/person.

Requirements to maximise irrigated agriculture during the Soviet era resulted in a general degradation of water resources. After independence, most countries in the region adopted national policies regarding water supply and sanitation. Still, about 90% of the total water supply are used for irrigation [23]. Intensified irrigation increases the water pollution by chemicals used in agriculture. Increased agricultural production leads to an increased usage of mineral fertilizers and chemicals protecting plants against pests, weed, and diseases. As a result, many chemical substances, pesticides, and herbicides are discharged to the environment. Some of the substances such as DDT are bio-resistant and have a reported half-life of about 15 years in soil.

The drying up of the Aral Sea and the decrease of the water surface area combined with increasing contamination levels in the remaining water bodies, constitute a threat for environment and humans [27]. Irrigation return contains salts, fertilizers, pesticides, herbicides, and cotton defoliant [43]. However, at present significant efforts are being made to restore wetlands, improve habitat conditions, and reduce pollution in the Aral Sea region [44]. Even so, I.V. Severskiy [2] notes that salinization and pollution problems are increasing due to irrational land and water use. About 50% of the irrigated area in the Aral Sea basin are experiencing increased salinization. This has resulted in up to 50% reduction in agricultural productivity [45,46]. Agricultural pollution is especially affecting downstream areas of Amu Darya and Syr Darya [2]. Copper, zinc, and chromium concentrations exceed maximum permissible concentration [47]. More than 70% of the area within the Amu Darya Basin in Uzbekistan have a water quality that is dangerous to health. More than 10% of the water are extremely dangerous [48,49].

The above clearly materializes two areas of strong concern, safe sanitation and safe management of chemical elements in agriculture. Large investments are needed to rehabilitate both water supply and sanitary systems in Central Asia. The public need to be made aware of the dangers with using open unprotected water sources and the direct benefits of paying for a safe water supply. For irrigated agriculture in the south Central Asia, wasteful irrigation techniques need to be curbed. If possible, re-use techniques of water should be developed. Alternative methods to the excessive use of herbicides and pesticides need to be established. At the same time, environmental control and management need to be put in place involving all concerned stakeholders.

### 3.3. Industry

Surface and groundwater quality in the Central Asian region, is commonly affected by agriculture, municipal wastewater as well as industry. In Kazakhstan, water sources are often classified as

unsatisfactory [18]. Common types of water pollution is chemical, oil, manufacturing and metallurgical industry contamination. The Kazakhstan Hydrometeorology Service Bureau classified less than 30% as clean out of 44 investigated water sources in 2002. Also, besides the common polluters such as industrial, mineral extracting and refinery enterprises, urban buildings, farms, irrigated fields, waste containers, and storage facilities for liquid and solid waste and oil products contribute to the general pollution level [18]. River water in Kyrgyzstan, however, usually displays good water quality due to that it is fed by glacial melt. Nitrate, organic matter content, and nutrient contents are usually low. There are a few cases of water pollution from storage facilities and use of fertilizers and chemicals, industrial waste, non-compliance of the sanitary code, improper conditions for sewerage systems, cattle breeding, and industrial effluent. The water source for drinking water is usually groundwater. Nuclear tailing dumps, however, are a serious problem in Kyrgyzstan. Also in Tajikistan, water supply is in general satisfactory, except for a few lakes and groundwater sources. In Turkmenistan, however, river water and drainage networks are often polluted. The river water repeatedly contains high concentrations of salts and pesticides both from domestic sources and upstream international basins. This is especially the case for the Aral Sea Basin where the human pressure on surface water is high. In Uzbekistan, some rivers that receive discharge of sewage and municipal wastewater display high pollution levels. Pollution from petroleum industry may reach 0.4 to 8.2 MAC (maximum allowable concentration), phenols pollution may reach 6 MAC, nitrates 3.7 MAC, and heavy metals 11 MAC [18]. This also threatens the groundwater.

#### 4. Access to Safe Water Drinking Water

##### 4.1. Drinking Water Supply

In general, during the last 10–15 years of independence, the quality of the water supply services has dramatically deteriorated [23]. The main cause for this deterioration is the marked reduction in public spending due to the general economic recession. In 2010, about 74% of the total population in Central Asia, 94% of the urban, and 64% of the rural population had access to improved drinking water sources (Table 2). About 7.5 million in Uzbekistan, 4.8 million people in Tajikistan, and 2 million in Kyrgyzstan lack proper access to clean drinking water [22,50,51]. The World Bank points at the Kyrgyzstan's worsening health indicators are caused by poor sanitation and hygiene [52]. However, the World Health Organisation (WHO) notes that improved access to water in Central Asia has occurred since 2011 [53]. WHO [53] summarized problems with safe access to drinking water in Kazakhstan but this also holds for most of Central Asia [54]:

- 1 Degradation of the water supply infrastructure that is 80%–100% in some cases leading to frequent interruption of water supply and massive losses of water;
- 2 Unclear relationships between willingness to pay for water supply service and installment of meters in relation to perceived gains;
- 3 Despite measures aiming at providing public access to fresh water it is still unavailable for a majority of the rural population.

**Table 2.** Access to drinking water and sanitation in Central Asia (adapted from [23]).

	Access to Water for Population (%)		Coverage of Sanitation System (%)	
	Urban	Rural	Urban	Rural
Kazakhstan	78	>35	84	10
Kyrgyzstan	82	58	68	28
Tajikistan	93	49	20	5
Turkmenistan	85	42	62	2
Uzbekistan	90	71	85	40

On the positive side, Roberts *et al.* [55] found that there have been improvements in access to piped water in Central Asia between 2001 and 2010. However, the authors state that still significant gaps remain. This is particularly true for the rural and poor households. There is a need for sustained investment in basic infrastructure for piped water in the region that ensures poorer and rural populations to benefit. In Kazakhstan, 78% of the urban population and >35% of the rural population have access to a varying degree of safe drinking water [23] (Table 2). In general, urban areas are supplied rather well with both drinking water and safe sanitation. Rural areas at large distances from central water supplies and piped sewage systems face serious difficulties. In Kyrgyzstan, the same figures are 82% and 58%, respectively. The wear-and-tear of the rural water supply system is >40% that often means contamination of microbes and chemicals [23]. According to Global Water Partnership, Central Asia and Caucasus [23], a population in excess of 600,000 people in Kyrgyzstan does not have access to safe sources of drinking water and take water from irrigation canals, ditches, and rivers. In Tajikistan, 93% of the urban population and less than 49% of the rural population have access to piped drinking water. About 80% of the rural population use water that does conform to hygienic standards [23]. In Turkmenistan about 85% and 42%, in urban and rural areas, respectively, have access to piped water. The same figures for Uzbekistan are about 90% and 71%. According to the above, it is clear that especially the rural and poor households do not have access to safe water supply. The situation is similar all over Central Asia.

#### 4.2. Treatment of Drinking Water

Inferior drinking water quality contributes to the general health problems of the population [55–65]. The low level of access to high-quality drinking water is only one of the major problems in Central Asian countries. Ageing and lack of maintenance of water pipeline networks cause emergency conditions, in which people have to use water from other, mostly untreated sources of water. Other factors also play a major role such as pollution of water supply sources, discharge from industry and agriculture, and secondary pollution of drinking water by bacterial activity caused by deterioration of the anticorrosion coating of pipe surfaces [31,66].

The majority of existing drinking water treatment plants and water supply systems in Central Asia were built during the period 1950–1980. The construction philosophy was to build systems that needed low capital investment and small cost for process equipment but considerably high operational costs [23]. The main emphasis was to exploit new water supply sources in terms of pumping stations, water treatment facilities, and maximum flow capacity in main water pipes. Efficient development of water distribution systems, their zoning and rational water use, metering and administrative issues were considered to be outside of the operators' scope of activities [23]. The main problem of today is often to supply rural areas with safe water in a degraded pipe system. In many cases disinfection by chlorine is the only method used. Sometimes no disinfection is taking place. However, even chlorination will not be satisfactory due to leaks and contamination during flooding. In order to modernize the water supply system that on average is older than 35 years over vast areas such as, e.g., the Kazakhstan territory, huge investments are necessary. A possible strategy would be to also invest in locally adapted small-scale water supply and sanitation systems.

### 5. Health Impacts

K. Frenken [18] investigated health effects from water-related problems in Turkmenistan, Kyrgyzstan, and Uzbekistan. The authors summarized that, although no information is available, similar problems may be present in also the other countries of Central Asia. Major factors affecting the spread of water-related diseases were identified as:

- 1 Use of untreated wastewater to meet water shortage;
- 2 Lack of infrastructure, especially related to wastewater treatment and discharge;
- 3 Lack of health awareness and proper handling of polluted water; and
- 4 Lack of regulations related to the protection of the environment and public health.

In Kyrgyzstan, 122,800 inhabitants were reported to be affected by water-related diseases (2005). In Turkmenistan, inhabitants affected by water-related diseases were estimated to be 12,295 (2004). Out of these, 7955 were intestinal infections, 22 were typhoid, and 4318 were virus hepatitis. An outbreak of malaria with 137 cases occurred in 1998. Since then malaria is reported as eliminated. In Uzbekistan, agricultural productivity is reduced due to land and water salinization. The population in these areas suffers from high levels of anaemia, together with growing levels of tuberculosis. Children are affected by liver, kidney and respiratory diseases, micronutrient deficiencies, cancer, immunological problems, and birth defects. In Karakalpakstan 40% of the rural population depend on small subsistence plots for their livings. These plots are negatively affected by water scarcity and pollution. The situation worsened during 2001–2002 in Karakalpakstan and Khorezm from a drought period and water shortage negatively impacted domestic and personal hygiene [18]. During this period the poor rural people were exposed to a higher risk for water-related diseases such as typhoid, diarrhoea, and worm infections. The government has made progress, however, still only 54% of the urban and 3% of the rural population have access to adequate sewage systems.

### 5.1. Non-Microbiological Contaminants

Release of contaminants from industry and agricultural areas can spread pollutants to extensive downstream areas. Raised concentrations of organochlorine pesticides and toxic metals such as arsenic have been found in human blood, milk, hair, and urine of the exposed population living in the Aral Sea Drainage Basin [67–70]. The exposed population is experiencing increasing maternal and infant mortality, delay in growth and puberty of children, liver and digestive problems, allergies, and diseases related to occurring bacteria in water [67,71,72]. In the area, only 20%–30% of the rural population have access to piped water and 25% use water from irrigation channels as their main drinking water source [73]. Also other elements have been found in the drainage basin's surface and groundwater with higher concentrations as compared to the World Health Organization (WHO) maximum recommended contents such as nitrogen species, copper, lead, chromium, and uranium [67,74–77]. The type of health effects depends on type of contaminant and exposure time [59,67,78]. Organic pollutants such as DDT, DDD, and DDE are used in controlling weeds and pests in the Aral Sea Drainage Basin and probably elsewhere in Central Asia. Törnqvist *et al.* [68] found that the surface water constituents copper, arsenic, nitrite, and DDT in Mejdurechye reservoir are above recommended maximum concentrations by WHO and represent cumulative health hazards. Even more alarming results were that groundwater was overall associated with much higher health risks as compared to surface water. Switching from surface water to groundwater, e.g., during drought periods, is therefore not encompassing better quality water.

### 5.2. Microbiological Elements

As mentioned above, contact between inappropriate sanitary facilities and drinking water supplies can result in serious infection risks. Matthys *et al.* [79] investigated the overall prevalence of infection with helminths and pathogenic intestinal protozoa in school children for a rural area in Tajikistan. Helminthiasis and intestinal protozoa infections are of considerable public health importance in Tajikistan and elsewhere in Central Asia [80,81]. The overall prevalence of infection with helminths and pathogenic intestinal protozoa was found to be 32% and 47%, respectively. There was pronounced spatial heterogeneity. The most common helminth species were *Hymenolepis nana* (26%), whereas the prevalence of *Ascaris lumbricoides*, hookworm, and *Enterobius vermicularis* was below 5%. The prevalence of pathogenic intestinal protozoa, namely *Giardia intestinalis* and *Entamoeba histolytica*/*E. dispar* was both 26%. Almost half of the households took drinking water from open water sources, such as irrigation channels, rivers, and unprotected wells. The households used sanitary facilities such as pit latrines, mostly private, and sometimes shared with neighbours. The use of public tap/standpipe as a source of drinking water supply proved to be a protective factor against *G. intestinalis* infection. Protected spring water also reduced the risk of infection with *E. histolytica*/*E. dispar* and *H. nana*.

Climate change is likely to have less effects on human vulnerability as compared to changes in land use and inefficient water management [82]. However, climate change is likely to increase the region's vulnerability through the water supply and thereby water-borne and vector-borne infections. The rapid economic decline after the Soviet State collapse in 1991 brought back epidemic typhus, tuberculosis, diphtheria, meningitis as well as other infectious diseases to Central Asia [83,84]. Another example is malaria through the *Plasmodium falciparum* that was almost eradicated in Soviet Union by the end of the 50ies through campaigns of insecticides, anti-malarial therapy, land reclamation, and water management. However, in the 1990s malaria was back in Uzbekistan, Kyrgyzstan, Turkmenistan, and Tajikistan [85]. Climate change resulting in increase in winter temperature and changing precipitation patterns may increase the region's vulnerability by creating more favorable conditions for vectors and parasites. In addition, infectious diseases spreading through oral-fecal mechanisms, e.g., typhoid, paratyphoid, salmonella, dysentery, amebiasis, and helminthiasis, are all associated to warm climate [82].

## 6. Conclusions and Discussion

The Central Asian countries share many common problems and unaddressed tasks in health-related water supply and sanitation [23]. The degradation rate of the water supply systems and sewage treatment plants are high. This leads to potentially high water loss rates and inadequate accessibility to safe water supply which is a specific problem for rural areas. Low tariffs in combination with absent metering and low collection rates for water fees mean that operation and maintenance costs for basic services of water supply and sanitation are not covered. The human resource base for the water supply and sanitation systems needs to be better trained and capacity building is needed for the governance. Large distances between remote and sparsely populated villages in rural areas means that alternative systems may be needed. Such systems may be constituted by efficient and small-scale water supply and sanitation systems.

The environmental codex and regulations need to be implemented and strengthened. Ecological expertise needs to be supplied to industrial as well as agricultural activities in order to ensure appropriate environmental monitoring of pollutants. The polluter pay principle needs to be introduced and legislated [31].

Legislative and controlling environmental authorities need be strengthened and made more efficient. There is a general lack of integration between ministries, nongovernmental organizations, and the general public. By implementing integrated water resources management all ministries for environmental protection, agriculture, water resources, health, local governments, municipal authorities, nongovernmental organizations, and representatives for industry can jointly solve water and environmental problems, create national action plans, as well as plans on the regional and local levels.

Ecological thinking needs to be stressed in education. Also, the general awareness regarding environment and detrimental effects of human and industrial waste needs to be strengthened.

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# Paper II





Article

# Access to Drinking Water and Sanitation in Rural Kazakhstan

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**Abstract:** The Sustainable Development Goals (SDGs) require nations to ensure adequate water supply for all. For Kazakhstan, this means that rural areas will need much stronger attention as they have been rather neglected in efforts to comply with the Millennium Development Goals (MDGs). This study aims to establish a baseline data concerning the current situation in villages that will need interventions according to the SDGs. The study was performed by means of questionnaires. The results should be seen as initial guidelines that can help to illuminate some of the uncounted challenges in future efforts to meet the SDG targets. As hardly any information exists about sanitation in rural Kazakhstan, the study essentially focuses on water services. The results show that 65% of rural dwellers want to connect and pay for the piped water supply. At the same time, about 80% have toilets outside their home. Consequently, the water program aiming at providing 80% of rural people with access to tap water from a centralized piped system will not be possible. However, by carefully managing the existing water supply and sanitation system in joint collaboration with the local users, significant progress can be made. The present results show the important first steps that need to be taken in this direction.

**Keywords:** access to drinking water; sanitation; water services; rural Kazakhstan; SDG

## 1. Introduction

Access to safe drinking water and sanitation is essential for both individual and population health as well as for quality of life and dignity. Indeed, improvement in water supply, sanitation, and hygiene has shown substantial influence on reduced water borne diseases such as diarrhea [1]. However, 663 million people worldwide still lacked improved drinking water sources [2,3], although the UN Millennium Development Goals (MDGs) for drinking water were achieved in 2010 on a global scale. However, several developing regions including Caucasus and Central Asia did not reach the MDG target. Moreover, with 2.4 billion still lacking improved sanitation facilities and 946 million practicing open defecation, the sanitation target was missed by almost 700 million people. Especially, there is a strong disparity between urban and rural populations. Eight out of ten people still without improved drinking water sources live in rural areas. The MDG progress report showed that the Kazakhstani urban population is 90% covered by piped water on premises, while only 28% of the rural people have access to piped water [2,3]. About 20% of the rural population in Kazakhstan actually has the same level of piped water coverage as sub-Saharan Africa.

The UN MDGs have now developed into the UN Sustainable Development Goals (SDGs) [4]. The SDGs present a continuation of the MDGs and a road map for how to ensure sustainable social

and economic progress worldwide. Thus, the SDGs seek not only to eradicate extreme poverty, but also to integrate the three dimensions of sustainable development. An important difference between the MDGs and the SDGs is the change from a top-down to a bottom-up approach [5]. Thus, the SDGs emphasize gender goals, people's participation, as well as local governance to reach sustainable development. The well-established links between poor sanitation and poor health mean that water supply must be viewed in connection with sanitation, and hygiene promotion as a coherent whole (WASH) [6,7].

Kazakhstan was the last of the Soviet Republics to declare independence after the dissolution of the Soviet Union in 1991 [8]. During the Soviet period, the poor living conditions experienced by much of the Kazakhstani population in the early part of the twentieth century were tackled by expanding access to essential services such as piped water. However, when the Soviet Union dissolved in 1991, the historically disadvantaged rural population still had limited access to water and the situation has become worse. Important elements of the state apparatus have been dismantled, leading to shortages of basic goods and services. Due to the transition from a socialistic to a market oriented system, the existing water supply system was not maintained and thus, has gradually deteriorated [9].

Information on access to drinking water and sanitation is based on official Kazakhstani statistics, data from the Joint Monitoring Program (JMP), and case studies provided by different researchers. According to [10], 17.3% of the rural Kazakhstani population had access to cold water on tap from the piped system and 2.8% had access to hot water on tap in 2001. The same survey showed that 92.2% of rural people had toilets outside the home, 7.5% inside the home, and 0.3% did not have access to toilets. According to the UNDP [11], the rural share of population corresponds to 43% and only 36% of them have access to a centralized water supply, 57.3% use groundwater (wells and boreholes), 2.6% use water from surface sources, and 4% drink delivered water. Previous studies have shown that only 2.8% of rural houses are connected to the sewage system. About 5% have in-house toilets, including 1.7% with toilets connected to local sewage systems, mostly wet pits [11]. This indicates that the sanitation level in rural Kazakhstan might be low.

Recent research has shown that there have been no significant changes in patterns of access to piped water during the period from 2001 to 2010, in neither rural nor urban areas in Kazakhstan [12]. In rural areas, access to piped water still remains about 29%. This situation is surprising because a massive governmental drinking water program for the rural areas was launched from 2002 to 2010 [13]. In any case, there is an urgent need to improve the water supply and sanitation conditions for rural areas in Kazakhstan. In addition, if rural water projects are to be both sustainable and replicable, an improved planning methodology is required that includes peoples' desire to use different levels of services [13]. In particular, the people's participation is crucially important. A new massive drinking water program in Kazakhstan has the aim to cover 80% of the rural people with access to tap water from a centralized piped system by 2020 [14]. Before executing such water supply projects, it is important to know the current situation of access to drinking water and sanitation services as well as whether or not people are willing to accept the new systems [15]. In line with this, the present study examines the current access to drinking water and sanitation services in rural areas of the Pavlodar region, Northern Kazakhstan. The aim is to estimate the willingness of different water users to connect to the piped water supply system to have tap water at home. The results are important since they can be used to predict the willingness to connect to public water supply and sanitation systems. Consequently, the results in this paper are important for the planning, policy development, as well as the management of new drinking water and sanitation programs in order to provide WASH for all.

## 2. Methodology

### 2.1. Area Description

The Pavlodar area is one of 14 regions in Kazakhstan. The region is located in the northeastern part of Kazakhstan within the Irtysh River Basin. It includes three cities and 412 rural districts (Figure 1). The population of the rural districts is about 270,000 persons. The area is dry with constant winds and

about 250 mm of precipitation per year on average. The scant precipitation is unevenly distributed within the territory and between the seasons. Up to 80% of annual precipitation falls during the summer period. Most of the rainfall ends up as soil moisture and evapotranspiration. Average annual class A pan potential evaporation is about 800 mm. Thus, the available water resources of the region are mainly the Irtysh River and groundwater. Smaller rivers usually have a short spring discharge after snow melt before they dry up [16].



**Figure 1.** The experimental rural area around Pavlodar City in Kazakhstan.

## 2.2. Water Supply Sources and Wastewater Management

The governmental decree on “Sanitarian-epidemiological requirements for water resources, drinking water sources, locations of cultural-domestic water use, and safety of water” regulates the water supply and drinking water sources in Kazakhstan [17]. Accordingly, main water supply systems are classified as centralized or decentralized (Table 1). The main difference between them is that the centralized water supply has a distribution system to provide water from the raw water source with or without treatment to the water user. The decentralized water supply system uses water directly from the raw water source with or without treatment. Consequently, centralized water supply means water provided through pipes to households (tap water) or public standpipes according to Table 1. Protected boreholes and wells are considered decentralized water supply sources. In order to be classified as having access to drinking water, one of the water supply sources should be accessible within a 500-m distance from the household. Both groundwater and surface water are sources for the centralized system. However, groundwater is the most common raw water source for rural centralized systems in the region. Official statistics also entail water users consuming water delivered by truck. Delivered water is regarded as an unsustainable water supply source and perceived as a temporary solution. Complex Block Module (CBM) is water for sale. It is typically constituted by treated groundwater that is sold by private vendors at a kiosk in gallons. This type of water is used



for drinking water purposes in villages where a public water source is not available. Official statistics do not distinguish decentralized water sources being used privately or publicly (shared) while this survey includes both private and public decentralized water sources (Table 1).

**Table 1.** Drinking water sources in northeast rural Kazakhstan.

Drinking Water Sources									
Centralized		Decentralized					Other		
tap water	standpipe	Borehole private	public	Well private	public	CBM	open source	other	

CBM: Complex Block Module.

The Soviet State tried to provide rural people with drinking water and build systems that needed low capital investment and small cost for process equipment but considerably high operational costs [18,19]. The majority of these water supply systems were constructed during the period 1950–1980. After dissolving the Soviet Union, the new government had little accountability and, in some cases, no financial capacity to maintain the water distribution systems. This led to a rapid deterioration. Although a national rural water program was put in place during 2002–2010, the poor management of the program was a major problem that resulted in virtually no progress. Even though the water supply systems are in a deteriorated state, not maintained, and officially recognized as not being used, rural people may still use these systems. The main problem of today is thus often to supply rural areas with safe water in a degraded pipe system.

As mentioned above, the Soviet State provided the water supply system. The wastewater collection and treatment system was, however, the responsibility of the villagers. Thus, the rural wastewater collection differs from village to village. Usually, however, rural houses have an outside pit latrine as a toilet. Greywater is often collected in a septic tank. Sometimes the water distribution system is complemented with sewage collection pipes where greywater goes untreated to local cesspools or wetlands. At present, however, there is no reliable information on how the wastewater is managed in the different villages.

### 2.3. Sample Collection

The survey was performed in the rural area around Pavlodar City outlined in Figure 1. The area covers 5578 km<sup>2</sup> and 37 rural villages. The survey was performed in three steps. Initially, a pre-survey included visits to two villages and interviews with village mayors, village council responsible, hydrogeologist in the area, and village inhabitants. The experiences from the pre-survey were used to jointly design a pilot study together with the above collaborators. As noted by, e.g., Grosh and Glewwe [20], it is important to involve a team of experts, including members of the organization implementing the household survey. In the pilot study, 10 villages were randomly selected for a study on willingness to pay for water supply. The results of the pilot study were reported by Tussupova et al. [7]. The rest of the villages, in total 27 rural villages of different size, were investigated in the present survey conducted during July–August 2013. Thus, due to the participation of the 10 first villages in the pilot study, these were not included in the present survey.

Through the above-mentioned close collaboration with the local municipalities, a questionnaire was designed and distributed to all households in the 27 villages and consequently collected by the village mayors. Due to the local rules for performing interviews, this was a necessary manner to collect interviews, which meant that the practicalities were beyond influence by the investigators. As a result, response rates came to vary significantly among different villages. Depending on village, the households had from several days to a few weeks to answer the questionnaire. Interviews represent households and not individuals. Interviews were performed with the head of the households. The response rate was about 42%, ranging from 4% to 100% in each village (Table A1). Altogether, 2570 questionnaires covering 8493 persons in the area were collected. The objective of the survey

was not to investigate conditions in individual villages but instead to get an overall picture of the access to water supply and sanitation in a larger representative area. Since the response rate varied significantly among different villages, the results should be seen as initial guidelines that can help to illuminate some of the uncounted challenges in future efforts to meet the SDG targets. The reasons for not receiving a higher response rate than 42% may have been: during the sampling period, some of the respondents were on summer work in the field and may not have been at home during the questionnaire distribution; some respondents might have had other reasons for not replying. In order to estimate the population-based representative sampling, Equation (1) was used to calculate the margin of error [21]:

$$n \geq N / (1 + e^2 N) \tag{1}$$

where *n* is the sample size, *N* is the population size, and *e* is the margin of error denoting the allowed probability of committing an error in selecting a small representative sample size. According to Equation (1), the margin of error *e* for the survey is less than 0.02%, hence, the overall results can be viewed as statistically highly significant.

The questionnaire contained enquiries regarding the water source for drinking water, its perceived quality, reliability, time spent for collection, water treatment methods together with access to toilets, socioeconomic, and demographic characteristics. The data were analyzed using SPSS Version 22.0.

### 3. Results and Discussion

#### 3.1. Description of the Households

Table 2 shows a general description of the investigated households. It is important to establish the general socioeconomic and demographic characteristics of the households since safe access to water and sanitation to a major extent is a question of socioeconomic conditions [22–24]. Most of the respondents were women (64%). This perhaps visualizes that women perceive water quality and sanitation as more important as compared to men. The span of age distribution was broad among the respondents. The migration in the area is quite low and most households have lived in the area for more than 5 years. The most common household structure is two adults and two children with an average of about 3.5 persons per household. A total of 96% of households do not include more than six persons.

**Table 2.** Description of investigated households (SD = standard deviation).

Description	Percent	Mean
Respondent characteristics		
Sex of respondent: 1 = female, 0 = male		0.64
Age of respondent (min = 17, max = 90)		47 (SD 4.6)
Socio-economic characteristics of the household		
Living time for the household in the area:		
Less than 5 years	7%	
Between 5 and 10 years	14%	
More than 10 years	79%	
Number of people in household (min = 1 and max = 12). 90% of households contain up to 5 persons		3.45 (SD 1.6)
Family with children up to 18 years old: 1 = yes, 0 = no		0.51
Household monthly income in KZT * (min = 1000, max = 650,000, Median = 40,000)		52,057 (SD 36,091)
Household income perception		
Very good	2%	
Good	19%	
Satisfactory	70%	
Bad	8%	
Very bad	1%	

\* 150 KZT around 1 USD as of January 2012.

The average monthly household income was 52,057 KZT with a standard deviation of 36,091 KZT (150 KZT around 1 USD as of January 2012). Probably, the notion of household income perception is a better description of household income. This displays how much the household can afford for a certain income. As shown by [10], there is a tendency in Kazakhstan to perceive the income better than before. This indicates that the economic situation of the households is improving.

### 3.2. Overview of Access to Drinking Water and Sanitation

Figure 2 shows the rural users’ water supply source depending on the toilet situation. As seen from the figure, more than 80% of the respondents have toilets outside their homes. Most of these (39%) take water from private boreholes. About 16% of them use standpipe water. A further 9% take water from private wells and 5% of rural users take water from open sources such as water directly from the Irtysh River. These users mainly live close to the river. In total, 15% have a toilet inside their homes and about 4% do not use a private toilet meaning that they use a public pit latrine. Only 3% have a toilet inside that is connected to a sewage system and 12% have toilets inside but are not connected to the sewage network.

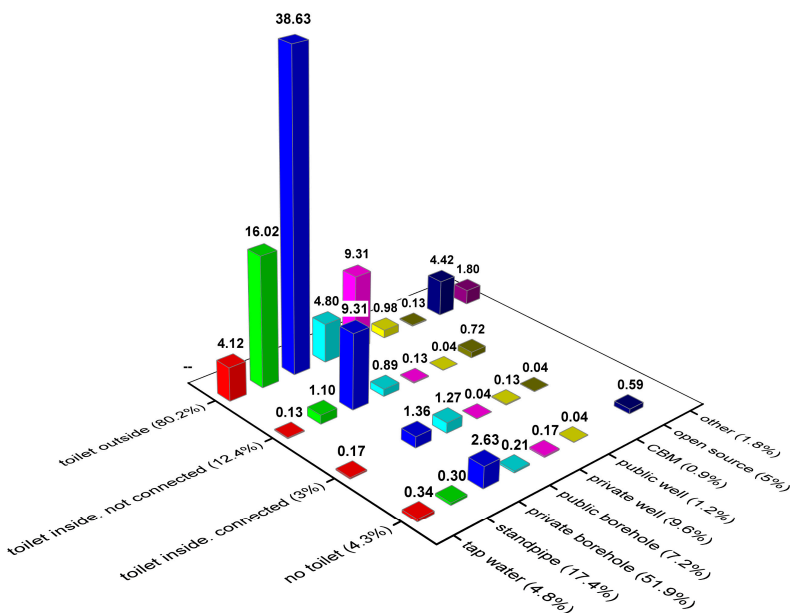


Figure 2. Rural users’ water supply source depending on toilet situation (%).

The most common raw water source is private borehole (>50%). The second most common water supply source is a standpipe (about 7%). Standpipes can usually be found at every street crossing in the rural villages.

Mainly four villages represent households that use open water sources (5%). All of these are relatively close to the Irtysh River. These villages, either in the past or currently, have had access to a piped water supply system. This leads to the conclusion that the water supply situation is problematic in these villages.

### 3.3. Household Access to Sanitation

Three questions were posed regarding access to sanitation, namely: (1) no private toilet; (2) private toilet outside home; and (3) toilet at home either connected to the sewer system or locally collected to

a septic tank (Figure 2). The majority (80%) have their toilets outside in the yard in the form of a pit latrine and they are not connected to a sewage system. This is usually a hole in the ground, up to a few meters deep, which is covered by a concrete slab. Only about 15.3% have their toilet inside the house. Moreover, those who have toilets at home mostly use septic tanks for the sewerage. No toilet means no access to private toilet, and the household most probably uses a shared toilet outside with no charge.

It is important that a management system be developed to provide safe sanitation for the rural areas. The SDG target 6.2. suggests to support and strengthen the participation of local communities for improving water and sanitation management. Thus, a key aspect of this management system is to build on local participation and needs. The sanitation system of today to a major extent separates toilet waste and greywater. Building on local solutions that preserve the advantages, such as possibilities to re-use the greywater, would decrease needs for large-scale and expensive public treatment plants. Thus, careful planning and management are needed for the next step in the sanitation development. The new SDG goes beyond access to basic facility and addresses the safe management of fecal waste along the sanitation chain. The SDG indicator “percentage of population using safely managed sanitation services” means the proportion of the population using different types of basic sanitation facilities such as flush toilets and pit latrines, which are not shared and safely disposed in situ or transported and treated off-site. The emphasis is not whether a flush toilet is connected to a sewer system or septic tank or if pit latrines are used but instead on safe disposal of the excreta in order not to pollute the environment. Thus, a more economically feasible alternative for a sustainable sanitation system may be to concentrate on safe excreta disposal for those who use pit latrines rather than building a new large-scale wastewater system.

#### 3.4. Household Access to Drinking Water

The most common water source, used by more than half of the investigated households, is groundwater through a private borehole (Figure 2). Boreholes are generally 8 to 50 m deep with a diameter of 10–30 cm. Water is usually pumped by electricity and in rare cases by hand. Boreholes are usually covered with a plastic top. Some of the households have connected the standpipe to their homes and have tap water from the borehole. All villages except one use water from boreholes.

The second most common water source is standpipe water (17%). Standpipe water is groundwater distributed through pipes and obtained from a standpipe at street crossings. In some cases, the standpipes may not be controlled and officially closed for usage. In many cases, however, people continue obtaining water from them. Only villages that historically have had or at present have access to pipelines may use standpipe water.

Private wells are used by about 10% of the households. Wells are usually about 10 m deep with a diameter of 0.5–1.5 m. In most cases, wells are covered with a wooden top. Public boreholes are used by 7% of the households. All households in a village can use standpipes connected to public boreholes. Often, piped water supply is constituted by groundwater from public boreholes. In some cases, people still use water from public standpipes created during the Soviet era.

The number of households that use open source water or have access to tap water at home coming from a central water supply system is almost the same, about 5% in each category. Groundwater is the main source of water for the central water supply. Open source water is taken from the Irtysh River either directly by the households or delivered from the source by payment. It is common for piped consumers to return to open sources when the system fails to deliver. This shows that there is an obvious problem in these villages to access safe water and a non-functioning public water supply. Households in few villages only, use water from a public well. Several households may share the well. The basic construction is similar to a private well.

Very few households use delivered water. A special tanker delivers this water usually for a fee. According to the law in Kazakhstan, the government is responsible for providing people with potable water. The local municipality usually provides delivered water to the households that do not have access to potable water. This is not a sustainable solution; however, it must be used when there is no

other way to provide potable water. In some cases, households themselves order delivered water and pay extra for this.

The CBM is an abbreviation for Complex Block Module that treats groundwater in a so-called local treatment plant. The water is sold in gallons and people collect it using their own containers. The cost for this water ranges between 20 to 40 KZT per 20 L. Bottled water is water that households buy only for drinking purposes. A small number of households uses other sources of water for drinking purposes.

### 3.5. Perceived Characteristics of Water Source

Three criteria were used to assess perceived characteristics of the water source, namely: (1) satisfaction with the water quality (such as turbidity, odor, and taste); (2) perceived safety of water; and (3) time spent to collect water (Figure 3).

water source	water satisfaction			reliability of water source			time spent to collect water			
	good	not bad	bad	safe	not often	not safe	much	not much	little	nothing
tap water	23%	69%	8%	36%	56%	8%	3%	18%	42%	38%
standpipe	13%	79%	8%	19%	59%	21%	17%	30%	47%	6%
private borehole	33%	57%	10%	36%	48%	16%	8%	20%	40%	32%
public borehole	15%	56%	28%	20%	44%	36%	32%	28%	14%	27%
private well	34%	62%	4%	61%	34%	5%	18%	23%	46%	13%
public well	4%	79%	18%	14%	64%	21%	43%	14%	14%	29%
CBM	86%	14%	0%	100%	0%	0%	0%	10%	85%	5%
delivered water	4%	69%	27%	15%	42%	42%	39%	39%	19%	4%
open source	4%	38%	58%	13%	39%	48%	41%	35%	13%	11%
other	8%	54%	39%	7%	43%	50%	57%	14%	21%	7%
<b>total</b>	<b>26%</b>	<b>61%</b>	<b>13%</b>	<b>33%</b>	<b>48%</b>	<b>19%</b>	<b>15%</b>	<b>23%</b>	<b>38%</b>	<b>24%</b>

Figure 3. Perceived characteristics of the water source.

The perceived water quality assessed the colour, smell, and taste of water. Most households (87%) perceived the quality of water as good or not bad and only a small portion was not satisfied with the quality (13%; Figure 3). Although the satisfaction with the quality of water appears relatively good, still for specific water users the satisfaction rate varies. The most unsatisfied are those who take water from the open and other sources (39%–58%), which is obvious. The most satisfied water users are those who buy water from CBM, although the portion of these water users is quite small. The next most satisfied are those who have a private water source such as private borehole and private well (33%–34%). Even standpipe users and public well users perceive the water quality as good or not bad (83%–92%).

Those who use tap water from the central water supply perceive the water as good (23%) or not bad (69%). Eight percent of the tap water users perceived the water quality as bad. The water from pipes often has a slight brownish colour and may appear to have some smell because of either old or not properly maintained pipes or contains a high mineral content from the groundwater.

In terms of reliability regarding the water source, the majority of households thought that the water source was not safe or not often safe (67%; Figure 3). This term is quite sensitive because it can be interpreted in several different ways. The question can both be interpreted as whether you are sure this water is safe to drink and whether you can obtain water from this source continuously regardless of season and other factors. In most cases, users with private water source find their water relatively safe (36%–61%). Except for the CBM water users, the majority of private well water users think their water source is reliable (61%). It is interesting to note that more than half of the standpipe and tap water users think that the water is not often safe, while one third of tap water users believe it is a safe and reliable source (36%). Only a small number of households think the tap water is not reliable (8%).

This might be due to the fact that the water supply is given on a pre-determined time basis and that people may be ill-informed about this. Further studies are needed to elucidate these problems.

The question regarding time spent to collect water may not have felt relevant to all water users. However, this is an important aspect of water access. Those who use tap water may still have problems with temporal disruptions of the system. A majority of households did not spend any time or any time spent was very little. Those who use public source water generally spend considerable time to collect water (>32%). Those who use private borehole and centralized tap water spend less time than others. For private borehole water users, this might be due to connection problems to the house. Some borehole water users may not spend any time because water is connected to the home and used as tap water. A somewhat surprising result is that CBM water users spend little time. This may be due to the fact that the CBM plant is close to their house. This study did not adopt the distance to the source or exact time indicator. The pilot study showed that even some water users who have water at home could spend time on collecting water and the value of time can differ from person to person [8]. In addition, we find it more relevant to investigate to what extent people value their time to obtain the water.

Table 3 shows the results regarding whether households apply water treatment. This question was meant to decipher whether water users feel a potential risk to use water directly from the source without treatment. As seen from the table, overall, 45% of consumers generally do not treat the water in any way. About 37% boil the water before drinking. Only a small portion of respondents stated that they either let the water settle or use a filter. Again, those who use private water sources such as boreholes, well or tap water use water directly without treatment. A majority of tap water users (59%) do not treat the water before use. Also, those who use delivered water mostly use water directly without pre-treatment.

**Table 3.** Household water treatment (percentage of households giving each response).

Water Source	Sample Size	No	Filter	Boiling	Settling	Other
Tap water	111	58.6	5.4	30.6	4.5	0.9
Standpipe	361	21.9	5.0	67.0	5.5	0.6
Private borehole	1155	51.8	14.2	27.4	6.5	0.2
Public borehole	153	37.9	6.5	47.1	8.5	0.0
Private well	219	50.7	5.9	33.3	9.6	0.5
Public well	26	34.6	0.0	65.4	0.0	0.0
Complex Block Module	22	13.6	77.3	9.1	0.0	0.0
Delivered water	25	52.0	8.0	32.0	8.0	0.0
Open source	89	42.7	5.6	48.3	3.4	0.0
Other	18	50.0	0.0	44.4	0.0	5.6
Total	2179	45.1	10.8	37.4	6.4	0.3

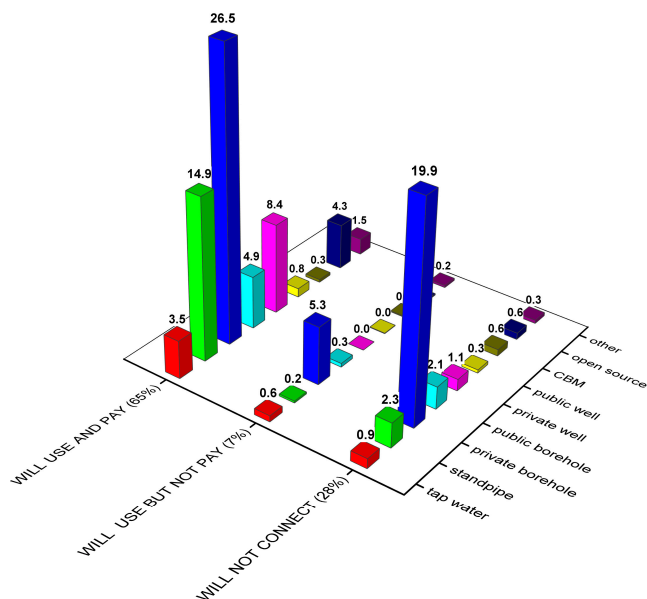
### 3.6. Importance of Water Supply to Household and Willingness to Connect to Piped Water System

Table 4 shows that a majority of households feel that water supply is important for the family. One may interpret this as the household feels either that there is an issue with the water supply or that the household generally thinks the water supply is important. In the questionnaire, we tried to make sure that the respondent understood the question as whether the household has an issue with the water supply and cares about its continuous improvement. In any case, in total, 72% think that the water supply is important.

**Table 4.** Importance of the water supply issue to the household.

Importance of the Water Supply Issue to the Household	Percentage
Absolutely not important	10
Not important	10
Between important and not important	8
Important	38
Very important	34

Figure 4 shows the willingness to connect to the piped water supply system depending on water source type. As seen from the figure, a majority (65%) are willing to connect and pay for the water. About 28% of the households do not want to connect to piped water and about 7% would use it only if there is no fee (Figure 4). Among those who would not use piped water, the majority are private borehole users (20%). It should be noted though that this group is mixed. About 27% of private borehole users say that they are willing to connect to the piped water supply. One missing but interesting question to borehole water users is if water is connected from the borehole to the home. From the pilot study, it was seen that those who have connected water to the home and have a water boiler at home regardless of income have low or no willingness to connect to the piped tap water [7]. One of the reasons is that usually in rural areas cold water only is given through the pipes and households have to heat it by themselves using water boilers. Thus, if the households already have installed a convenient system using borehole water they are unwilling to use anything else.



**Figure 4.** Willingness to connect to the piped water supply system depending on water user type.

Generally, in each category of water users a majority would like to connect to the piped tap water at home and pay monthly maintenance costs for the system. Regardless of perceived low quality of piped water, piped water users (tap and standpipe) still have a high willingness to connect. Particularly open source water users, as mentioned above, come from villages where they either used to have or still have access to piped water, and would like to connect and pay for the usage of tap water. This means that currently there are problems with the water supply system, but people still have a

strong willingness to use piped water. One may assume that although there is a low satisfaction with the current tap water quality, still a well-functioning system in terms of water quality and absence of interruptions in the system seems attractive.

The households currently connected to the piped water system were asked whether they are willing to connect to the piped water system providing them with 24-h access to potable water. The answers confirmed that there is a high willingness to connect and pay for the continuous piped water supply.

It may be concluded that the majority of households are willing to connect to and pay for public water supply (65%). The major group that is satisfied with the present water supply situation is private borehole users (20%).

#### 4. Conclusions

The current survey investigated access to drinking water and sanitation services as well as assessed households' willingness to connect to the piped water system in 27 rural villages of the Pavlodar region. The results are important since they can be used to predict the willingness to connect to public water supply and sanitation and at what potential cost. Thus, they are important for the planning and fulfilment of the UN SDGs in Kazakhstan.

A majority of households (52%) use groundwater from private boreholes and, of these, 96% believe that the water is of good or not bad quality. About 17% of all households take water from the public standpipes and only 5% of them enjoy in-house tap water. About 5% use water from an unsafe water supply such as the Irtysh River. At the same time, 80% of people have private toilets (pit latrines) outside the house. About 15% have access to an indoor toilet and only 3% have access to and use a sewer system.

Despite efforts to provide people with potable water during the recently completed national water supply program, there is still a lack of access to tap water from the piped water supply system as well as access to safe sanitation. This may largely be explained by the severe lack of baseline data needed for targeting and designing improvements. Thus, there is a need for more ambitious data collection, as well as more selective and innovative ways to understand, share, and audit the data. Another reason is that interventions so far have been top-down. Furthermore, the responsible authorities need to appreciate that national drinking water programs need to be based on surveys of existing water and sanitation service, as well as a shift to more bottom-up and WASH oriented planning approaches. National drinking water programs need to include surveys of existing wastewater collection systems and need to collect and treat the wastewater centrally or on site. Thus, regardless of the type of basic sanitation, the safe management of fecal disposal is the core in a sustainable sanitation system.

A majority think that water supply is an important issue for the household and 65% would like to connect and pay for the piped water system. The fact that so many want to connect but still lack access to piped water indicates that there have been serious problems affecting the 2002–2010 drinking water supply campaign. The main water users who are reluctant to connect to a central water supply are those who have private boreholes (20%).

The results show that it will not be possible for Kazakhstan to reach 80% coverage of tap water from a centralized piped system to the rural people by 2020 according to the water program, whereas safe access to WASH for rural people is the most important. In any case, considerable progress can only be made by carefully managing the existing water supply and sanitation system in joint collaboration with the local users. Hence, we see the present results as an important first step in this direction.

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**Author Contributions:** The first author planned the survey design, analyzed the initial results, and wrote the first version of the paper. The other authors contributed in an equal manner to the paper by adding comments and writing parts of the final paper.



**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** Collected samples from each village.

Village	Official No. of Households	Observed No. of Households	Percent of Questioned Households	Official Access to Water
Chernojarka	181	134	74%	Decentralized
Novochnojarjarka	439	319	73%	Decentralized
Sychevka	150	39	26%	Decentralized
Chernoreck	402	160	40%	Decentralized/Centralized
Dostyk	138	77	56%	Centralized
Karakol	64	51	80%	Decentralized
Efremovka	333	190	57%	Decentralized
Naberezhnaja	459	174	38%	Centralized
Zhana kala	163	29	18%	Decentralized
Aitym	79	5	6%	Decentralized
Novojamyshevo	485	287	59%	Decentralized
Krasnoarmeika	648	121	19%	Decentralized/Centralized/CBM
Akkuduk	34	34	100%	Decentralized
Bogdanovka	108	97	90%	Decentralized
Lugansk	479	105	22%	Decentralized/Centralized
Maraldy	152	150	99%	Centralized
Olginka	297	183	62%	Decentralized
Presnoe	300	89	30%	Decentralized
Maksimovka	57	8	14%	Centralized
Rozhdestvenka	230	10	4%	Decentralized
Rozovka	440	47	11%	Decentralized/Centralized
Koktobe	16	4	25%	Decentralized
Shakat	194	135	70%	Centralized
Tolubai	55	9	16%	Decentralized
Zaozernoe	45	17	38%	Decentralized
Korjakovka	53	24	45%	Decentralized
Zangar	128	72	56%	Decentralized
Total	6129	2570	42%	

CBM: Complex Block Module.

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# Paper III



# Enabling Full Access to Safe Drinking Water and Sanitation in Rural Kazakhstan: A Major SDG challenge

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**Abstract:** The Sustainable Development Goals (SDGs) call for full drinking water coverage by 2030 importantly this requires a focus on rural areas which have been greatly neglected until now. This requires a database that most developing countries do not have access to. Thus, the aim of this paper is to examine discrepancies between official statistics and the actual outcome regarding improved access to safe water and sanitation in rural areas. For this purpose, questionnaire surveys were made with local villagers in a rural area in northern Kazakhstan. The results display that there are large differences between official data and actual conditions in the region.. Good water service delivery requires reliable data that seem currently to be lacking for rural Kazakhstan. Data and statistics that may exist have not been sufficiently analysed or shared. Thus, achieving SDGs will require investment in data collection as well as more selective and innovative ways to understand, share, and audit the data. The results are important for the planning and fulfilment of the UN SDGs in Kazakhstan.

**Keywords :** Sustainable Development Goals, rural water supply, Kazakhstan, baseline data

## Introduction

Although, the Millennium Development Goals (MDGs) did bring considerable progress in terms of global access to drinking water, there is still a lack of access to improved sanitation facilities. However, there are large regional differences and inequalities such as the gap between urban and rural residents and persistent exclusion of the poor from water and sanitation services remain problematic [2].

The target year for MDGs was 2015. The new UN SDG agenda has 2030 as a target. The SDGs are much more stringent than the MDGs concerning Water Supply and Sanitation (WSS). The target is now full coverage, not just halving the number of people without adequate water supply as for the MDGs.

The Joint Monitoring Program (JMP) assessed the global achievement towards the progress in access to drinking water and sanitation [3]. According to JMP, eight out of ten people, still without improved drinking water sources, live in rural areas. Seven out of ten people without improved sanitation facilities, and nine out of ten people still practising open defecation, live in rural areas [2].

JMP also notes that there are serious problems especially concerning data coverage. There is an increasing amount of remotely sensed data, but very limited data concerning local conditions in the field.

Central Asia is one of the five developing regions that neither met the drinking water nor the sanitation target [2]. It is the only region in the world where the share of surface water users increased from 5 to 6% during 1990-2015. The dissolving of the Soviet Union led to a dismantled state apparatus and lack of investment into the infrastructure during ten years after the dissolving which caused a quick ageing and poor maintenance of water pipeline networks, causing condition in which people had to use water from other, mostly untreated sources [4].

Obviously, the SDGs present a major challenge. For example, at present, the poorest fifth of the population in Kazakhstan has the same level of piped water coverage as sub-Saharan Africa (Fig. 1) [2]. Research has shown that no difference in access to drinking water in rural areas in Kazakhstan between 2001 and 2010 occurred and that it still stands at 29% although the economic situation of people has improved. The access to flushed toilets decreased from 18.2% in 2001 to 7.6% in 2010, toilets outside the home increased to 91.6%, and the number of people lacking personal toilets increased to 0.8% in 2010 [5]. Thus, the perceived improvement of the economic situation of households has not changed the access to piped water and sanitation in rural Kazakhstan and there is still a gap between rural poor and urban households.

The above facts are astonishing since a massive state-managed drinking water supply program was set up to provide drinking water to rural areas in Kazakhstan during 2002 – 2010 [6]. Several reasons caused the failure of the program: corruption in the system, improper distribution of limited financial resources to the villages that were in urgent need for water supply, and the lack of knowledge about the local conditions [7]. Other factors such as pollution of water supply sources, and secondary pollution of drinking water by bacterial activity caused by deterioration of the anticorrosion coating of pipe surfaces aggravated the situation [8,9].

Despite of the failures in the above water supply program a new water program started in 2010 aiming to increase the coverage of rural people with access to tap water from the pipeline network system to 80% until 2020. The underlying assumption of the program is that a pipeline network system is the safest way of drinking water provision [10]. However, previous research has shown that only half the tap water users were satisfied with the service in the Pavlodar region [12]. If rural water projects are to be both sustainable and replicable the integration of local water users, adequate understanding of their willingness to use different levels of services as well as knowledge about the actual situation concerning access to drinking water and sanitation are crucial [11].

In view of the central role of water in poverty eradication and securing a basis for sustainable development, progress on WSS issues will have an important impact on the achievement of several SDGs.

In view of the above, there is no clear information regarding the actual outcomes of the MDG-related efforts in rural Kazakhstan's water and sanitary provision change. Instead, it appears reasonable to assume that water supply and sanitation efforts have been marred by serious problems and that there is a strong need to assess the water supply and sanitation conditions through the local users' viewpoints. In this respect, the paper which based on questionnaire surveys of WSS conditions in villages in the Pavlodar region, investigates the usage of water

from the piped systems, thus looking at the discrepancies between official statistics and the actual outcome in the rural villages regarding water and sanitation in the area. Such results are important since they can be used to identify important implementation shortcomings and decipher reasons for differences between official records and actual reality in the field. Thus, results have implications for how better water supply programs can be planned and executed. Consequently, the results are useful for water engineers and water supply planners as well as for public health specialists.

### *Description of the area, water sources and official access to water*

The Pavlodar area is located in the northeastern parts of Kazakhstan in the Irtysh River Basin. A major part of the region is constituted by steppe. The climate is continental with long and cold winters (5.5 months/year) and short and hot summers (3 months/year). The climate is dry and windy with an average of about 250 mm precipitation per year. The temperature ranges from -40-45°C in winter to +35-42°C in summer. Available water resources in the region are mainly the Irtysh River and groundwater [13]. The experimental area is rural villages from Pavlodar region with a total population of 27,083 persons (in 2013). The area has 38 villages situated in a rural area with the population ranging between 50 and 2,416 persons per village with an average of 712 persons per village.

During the Soviet Union period piped water provision was made in several different ways: 1) Nationally important water pipelines connecting distant rural areas were provided by the government and were without exception the property of the government, 2) Local pipelines providing water in local systems to the villagers were managed by the local municipality, and 3) Decentralized water sources that could either be private or public. In the case of nationally significant water pipelines, water could be taken from one or several boreholes at the same location and distributed through pipelines to a number of villages. The maintenance of the pipelines was the responsibility of the central government, while local pipelines were the responsibility of the local municipality. The water quality in the decentralized water sources such as boreholes and wells was under the strict control of epidemiological services. After the dissolving of the Soviet Union many monitoring and managing systems dismantled and the maintenance became poor causing deterioration of the piped water systems.

The official characterization of drinking water sources in Kazakhstan is shown in Table 1. Main water supplies in rural districts are classified as either centralized or decentralized. In centralized water supply systems the water provision is through pipes, with raw water supplied from either surface or groundwater. This water is usually treated (sometimes it may not require treatment). Thus, water is provided through pipes either as standpipes in the villages and/or directly to the households through tap. Standpipes are provided along the pipe lines at a specified interval. Therefore, villagers supplied by centralized systems by default have access to standpipe water. Provision of piped water inside the house is available at a cost for the house owner [14]. Groundwater is the most common type of water course for rural centralized systems in the region.

Decentralized water supplies do not have delivery/distribution system to the consumption point, and can be used publicly or individually. Borehole and well water are typical decentralized water sources [14]. Other sources of drinking water are not considered to be safe but are



included into official statistics such as water from local treatment kiosks for sale or water delivered with tanker to the village and people pay for it. Complex Block Module (CBM) is water for sale, typically it is treated groundwater that is sold at a kiosk in gallons. This type of water is used for drinking water purposes in villages where a public water source is not available.

The majority of present water supply systems in rural areas of Kazakhstan was built during the period 1950–1980. The wastewater collection and treatment system was supposed to be supplied by the villagers themselves. For this reason, the rural wastewater collection varies from village to village. In most cases, rural wastewater is not treated but instead ends up in public cesspools or private pit latrines. In some cases, wastewater from individual houses is collected in septic tanks. There is, however, no reliable information on how the wastewater is managed in the different villages.

## Methodology

The data used for this analysis are part of a questionnaire survey in the Pavlodar region conducted during July-August 2013. The survey was done using questionnaires distributed to households and collected by the local municipality. The results of the questionnaires and deciphering what kind of water source people use for their drinking purposes and what sanitary conditions they have are used to assess the present situation with access to drinking water and sanitation.

The questionnaires contained questions regarding type of drinking water mostly used for drinking purposes, its perceived quality, reliability, time spent, water treatment methods together with access to toilet, socio-economic, and demographic characteristics. For user of decentralized systems the authors include additional questions whether the system is used privately or shared/publicly (marked in red in Table 1).

The survey sample covered villages with official access to piped water in the area. One of the main reasons is that water interventions had been made in the area and there is a statistics for that. Among the surveyed villages only 10 had official access to a centralized piped water system and out of these, two had mixed access both to centralized and decentralized water. Among these, 3 villages were excluded from further investigation due to a low response rate. This left 7 villages remaining for the analyses (Table 1). The answer rate for the investigated villages was about 43% in general ranging from 25% to 89%. The official statistics represent access to water per person in each village. The water in the pipes in these villages come from local boreholes, and the piped system is mainly administered by the local municipality.

**Table 1.** Investigated villages with access to centralized piped water system.

Village	Population	Surveyed population	Per cent surveyed households	Official water supply system
Chernojarka	604	397	66	centralized/standpipe
Chernoreck	1410	356	25	centralized/home
Dostyk	589	299	51	centralized/standpipe
Naberezhnaja	1559	498	32	mixed centralized/decentralized

Maraldy	549	487	89	centralized/standpipe
Presnoe	807	243	30	centralized/home
Shakat	785	434	55	centralized/home
<b>Total</b>	<b>6303</b>	<b>2714</b>	<b>43</b>	

The classification of drinking water sources used as the basis for official statistics in Kazakhstan is presented in Table 2 (in black text). Access to water is defined as any protected source of potable water within a distance of 100 m from the household. Thus, households with any source of water such as standpipe water, borehole, and well water within the distance of 100 m regardless whether the borehole or well is private or public are considered to be covered with access to safe drinking water [6]. Therefore, the investigation also included mapping of households with decentralized water supply and if they used a water source in their own yard or a public borehole/well water and those are defined as private or public in Table 2 (in red text).

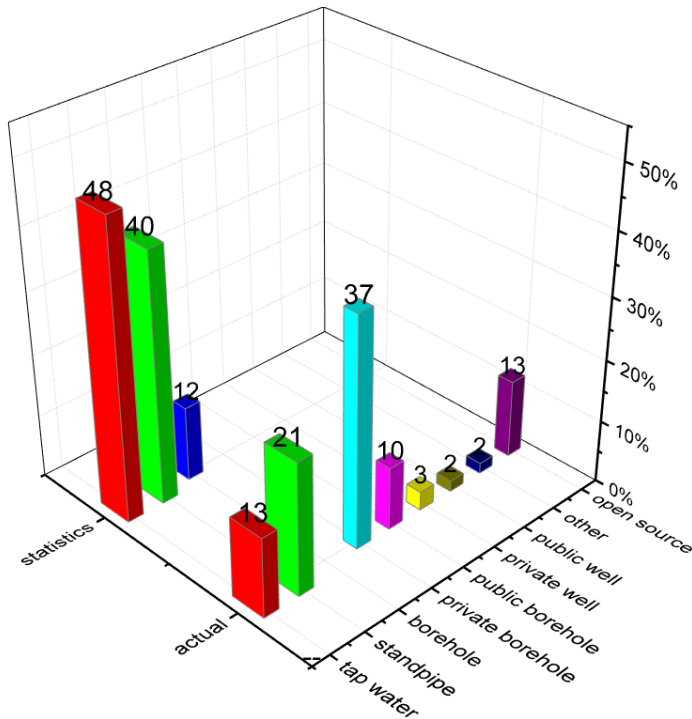
**Table 2.** Classification of drinking water sources in Kazakhstan.

Centralized		Decentralized				Other	
		<i>borehole</i>		<i>well</i>			
<i>tap water</i>	<i>standpipe</i>	<i>private</i>	<i>public</i>	<i>private</i>	<i>public</i>	<i>CBM</i>	<i>open source</i> <i>other</i>

## Results

The main findings regarding the comparison between access to safe drinking water according to official statistics as compared to results from the interviews are presented in the Figure 1. It is clearly seen that there is marked difference in results. According to the figure, official statistics include three types of water supply users only, namely tap water, standpipe, and borehole. Consequently, 100% of village users have access to safe water supply. The survey results, however, give a quite different picture. The major water supply type according to official statistics is tap water with 48%. According to the survey results tap water users are only 13%. A second major difference is the standpipe users. Official statistics state 40% standpipe users while survey results only give 21%. About 12% of all users have boreholes in the official statistics while the survey indicates about 47%. The survey also lists users such as open source (13%), public and private wells (5%), and other (2%). These categories are completely absent in the official statistics. Overall, while official statistics state a 100% access to safe water supply, the survey indicates a mere 85%.

The official statistics regarding boreholes does not distinguish between private and public water source. This is an important aspect of water access that should be defined.

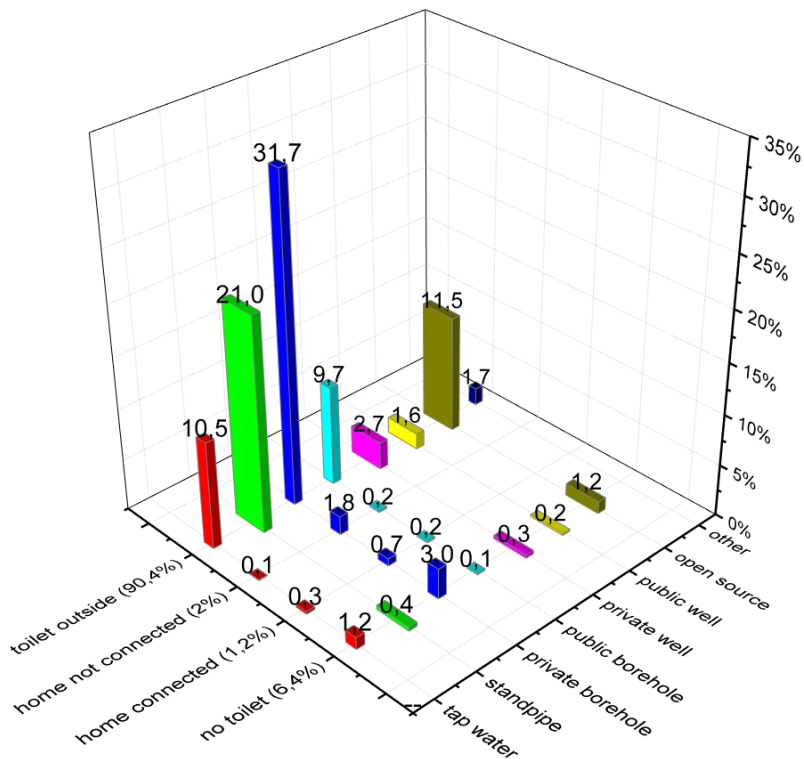


**Figure 1.** Access to drinking water according to official statistics as compared to results from the survey.

As seen from Fig. 2, 13% of all users take water from an open source. This indicates a significant problem with the water supply that officially is covered by safe access.

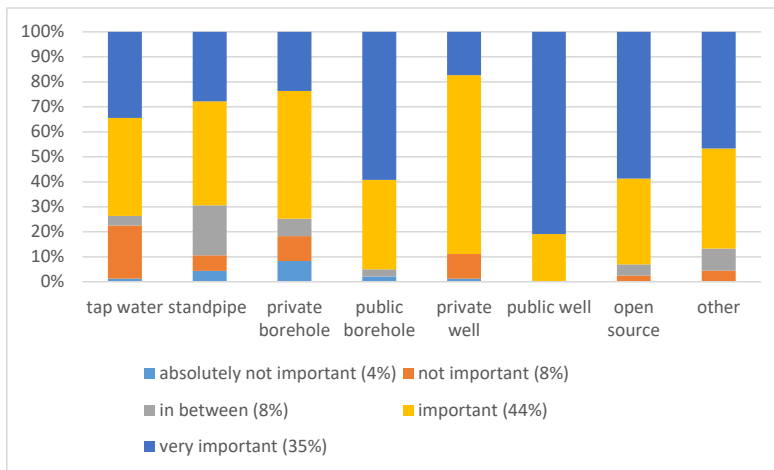
Figure 3 shows the survey results regarding access to drinking water sources depending on actual sanitation situation. From the figure it is seen that a majority of people have their toilets outside of the house (90%). About 32% of households with outside toilet combine this with private boreholes for water supply. Private boreholes and private wells represent 34% of those who have outside toilets. If toilets discharge into pit latrines and this is combined with wells and boreholes within the same yard area, a concrete risk may be fecal contamination of the water supply.

About 12% of all villagers have tap water but still have toilet outside or no toilet. Similarly about 12% of the open source users also have toilet outside. Those who have tap water at home could also have access either to a sewer system or to a septic tank or other in-household wastewater treatment technique. In all the cases, there might be possibility to use flush toilets. As seen from the figure, some of the private borehole water users have flush toilets at home. This means that they have access to piped water and some sewer collection system or septic tank but only use the sewer system without paying for it. Payment for the sewer system is done through using the drinking water from the piped system.



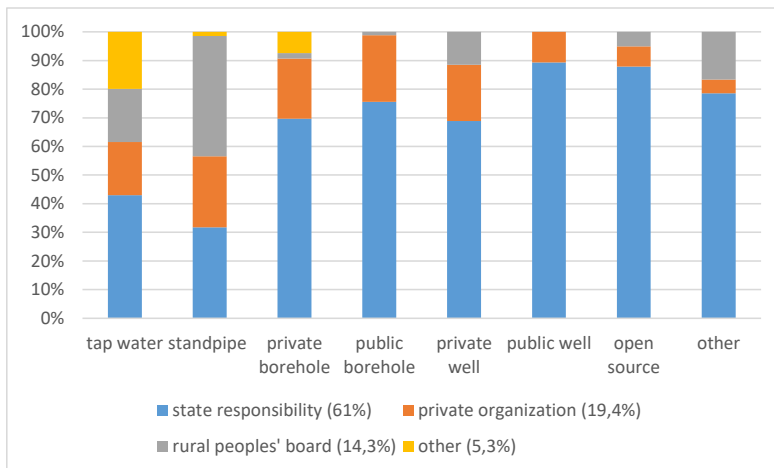
**Figure 2.** Survey results for type of drinking water source and depending on sanitation situation.

Figure 3 shows the perceived importance to households regarding safe water supply. The majority of people (79%) perceive the water supply as important or very important to their household. However, public well (100%), public borehole (96%), and open source users (94%) stand out. At the other end, tap water, standpipe, and private borehole users stand out. About 25, 30, and 25% of these categories, respectively, either feel that water supply is absolutely not, not important, or unsure. Somewhat surprisingly, about 22% of all tap water users feel that water supply is not important.



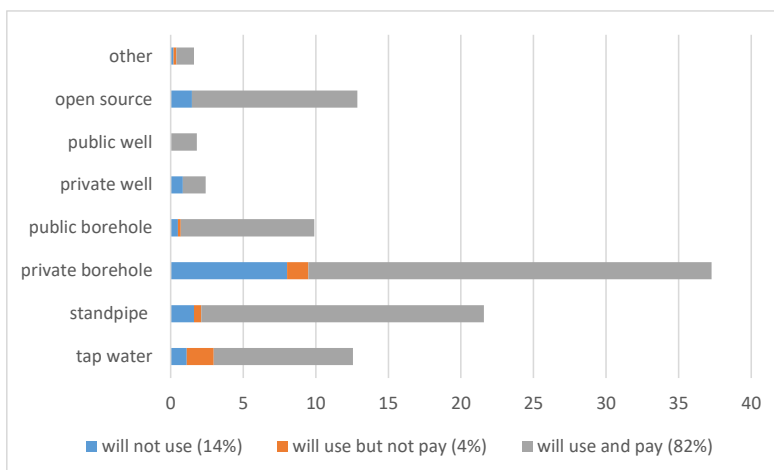
**Figure 3.** Perceived importance of water supply for the household depending on water user type.

Figure 4 shows the villagers' view on responsibility for piped water system. An overall majority of 64% feel that the government should take responsibility for the management of the piped water supply system. A smaller portion of about 19% think that this should be the responsibility of a private organization. About 14% feel that it should be the local government that should manage the piped water supply system while 5% represent other types of management. A state responsibility is in a clear majority for public well (89%) and open source (87%) users. Standpipe and tap water users represent disparate groups in this respect. A minority of standpipe users (31%) think that the state should have responsibility. The corresponding figure for tap water users is about 42%. These two groups also have strong representation of villagers that think that the water supply should be the responsibility of local government or private organizations. In other groups, a majority prefer governmental control (69-75%) and the remaining often prefer private organizations.



**Figure 4.** Villagers' view on responsibility for piped water system.

Figure 5 shows the willingness to connect to and pay for water through a piped water system (tap water) depending water user type. There is a high portion of people who would like to enjoy 24-hour access to potable tap water and pay for this (82%). About 14% are unwilling to connect and 4% want to use but not pay. The largest water user group that wants to connect and pay, is private borehole users, representing 27% of all water users. However, also about 9% of this user category either would not connect or not pay to be connected. Thus, this group appears most disparate of all user groups. For other groups there appears to be an overwhelming agreement on the willingness to both connect and pay for the connection.



**Figure 5.** Willingness to connect to and pay for piped water system (tap water) depending water user type.

## **Discussion**

### *Monitoring and recording progress – A major SDG challenge*

The present investigation displayed that there are large discrepancies between official statistics regarding access to safe water supply and sanitation and actual conditions for a region in rural Kazakhstan. The discrepancy between official and actual individual water supply types is even larger. In our survey we found that this difference could be more than 300%.

Official statistics depend on whether there are water supply pipes at a distance of 100 m from the household, and if the household is covered with piped water. Once the household has notified the authorities that it has tap water at home and is connected to the piped system, this is put in the official records unless the household cancels the connection. It may happen that when the household start using other types of water sources not notify the appropriate authority.

Official statistics also appear to lump together a few major water supply sources. These lack the detail and diversity of actual conditions. Some water supply types such open water sources were completely absent in the official statistics. There is as well, no a distinguishing between public and private boreholes and wells.

The official policy regarding how to provide rural Kazakhstan with safe drinking water appears to be a centralized pipeline network system. Access to tap water at home dramatically increases the amount of water that can be used for hygiene and cleanliness purposes and thus also increases public health. Official statistics state that the region has 100% safe access to water supply, however, the reality is quite different. The majority think that water supply is an important issue for their household. Although many people do not use water from the piped system, if questioned, they are willing to connect and pay for a 24 hour, 7 day a week access to potable water. This indicates that there are problems with the current piped water supply and this needs further investigation.

The perceived responsibility for the piped water system is the government according to a majority of users. But still the majority of those who do not use piped water believe that it should be the responsibility of the local municipality, and the majority of those who currently use piped water believe it is either water users' responsibility or another private organization. It might give us a thought that the environmental awareness among piped water users is increasing and people do not perceive the maintenance only as a responsibility of the government, but also ready to be partly responsible for the maintenance of the systems. In any case, the proper water supply and sanitation management should require both the provider and the consumer to have clearly defined responsibilities under the consideration of WASH (Water, Sanitation, and Health).

## **Conclusion**

There are large discrepancies between official statistics concerning access to safe water supply and sanitation and actual conditions for the investigated region in rural Kazakhstan.

In case of the investigated region in Kazakhstan, a majority of users appears to combine private boreholes and wells with pit latrines in their yard. A sustainable solution to this problem needs to consider both water supply and sanitation.

The present survey only covered a small area of rural Kazakhstan. However, if similar principles are used nationwide, great uncertainties may be found in the national statistics. In any case, the results are important because they indicate agreed willingness of different water user groups to connect to a safe piped water supply. Thus, the results are important for the planning and fulfilment of the UN SDGs in Kazakhstan.

The lack of reliable statistics and data misdirect the efforts made by the local government in terms of water supply programs. The reality shows that people use different water sources and sanitation services, which are not monitored and regulated. In the investigated rural area in Kazakhstan, there is virtually no reliable information on how the wastewater is collected and treated. As well, there is no information on access to sanitation facilities and how they are managed. An unsafe management of the wastewater and excreta disposal are likely to increase the risks for contamination of the drinking water supply.

As many other developing countries, Kazakhstan has numerous public systems that have suffered considerable deterioration due to deferred repairs and maintenance. In light of this, rehabilitation and maintenance technologies for household or community-based WSS services can save a lot of expenses while reducing operation and maintenance costs. In this regard, community participation in planning, development and management of water supply schemes is of paramount importance.

Good water service delivery requires reliable data that seem currently to be lacking for rural Kazakhstan, Data and statistics that may exist have not been sufficiently analysed or shared. Achieving SDGs will require investment in data collection as well as more selective and innovative ways to understand, share, and audit the data.

**Conflicts of Interest:** The authors declare no conflict of interest.



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# Paper IV



Article

## Investigating Willingness to Pay to Improve Water Supply Services: Application of Contingent Valuation Method

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**Abstract:** Safe water supply is one of the important Millennium Goals. For development of market water supply services, the willingness of consumers to pay is essential. The consumers' willingness to pay (WTP) for piped water supply using the contingent valuation (CV) method with different starting point bids was investigated for the Pavlodar Region, Kazakhstan. The results showed that households with access to groundwater (well or borehole water users) perceived this as of good quality. Consumers without access to groundwater used open-source, standpipe or delivered water for which they had to travel and spend time or to pay. Open source water and standpipe water quality was perceived as bad or satisfactory. More than 90% of the consumers were willing to pay for better water quality and regular water supply. The mean WTP was estimated to be about 1120 in bids and about 1590 KZT per household per month in open-ended question format (150 KZT is ~1 USD as of January 2012). The results can be used to better identify the proper technological choice and the level of service to be provided making rural water projects both sustainable and replicable at a larger scale.

**Keywords:** willingness to pay; rural water supply; contingent valuation method; Kazakhstan

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## 1. Introduction

### 1.1. Background

Kazakhstan is a former Soviet Republic that is transitioning from state planned to market economy. This transition is changing patterns of basic services such as water and sanitation. The Soviet Union sought to tackle the desperate living conditions that the major part of the population suffered from in the early twentieth century by expanding access to essential services such as piped water. However, when the Soviet Union broke apart in 1991, many people, especially in rural areas that historically have been disadvantaged, still had limited access to drinking water. Since then, the situation has not improved much. Important elements of the state apparatus have been dismantled, leading to shortages of basic goods and services while the economic crisis has reduced funds that could otherwise have been used to invest in basic infrastructure for water and sanitation. During the transition from a state planned to a market economy, existing water supply systems have deteriorated due to lack of maintenance [1,2].

Recent research has shown that there have been no significant changes in patterns of access to piped cold water in rural and urban areas of Kazakhstan during the last 10-year period [3]. In rural areas, the access to piped cold water remains at a constant 29%, although the economic situation of people has improved. Roberts *et al.* [3] found that respondents with stated bad to very bad economic situations changed from 24% to 7% and good to very good economic situations changed from 16% to 32% between 2001 and 2010. Consequently, the perceived improved economic situation of the households has not changed the access to piped-water in rural Kazakhstan and there is still a gap between rural and poorer households compared to urban households. These results are surprising since a massive state-run drinking water program has supposedly financed provision of drinking water to rural areas since 2002 (UNDP, 2004).

A survey made in 2005 (UNDP, 2006) showed that people in Kazakhstan have a strong incentive to pay for water and, in particular, for improved water supply and water quality. However, the survey also showed that the interviewees did not know how much this service should cost. A large part of the respondents (27%) who expressed willingness to pay (WTP) for improved water quality could not define the maximum amount they would be willing to pay. Individuals unwilling to pay saw no problem with water supply, could not afford extra costs, or believed that the state should cover such costs [4].

If rural water projects are to be sustainable and replicable, an improved planning methodology is required that includes a procedure for eliciting information on the value placed on different levels of service. Also, tariffs must be designed so that at least operation and maintenance costs can be recovered [5]. The importance of the concept of WTP for water in rural areas has been understood for some time. The WTP is a measure of the maximum amount that a person would be willing to pay for a service rather than do without it.

In view of the above, the Kazakhstan authorities have incentive to provide a better water supply to rural families, e.g., by attracting the private sector into the field. However, to expedite the process and to make it more efficient, customers' opinion and their WTP for improved water services should be studied. Thus, the study had two main objectives. First, to test the contingent valuation (CV) method using open-ended and bids format questions with different starting points to identify the WTP for

maintenance of the piped water system. Second, to investigate and quantify rural peoples' WTP for (individual and standpipe) piped water connection and maintenance cost.

### 1.2. Review of Contingent Valuation (CV) Method

The Contingent Valuation (CV) is one of the commonly used methods by economists, policy makers, and water utility organizations to improve water supply [6]. It has been implemented in many different water supply and sanitation projects and particularly in rural water supply, both in developed and developing countries [7–10]. Griffin (1995) compared the results of the CV survey and actual outcome three years later. He found that 15% of households got connected to piped water as compared to 15% predicted [11]. This shows that CV is reliable once it is designed and administered properly. The World Bank has been the prime user of CV in testing, and subsequently promoting, the use of the method to assess the demand for water and sanitation services in both rural and urban locations [6]. Department for International Development (DFID) is also moving towards the use of CV, particularly to guide tariff structuring on large capital investments. The DFID Manual states that “Choice of the right technique depends on the size and complexity of the proposed program and the existing capacity in the community for self appraisal. If resources are available, the Contingent Valuation Method is the most reliable” [12].

The CV uses hypothetical data to estimate the *ex-ante* WTP. The strength of the method is its flexibility [13]. It can be used to construct realistic policy scenarios for most new policies. Another strong point is the ability to measure non-use values. The main weakness of the method is its hypothetical nature. Respondents can sometimes find themselves in unfamiliar situations in which complete information is not available. At best, respondents may give truthful answers that are limited by their unfamiliarity. At worst, respondents may give trivial answers due to the hypothetical nature of the scenario [13]. There are three obstacles that should be considered when using CV: (1) Proper administration and execution of the CV survey; (2) properly conducted CV scenario; and (3) reliability of the key assumptions, where results can be robust with respect to simple variations in research design and survey method. Properly performed, the CV survey might be the most informative technique for WTP surveys [14].

One of the main problems with many CV investigations conducted in developing countries is that the surveys themselves are poorly executed. This is quite often due to poorly trained enumerators and resulting enumerator bias [14]. Economists recognize it as a principal-agent problem, in which the CV researcher (principal) typically does not know the enumerator (agent) before the survey. It is crucial that the enumerator does not have influence on the answers of interviewees, such as to see his/her role as an educator who is to convince respondents that they should be willing to pay for the service offered, or to “improve” the CV scenario in any way. Even the best CV scenario may make little sense to an interviewee if the enumerator does not pose the question in a relevant manner [14].

A constraint using the CV method may be that respondents do not face a real economic choice. Developing a relevant CV scenario means to pose a short explanation of the problem and then present a logical choice for the respondent. It implies a better connection between the CV scenario and the selection of the elicitation procedure. There are several elicitation procedures and the effect of these methods upon WTP may be large. Open-ended maximum WTP valuation question and closed ended, yes/no valuation question are often discussed in contemporary research. Open-ended questions mean

that the respondent is asked to give a maximum price for the offered hypothetical good or service. Closed-ended questions mean that yes or no is used for an already defined price and the respondent should either accept or reject it.

In order to better understand the reaction of the respondent to a CV scenario and the elicitation procedure, the importance of carrying out a variety of split-sample experiments has been stressed in the literature [15,16]. There are two main reasons for conducting split-sample experiments in CV research designs. The first is that the CV researcher almost always faces some difficult choices in the study design with respect to the development of the CV scenario and elicitation procedure. Second, performing a CV survey provides an opportunity to learn more about possible procedures in terms of alternative research design choices in different cultures [14].

## 2. Experimental Area and Methodology

### 2.1. Area Description and Drinking Water Sources

The Pavlodar area is one of 14 regions in Kazakhstan. It is situated in the northeast of the country in the Irtysh River Basin. The area has three cities and 412 rural districts. The rural districts have a population of about 270,000 people. The steppe comprises the greatest portion of the region. The climate is highly continental, relatively dry with large temperature amplitude (about  $-40\text{ }^{\circ}\text{C}$  to  $+40\text{ }^{\circ}\text{C}$ ), a long and cold winter (5.5 months) and a short and hot summer (3 months). This very large intra-annual temperature variations limit the regional water resources that mainly depend on the snowmelt.

The scant precipitation has an uneven distribution within the territory and within the seasons. Up to 80% of annual precipitation fall during the summer period. Most of the rainfall ends up as soil moisture and evapotranspiration. Average annual Class A pan evaporation is about 800 mm. The available water resources of the region are mainly the Irtysh River and groundwater. Smaller rivers usually have a short spring discharge before they dry up.

Main water supply systems can be classified as centralized and decentralized. The main difference is that centralized water supply has a distribution system to provide water from the natural water source with or without treatment to the water user, while decentralized water supply system uses water directly from the water source with or without treatment. Consequently, centralized water supply generally means water provided through pipes to households (tap water) and public standpipes. Protected boreholes, wells, and springs are considered to be decentralized water supply sources. Centralized and decentralized systems can be either private or public. Both groundwater and surface water may be used for the centralized systems. However, groundwater is the most common type for rural centralized systems in the region.

### 2.2. Survey Design

The survey was performed between October 2011 and January 2012, in eleven villages of Pavlodar region. In total, 168 questionnaires were completed and included in the survey analysis. Since the villages are of different sizes, each household was chosen randomly so that at least half of the respondents would live in four different directions outside of the central part of the village.

Face-to-face interviews with the heads of households were conducted in the respondents' homes. Standardized questions regarding socio-economic and demographic characteristics, existing drinking water sources and their characteristics, trust to water management types, and direct open-ended and bids questions on WTP were used.

The study adopted both stated preference and revealed preference methods to value the existing and hypothetical water supply service. For stated preference approach, the CV method was used where respondents were directly asked about their WTP for the piped water system. The question asked was: How much is your household willing to pay monthly for the maintenance of a private connection and 24 h a day access to potable water?

For the revealed preference approach, averting behavior method was used. The averting behavior method begins with the recognition that individuals seek to protect themselves when faced with environmental risk such as contaminated drinking water [17,18]. The questions asked were: (1) What is your main drinking water source? Is your water source private or public? (2) How do you assess your drinking water quality: turbidity, odor and taste in a scale—bad, satisfactory or good? Are there visible suspended particles in the water? Perceived water quality was assessed as acceptable or bad based on the answers. If the answer is “bad”, or there is a visible suspended particle in the water, then the quality is “bad”, otherwise “acceptable”; (3) Do you treat (boil, filter or other) your water before drinking? Do you use bottled water or get water from a local treatment point?

The CV method was used to identify WTP for individual water connection and public standpipe. One scenario was developed for all categories of water users depending on respondents' answer to type of water source that they are using. If they do not use standpipe and do not have the individual connection respondents would answer how they would like to pay for one of them when connected and if the family use a standpipe or have a individual connection and how much they would like to pay for potable water available 24 h a day (Table 1).

Across the questionnaire, two types of questions were asked. The first, open-ended, directly asked about the maximum amount(s) (s)he would be willing to pay for the proposed water supply improvement. The second was a bidding game, when households are asked different prices until settling at a maximum offered price. The reason for having these two question formats is to see whether respondents react similar regardless of type of asked question.

The split-sample experiment was incorporated into the research design; three different bidding games with different starting points were randomly assigned to respondents in the study. All three bidding games were evenly distributed among the respondents in the survey. The purpose of the split-sample experiment was to test whether respondents' WTP would be influenced by the magnitude of the first price that they received and the sequence of follow-up questions. There are two differing viewpoints on such a “starting point” test. One is that a differing starting point conveys information about the cost of the service provided. From this viewpoint, different starting points will induce different answers from the respondents. Consequently, if the split-sample test elicits different answers, one would conclude that respondents are in fact taking the CV scenario seriously. A second perspective is that a respondent holding the precise WTP amount in his/her mind and receiving different starting points will provide essentially the same WTP answers. If so, one would have greater confidence that they are revealing a “true” WTP [14].



**Table 1.** CV scenario and the choice of elicitation procedure.

Type of Elicitation Procedure	CV Scenario for Public Standpipe	CV Scenario for Private Connection
Open-ended maximum WTP	If water is provided for your village with public standpipes on each street and unlimited potable water supply at any time of the day, how much would your household be willing to pay each month?	Besides the use of water from the public standpipe you can have private connection, that is, the water will be in your house. You will not be able to sell water or use it for watering the garden. If you do not pay a monthly fee, your private connection will be disconnected. How much would your household be willing to pay monthly for the <b>maintenance of a private connection and 24 h access to potable water?</b>
Closed end, bidding game	How much would your household be willing to pay 100, 200, 500, 700 or 1000 KZT * a month for maintaining the standpipe in your district?	Suppose your household pays for the installation of individual connection (taps at home) and there are already public standpipes so that everyone will have at their disposal good drinking water. Would your household be willing to pay 300, 500, 1000, 1500 or 2000 KZT * <b>each month to have a private connection and 24 h access to potable water?</b>

Note: \* 150 KZT ~ 1 USD (as of January 2012).

In order for the CV-based estimates to be reliable, strategic and hypothetical bias sources were considered. Strategic bias will not occur or will be minor if there is no cost associated with telling the truth and little or nothing is gained if the respondent does not tell the truth. The study tried to estimate this type of bias. Two types of respondents’ answers were considered; the first question was explained as a possible future project and the second was explained as a general survey without practical influence. Avoiding hypothetical bias requires the presentation of believable and familiar scenarios for the resource under consideration. One concern in water supply projects is the permanent availability of good quality water. For this reason, questions were designed as offering 24 h access to treated potable water distributed through the piped system.

The enumerators were specially trained students, following the principle that good enumerators make respondents feel comfortable and at ease. Therefore, the enumerator was not supposed to influence or convince the respondent’s WTP by remaining quite neutral about answers. The enumerators were explained what the study was about, so that they would be able to explain what the maximum WTP is as well as to read slowly and clearly the questions.

2.3. Data Analysis

The collected data were used to calculate the mean WTP according to the following:

$$E[WTP] = Pr_{(Zero)} \cdot 0 + E(WTP_{WTP>0}) \cdot Pr_{(Positive)} \tag{1}$$

where

$Pr_{(Zero)}$  is probability that a respondent has zero WTP;

$Pr_{(Positive)} = 1 - Pr_{(Zero)}$  is probability that a respondent has a positive WTP; and

$E(WTP_{WTP>0})$  is mean WTP for the positive WTPs.

A few extreme outliers had to be excluded in the open-ended format before analyses. Due to more or less equal distribution of WTP among the bids both for standpipe and private, connection WTP was split into two categories. For private connection, low bids were between 300 and 1000 KZT and high bids were between 1500 and 2000 KZT. For standpipe connection, lower bids were 100, 300, and 500 KZT and higher bids were 700 and 1000 KZT. Binary logistic regression commands in the SPSS software were used to find the maximum likelihood estimation of the independent variables (determinants) as regards lower and higher bids (lower and higher WTP) according to:

$$\ln(WTP) = \ln\left[\frac{\text{Pr}}{(1-\text{Pr})}\right] = a + bX$$

$$\left[\frac{\text{Pr}}{(1-\text{Pr})}\right] = e^{a+bX} \quad (2)$$

$$\left[\frac{\text{Pr}}{(1-\text{Pr})}\right] = e^a (e^b)^X$$

where  $a$  and  $b$  are constants and  $bX$  is consumer index.

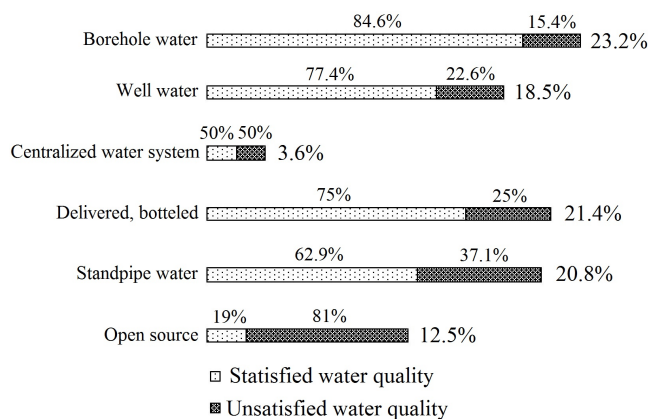
### 3. Results and Discussion

#### 3.1. Existing Water Sources and Perceived Quality

There are several water source types available in the region. Figure 1 shows these sources divided by the total users. One of the most used water source is a private borehole. The boreholes are generally 8 to 50 m deep with a diameter of 10–30 cm. Water is usually pumped by electricity and in rare cases by hand and usually covered with a plastic top. Private wells supply 18.5% of the respondents with water. Wells are dug down to about 10 m with a diameter of 0.5–1.5 m. In most cases wells are covered with a wooden plain. Almost every fifth household uses delivered water that is obtained from the local treatment plant by paying a fixed amount for each five gallons of water. The price can vary between 20 to 40 KZT for five gallons (about 19 L) depending on the locality. Thirteen percent of respondents use water from an open source, which is taken from the river either directly by the households or delivered from the source for payment. Standpipe water is usually groundwater distributed through pipes and obtained from a standpipe. Only few households (4%) use water from the centralized system and have tap water at home. Groundwater is the main source of water for the centralized piped system. All water users, except those who use open sources, can drink their water without pre-treatment and only those who use open source have mechanical treatment and boil their drinking water.

Totally, nine persons have tap water at home, out of these six have water from the centralized system, and three have constructed by themselves taps at home and take water from wells and boreholes.

Figure 1 shows the perceived water quality depending on water source. The overall satisfaction with the water quality is 67%. The most satisfied with the quality of water are borehole water users and the least satisfied with the quality of water are those who use water directly from the river.



**Figure 1.** Drinking water users' perception of water quality.

### 3.2. Willingness to Be Connected to the Piped Water System

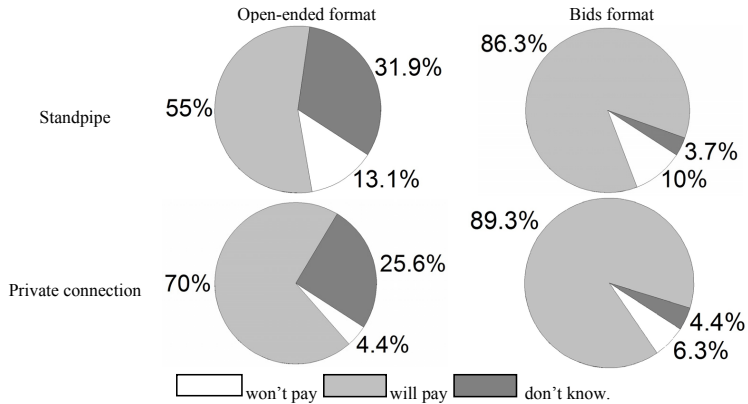
Respondents were asked about their willingness to be connected to the piped water system and pay 20,000 KZT (~133 USD) as a connection fee. In total, seven persons do not want to be connected at all and one person does not know. Thus, 160 households are willing to be connected and out of these 60% are ready to pay a connection fee. About 83% of households would like to have a water meter and pay according to the actual volume used. The rest would like to pay a fixed amount per month and household. Since the piped water system includes a standpipe within the village, the question about the responsibility for the maintenance of the piped water system and standpipes was included. About 75% of the respondents believe that the government should take the responsibility for maintaining the piped water system while 15% of the respondents find it is the user's responsibility. The rest would like to rely on a private or profit organization.

### 3.3. WTP for Open-Ended Question and Bids Format

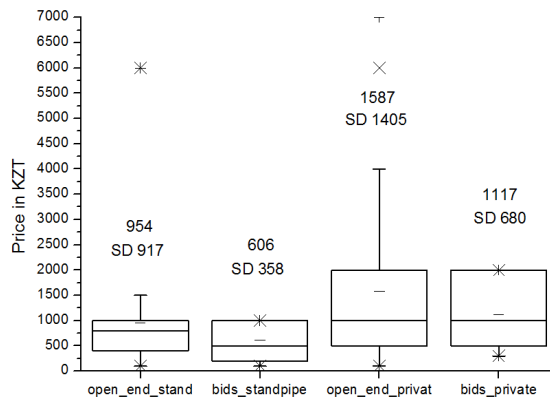
Two types of question formats were used to identify peoples' WTP: open-ended question format and bids format. In total, for private connection and standpipe, 160 questionnaires were used. These correspond to those who would like to be connected to the water supply system. Figure 2 shows the reduction of "I don't know" answers in bids format in both standpipe and private connections. For standpipes, there were even some changes of mind from "zero" payment to some payment from open-ended to bids format. Those who were not sure in the open-ended question format after bids prices preferred to pay nothing for private connection. Thus, this increased the number of respondents from seven in open-ended format to 10 in the bidding game. The bids question type gives higher response rates.

Figure 3 shows that the mean value for both connections in open-ended and bids format differs significantly. Mean value for open-ended format was 1587 KZT and for bids format 1117 KZT for private connection. The median was, however, almost the same, indicating that at least half of the households are willing to pay up to 1000 KZT. Both mean and median WTP were different for standpipe connection in open-ended and bids formats. Still, it is not surprising that mean WTPs were different

since the range of the price in both bids was fixed and those with a high WTP in open-ended question may simply give a higher than maximum offered price in bids format.



**Figure 2.** Answer rate to open-ended and bids format questions for standpipe and private connection, respectively.



**Figure 3.** Boxplot of WTP for open-ended and bids answers both private connection and standpipe water (SD = standard deviation).

A paired sample *t*-test was conducted to compare the mean values for both open-ended and bids format questions excluding all values above 2000 in open-ended format and “zero” answers in both (Table 2). This test was carried out to see whether those who give some price in open-ended question give similar answer in bids format. Table 2 shows that there is no significant difference between both groups for private connection and standpipe. This indicates that both methods can be used if ranged within some amount. An advantage of the bids format is a larger response rate.

**Table 2.** Comparing means for open-ended and bids format standardized from 100 to 2000.

	Public Standpipe		Private Connection	
	Open-Ended	Bids	Open-Ended	Bids
Mean	607	588	1110	1089
SD	329	354	637	667
t-statistics	0.5 *		0.3 *	
DF	65		88	
Prob.	0.6		0.8	

Note: \* At the level 0.05 the difference of population means is not significantly different.

All WTPs above 2000 KZT in private connection and above 1000 KZT in standpipe connection in open-ended format were compared with the answers from the bids format to see whether respondents would give the same answer for open-ended question by giving the maximum offered in the bids format. In open-ended format for standpipe water 70%, and for private connection 77%, of respondents would pay the highest offered amount in the bids and about 30% and 23%, respectively, would pay lower than offered maximum amount in the bids format. Consequently, bids format give more reliable replies. Thus, for further analyses, only answers from the bids format were used due to their higher response rate and more reliable replies.

#### 3.4. Testing for Strategic Bias

To test for strategic bias, two types of narratives were used to the different respondents. For the first group of respondents, the questionnaire was for a possible future water project and for the second group it was for a research survey without any connection to real water provision. This was done to see whether people in the first group would answer strategically by overestimating or underestimating the real WTP.

For the private connection, there was no significant difference between mean WTP in the bids format (at 5% probability level; Table 3), assuming that people did not try to influence the outcome of the project. A slight difference was noted for the mean WTP in the standpipe bid answers. Most of the current standpipe and central water supply users were in the first group and the second group households mostly using either open source or delivered water. Also, many private borehole water users were in the first group, assuming a benefit from not having to obtain water from the standpipe, especially in winter with a very cold climate. It can be concluded that overall respondents did not reply in a strategic manner.

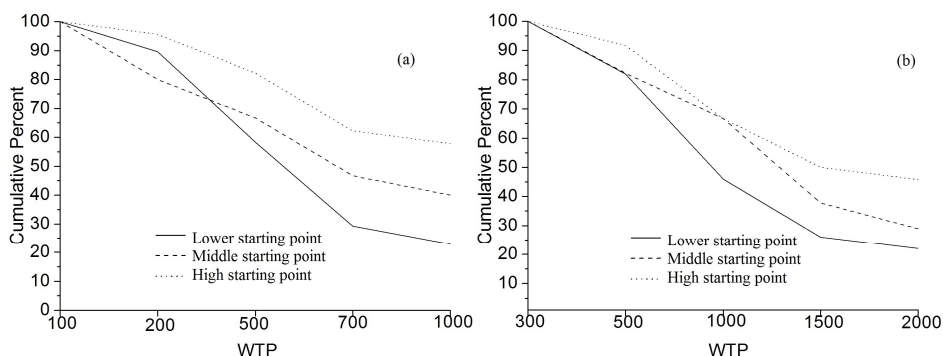
**Table 3.** Test results for strategic bias.

	Public Standpipe		Private Connection	
	Group 1	Group 2	Group 1	Group 2
Mean	533	678	1112	1123
SD	374	327	716	644
t-Statistics	−2.4 *		−0.09 **	
DF	136		141	
Prob.	0.02		0.9	

Notes: \* At the level 0.05 the difference of population means is significantly different; \*\* At the level 0.05 the difference of population means is not significantly different.

### 3.5. Comparison of Bids with Different Starting Points

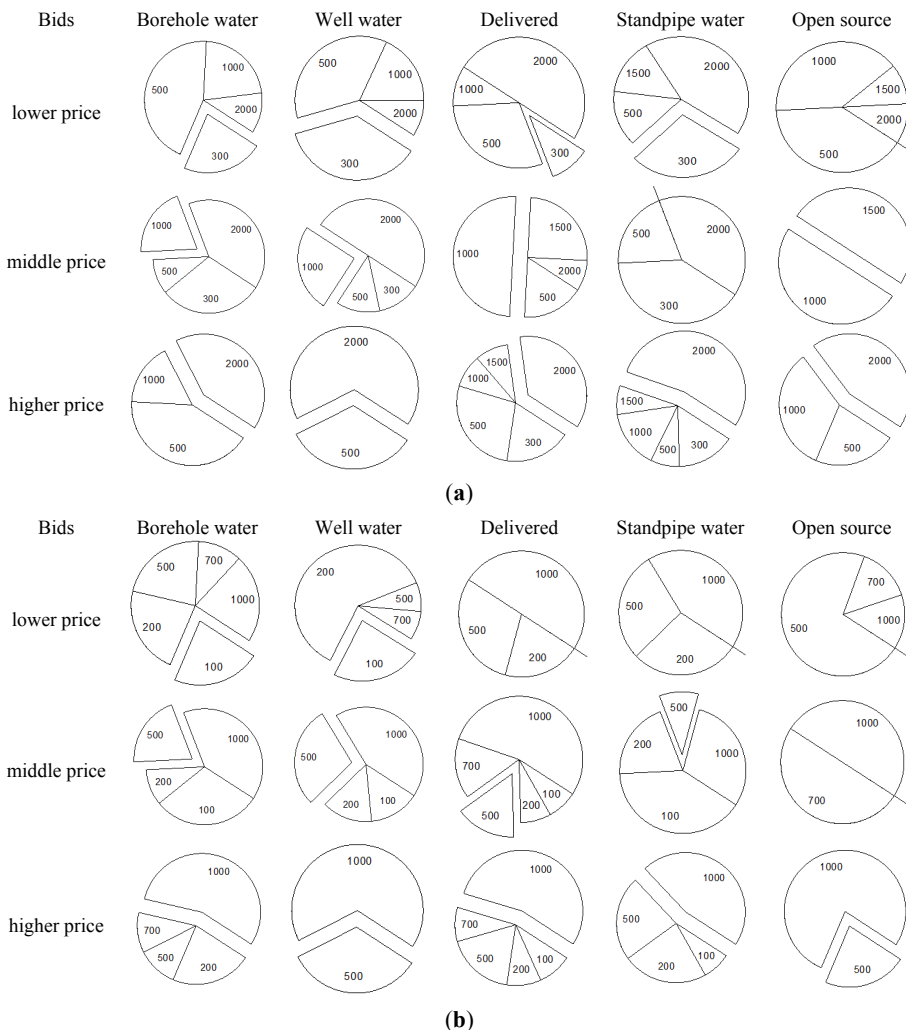
Figure 4a,b show the cumulative distribution of maximum WTP for standpipe and private connection, respectively. In both cases the bids with different starting points lead to different maximum WTP price. This means that the lower the starting point, the lower the maximum WTP price. Although, this leads to different mean value of WTP, respondents still do not react positively to the starting price. Even though there is a tendency to give a WTP bid closer to the starting point, respondents still did not directly say yes to the first offered WTP bid. Therefore, further analyses were made to decipher how different water users react towards bids with different starting prices.



**Figure 4.** Cumulative distribution of maximum WTP (KZT) for standpipe (a) and private (b) connection.

Figure 5a,b shows bid distribution with lower, middle, and higher starting prices for private connection and public standpipe depending on water supply source. As seen from the figure, the respondents using different water supply sources react differently to the different bid technique. Borehole, well, and open source water users have a tendency towards the starting WTP price, but this is mostly for higher bids. For delivered and standpipe water the starting WTP price does not have a large influence. One of the reasons for this is that respondents that use delivered water and water from standpipe already have expenses compared to those who use private borehole, private wells, and water from open source. The only difference between private borehole, private well water, and open source water users is that the latter one has to spend time for the water delivery. The general tendency is that for higher WTP bids, respondents were more inclined towards the starting WTP price compared to lower and middle starting prices.

To conclude, those who already have expenses for water already have a price in mind and the bids with different starting points do not have influence on either the starting price or the mean value for each bidding game with different starting point. Those who do not have current expenses for water supply are somewhat influenced by the bids leading to a different mean value in each bid with different starting price. However, respondents still considered this and did not agree on the first price. Therefore, the bids format questions for those who use borehole, well water, and open source water need to be carefully constructed for a relevant design of a future drinking water supply system.



**Figure 5.** (a) WTP bids distribution for private connection depending on water supply type (KZT); and (b) WTP bids distribution for standpipe water depending on water supply type (KZT).

### 3.6. Determinants of WTP

The study also investigated factors that may influence respondents WTP. The descriptive statistics of these factors can be found in the Appendix 1. Using a stepwise regression method, affecting variables were included into a final binary logistic model. The summary of these variables for both standpipe water and private connection are given in Tables 4 and 5. Especially, the variables water source type and payment for the connection appeared to be significant at 5% level in both cases. Public water users, *i.e.*, users of water from open sources and public standpipe or delivered water, are more likely to be in the higher bids

category compared to those who use private sources such as private wells, borehole water, and centralized water supply. Private well and borehole water users represent about 95% of all private water supplies that do not have any monthly fees. These water sources are perceived as of good quality compared to the public sources such as open source and standpipe water.

**Table 4.** Explanatory variables of WTP for standpipe water.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Sex: 0 = woman, 1 = man	0.223	0.392	0.323	1	0.570	1.250
Family with children: 0 = no, 1 = yes	0.280	0.384	0.534	1	0.465	1.324
Water source: 0 = private, 1 = public	0.877	0.394	4.968	1	0.026	2.405
Water quality: 0 = bad, 1 = satisfactory	0.899	0.417	4.654	1	0.031	2.456
Connection fee: 0 = no, 1 = yes	1.146	0.407	7.922	1	0.005	3.146
Constant	-2.300	0.586	15.401	1	0.000	0.100

Note: Cases selected 137 Nagelkerke R Square 0.183 Significance 0.348.

**Table 5.** Explanatory variables for private connection.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Sex: 0 = woman, 1 = man	0.447	0.384	1.350	1	0.245	1.563
Family with children: 0 = no, 1 = yes	0.828	0.395	4.390	1	0.036	2.289
Water source: 0 = private, 1 = public	0.806	0.398	4.087	1	0.043	2.238
Water quality: 0 = bad, 1 = satisfactory	0.599	0.414	2.091	1	0.148	1.820
Connection fee: 0 = no, 1 = yes	1.160	0.432	7.202	1	0.007	3.189
Constant	-2.874	0.629	20.863	1	0.000	0.056

Note: Cases selected 142 Nagelkerke R Square 0.191 Significance 0.005.

The connection fee can be seen as an indirect wealth indicator of a household, since occupation in the stepwise regression did not display any significance. Thus, occupation was not included into the model. Not surprisingly, those who were ready to pay a connection fee in the amount of 20,000 KZT to have a private connection at home were very frequent in the high WTP category. This can be explained by the fact that respondents may have savings without necessarily having either permanent income or garden or livestock. This may also indicate that respondents do not have proper access to water and therefore give a high priority to safe water connection. In any case, the impact of the household wealth needs to be further investigated in future surveys.

The perceived water quality was not significant for the private connection but appeared to be significant for the standpipe connection. This displays that the more respondents are satisfied with the quality of the existing water source the more they are willing to pay. This appears to be somewhat strange, but might be explained by the fact that the most satisfied respondents are mostly those who use delivered water.

The variable Households with children is statistically significant at the 5% for private connections. Respondents with children were willing to pay more on average. Obviously households with children may gain much in having access to water at home in terms of, first of all, water quantity and, if possible, water quality. This variable is not significant for standpipe connection, which is not surprising. Most respondents either use a private water source, meaning that they have water access very close to home or delivered water, and for them there is no point of paying more for standpipe water with walking and queuing for water in a limited amount.



Although men are more frequent than women in the higher category bidding, gender is not statistically significant in either type of water source. Further analyses are needed to verify these results in comparison with age and/or occupation.

#### 4. Conclusions

The paper investigated whether the CV method using bids with different starting points and open-ended format questions can be used to quantify rural peoples' WTP for improved water services. In total, 95% of the rural respondents were willing to be connected to the piped water system. Out of these, more than half were ready to pay the fee of 20,000 KZT for the individual connection. The mean WTP for the maintenance of the individual piped water system was about 1120 KZT per month per household in the bids format and about 1590 KZT per month per household in the open-ended format question. For public standpipe, the mean WTP was about 950 KZT per month per household in the open-ended category answers, and about 610 KZT per month per household in the bids format. When open-ended answers are adjusted up to the maximum amount in bids format, the difference of mean values are insignificant.

The response rate for the bids format was higher than for the open-ended format questions due to a huge shift in "don't know" answer in open-ended format to "some payment" in bids format. However, using bids with different starting points can thus be influential. If respondents have not paid to obtain water and have no real idea how much they should pay, then the first price is interpreted as a reference price. Private borehole and private well water users as well as open source water users were partially navigated by the first price, although the magnitude of the first price was not high. In contrast, if users are already charged and/or have to spend some time to obtain water, such as delivered water and standpipe water users, their bids with different starting point do not have significant influence. Consequently, this should be considered when implementing the survey in villages with different water sources.

The main influencing factors for high or low WTP were the existing water source and the payment of fee for the private connection. Private water users with borehole and well water do not have charges and perceive their water to be of good quality. Thus, they were willing to pay less. Those who use public sources such as open source and standpipe water were ready to pay more every month to get access to piped water, which is more convenient compared to the existing sources, as they have to travel, as well as sometimes pay, to obtain water. They perceived the water quality as not good. The readiness to pay the connection fee for private access to water as a possible indicator of the household wealth showed that those who are ready to pay the connection fee of 20,000 KZT were much more frequent in the higher bids category. The connection fee might be an implicit indicator of the household having savings and the ability to pay. However, the household wealth indicator should be well constructed in future surveys.

The obtained results can be used by water supply managers and engineers in order to better identify the proper technological choice and the level of water service to be provided. Thus, it will make rural water projects both sustainable and replicable at a larger scale.

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### Author Contributions

The first author planned the survey design, analyzed initial results, and wrote the first version of the paper. The other authors contributed in an equal manner to the paper by adding comments and writing parts of the final paper.

### Conflicts of Interest

The authors declare no conflict of interest.

### Appendix

**Table A1.** Descriptive statistics of survey results.

Description	Percentage	Mean
Living time for the household in the area:		
Less than 5 years	8%	
Between 5 and 10 years	16%	
More than 10 years	76%	
Number of people in household (min.=1 and max. =7)		3.9 (SD 0.28)
Family with retired person: 1 = yes, 0 = no		0.32
Family with children up to 18 years old: 1 = yes, 0 = no		0.59
Household owning either life stock or garden: 1 = yes, 0 = no		0.84
Household owning the livestock: 1 = yes, 0 = no		0.50
Household having a garden: 1 = yes, 0 = no		0.75
Occupation of household head or main income source in household:		
Budget worker (including teacher and retired person)	54%	
Self-employed with no permanent income, including seasonal jobs	31%	
Self-employed hiring people (relative permanent income)	8%	
Unemployed	7%	
Sex of respondent: 1 = female, 0 = male		0.64
Water source: 0 = private, 1 = public		0.57
Water quality: 0 = bad, 1 = satisfactory		0.68
Connection fee: 0 = no, 1 = yes		0.060

Note: SD = standard deviation.

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# Paper V



# Determinants of willingness to pay for improved water supply services in rural Kazakhstan

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**Abstract.** The UN Sustainable development goals declare to provide water, sanitation and hygiene for all (3). The supply of affordable and safe water is a global priority and there is thus a requirement for a safe drinking water management and management of excreta disposal and wastewater. The current paper assesses the determinants of consumers' willingness to connect and pay (WTP) for the piped water in rural Kazakhstan. The results show that local villagers use water from different sources and at least three quarters of the respondents are willing to connect and use water from the piped water supply. The general defined determinants for WTP should be carefully considered among the different water users. Perceived water quality is a variable that is relevant for all water users. Other variables such as perceived reliability and the time-spent to collect water from the source, in-household treatment of water, and income perception are also significant but differently correlated with the WTP among different water users. Although, piped water is considered to be a safe system if properly managed, still some water users are reluctant to pay for the system and are satisfied with their current water supply and sanitation services. In this case, a proper management for the drinking water and wastewater and safe management of the excreta disposal should be supplied. It is recommended to include local water users' opinion as regard the willingness to connect and pay for the piped water system. The findings are of particular importance for policy-makers, water managers, engineers, and public health specialists.

## 1. Introduction

Access to water supply and sanitation is a fundamental need and a human right (1). It is vital to the dignity and health of all people (2). The UN Sustainable development goals have declared to provide water, sanitation and hygiene for all (3). Thus, the supply of affordable and safe water is a global priority. This means that everyone should be able to have access to safe drinking water and sanitation services. In turn, there is thus a requirement for a safe drinking water management and management of excreta disposal and wastewater.

There are potential gains from developing safe drinking water, sanitation, and environmentally safe hygiene facilities. Recent findings have shown that peoples' appreciation of drinking water supply service has increased. In many cases, poor people pay more for worse drinking water supply service as compared to wealthier people (4).

It is commonly assumed that so long as financial requirements do not exceed 3 to 5% of income, rural consumers will choose to abandon their existing water supply in favor of a safer system. Recent research in developing countries has shown, however, that this simple model of behavioral response to improved water supplies often is incorrect. When the general 3 to 5% of income rule is used to set the level of service, many communities experience that the level of service is too low (the community does not value the improved service and, therefore, will not pay for it). In other communities, the level of service may be too high, i.e.,

the community wants the service but the cost is too high (5). Thus, if rural water projects are to be both sustainable and replicable, an improved planning methodology is required that includes a procedure for eliciting information on the value placed on different levels of service, and tariffs must be designed so that at least operations and maintenance costs (and preferably capital costs) can be recovered (6). Besides, we also need to know the determinants of drinking water supply facilities and proper sanitation (4). The factors that hinder the supply of drinking water services from meeting peoples' expectation are under-usage, low maintenance, and low return of investment/cost recovery. We also must pay attention to other determinants such as social and economic factor of household. If people are willing to pay for a particular service, this is a clear indication that the service is valued (and therefore will most likely be used and maintained) and that it will be possible to generate the funds required to sustain and even replicate the project.

In recent decades, Kazakhstan has been transitioning from a state planned to a market economy. This transition has affected many facets of life including provision of water and sanitation. The Soviet Union sought to tackle the desperate living conditions that the major part of the population suffered from in the early 20<sup>th</sup> century by expanding access to essential services such as piped water. However, when the Soviet Union broke apart in 1991 many people, especially in rural areas that historically have been disadvantaged, still had limited access to drinking water (8,9). Recent research has shown that there have been no significant changes in patterns of access to piped cold water in rural and urban areas of Kazakhstan during the last 10-year period (10). In rural areas, the access to piped cold water remains at a constant 29% although the economic situation of people has improved. Roberts et al. (2012) found that respondents with stated bad to very bad economy changed from 24 to 7% and good to very good economy changed from 16 to 32% between 2001 and 2010, respectively. Consequently, the perceived improved economic situation of the households had not changed the access to piped-water in rural Kazakhstan and there was still a gap between rural and poorer households as compared to urban households. These results are surprising since a massive state-run drinking water program has supposedly financed provision of drinking water to rural areas since 2002 (11).

A survey from 2005 (UNDP, 2006) showed that people in Kazakhstan have a strong incentive to pay for water and, in particular, for improved water supply and water quality. However, the survey also showed that the interviewees did not know how much this service should cost. A large part of the respondents (27%) who expressed WTP for improved water quality could not define the maximum amount they would be willing to pay. Individuals unwilling to pay saw no problem with water supply, could not afford extra costs, or believed that the state should cover such costs (11). In view of this, the Kazakhstan authorities have incentive to provide a better water supply to rural families, e.g., by attracting the private sector into the field. However, to expedite the process and to make it more efficient, customers' opinion and their WTP for improved water services should be studied. Therefore, the aim of this study is to assess the determinants of (factors influencing) consumers' willingness to connect and pay for the piped water in rural Kazakhstan.

## **2. Review of WTP in developing countries**

WTP surveys for safe drinking water access have been conducted in many countries around the world. Roy et al. (2003) conducted a WTP survey for safe drinking water in a ward of Calcutta Municipal Corporation (12). The survey was conducted among 240 households selected both from residential and slum areas. A basic hypothesis was that variations in WTP for drinking quality water across households can be explained by the household income.

Resistance against change of system was assumed to vary with household perception on likely benefits that may be accrued from the new system. The study considered education to be an indicator of the household's access to relevant information. A multiple linear regression model was used to estimate the contribution of various determining factors for the WTP. The explanatory variable was monthly family expenditure adjusted for family size and educational level. The dependent variable was the averting expenditure, a proxy for WTP, incurred by the households (Indian Rupees/litre). They reported that WTP of households varied within a wide range from 0.0023 to 1.06 Indian Rupees/litre (US\$ 0.023). Unlike food, water followed the trend of a luxury item.

Jalan and Somanathan (2004; 13) investigated WTP from an awareness perspective. In their study, a randomly selected group of one thousand households in Gurgaon, a suburb of New Delhi, was informed whether (or not) their drinking water had tested positive for faecal contamination. Households that were initially not purifying their water were to 11% more likely to begin some form of home purification in the next 7 weeks than households that received no information. By way of comparison, the addition of one year of schooling to the most educated person in the household was associated with a 4% increase in some treatment of the household water. Furthermore, shifting from one wealth quartile to the next was associated with a 15% increase in household treatment. The researchers concluded that the issue of under-provision of information needs to be addressed when estimates of the demand for water quality are used for welfare or policy analysis.

In Vijaywada, India (Zerah 2002; 14) a survey examined the connection between the perception of the service and the WTP for water in the higher income group. The survey indicated that 77% of the group considered that water is inexpensive. Their preference for improvement was primarily for an increase of quality (81% of the households), rather than the provision of a water connection, additional hours of service, or an increase of the pressure level. The option to increase water quality was significantly more in some zones, as well as the option of asking for additional supply hours. In other zones, the preference seemed to be increase of pressure. For the connection charges, households were willing to pay about Rs. 2,600, which was lower than contemporary rate for the monthly charge. Households were ready to pay somewhat more than what they paid during the time for investigation. However, in both cases, WTP was more than one and a half times the current tariff.

Asthana (1995; 15) studied the economic behavior of poor citizens through the collection of safe drinking water. The study revealed that perception of health benefits by the participants was significant, and they were prepared to spend a significantly higher amount of time collecting safe water as opposed to unsafe water. In the author's opinion, the common assumption that people are either unwilling or unable to pay for water is incorrect.

In Varanasi, India, Singh et al. (2003; 16) attempted to find the consumers' WTP, and the affordability of cost of water through a bidding game. They found that about 37% of the population were willing to pay the sum of Rs. 40, twice the contemporary charge per month for water supply. They further concluded that as compared to large water supply projects small water supply projects could be financially more viable.

Jordan and Elnagheeb (1991; 17) conducted a survey in Georgia of WTP for improvements in drinking water quality and people's perceptions of potential groundwater contamination. Results showed that 27% of the respondents served by public water supplies rated drinking water quality as poor, and 23% were uncertain about their drinking water quality. The contingent valuation method was used to estimate WTP using a checklist format. The median estimated WTP was \$5.49 per month above their current water bills for people on public systems and \$7.38 for those using private wells, after rejecting outliers and using the maximum likelihood method.



A population's opinion of the adequacy of its current water supply may vary tremendously from one country to another and sometimes, between different parts of the same city. Therefore, the dispersion in WTP estimates should not be surprising. Studies on methodological issues provide some explanations as to why the range of WTP estimates is wide. In several studies evaluated by Reddy (1999; 18), a rule of thumb of 5% of total expenditures is arbitrarily assumed to be the maximum a household is willing and able to pay. Hardner's (1996; 19) WTP estimates measured in terms of labour, for an isolated community in north-western Ecuador, was as high as 23% of the real income. However, other studies contend that such estimates could be too high. From empirical research conducted in Nigeria, Whittington et al. (1992; 20) found that either giving respondents a day to think before formulating a WTP estimate or allowing them to revise their initial bid resulted in significantly lower WTP estimates for improved water systems.

There are different determinants that can significantly influence WTP, such as the distance to the water supply source. For example, a 50% increase in the relative distance of water sources increased WTP by 13% when the initial ratio relative distance-WTP was equal to one, which was found in a study for Mali (21).

Katz et al. (1998; 22) in a UNDP – World Bank study proposed that water supply projects should adopt flexible design standards. It should allow communities that prefer higher levels of service to bear the cost of household connections as part of the original design. Projects should also provide the option of lower service levels for communities that prefer to pay less.

### **3. Methodology**

#### **3.1 Survey design and data collection**

The survey was performed in the rural area around Pavlodar City, Kazakhstan. The area covers 5,578 km<sup>2</sup> and 37 peri-urban villages. The survey was performed in three steps. Initially, a pre-survey included visits to 2 villages and interviews with village mayors, village council responsible, hydrogeologist in the area, and village inhabitants. The experiences from the pre-survey were used to jointly design a pilot study together with the above collaborators. As noted by e.g., Grosh and Glewwe (20), it is important to involve a team of experts, including members of the organization implementing household surveys. In the pilot study, 10 villages were randomly selected for a WTP for water supply. The rest of the villages, in total 27 peri-urban villages of different size, were investigated in the present survey conducted during July-August 2013. Thus, due to the participation of the 10 first villages in the pilot study, these were not included in the present survey. Through the above mentioned close collaboration with the local municipalities, a questionnaire was designed, distributed to all households in the 27 villages and consequently collected by the village mayors. Due to the local rules for performing interviews, this was a necessary manner to collect interviews. The questionnaires were delivered in different ways. Usually, the local participants collected the questionnaires from the local mayor and brought it back. In some cases the mayor assistant would distribute and also collect the questionnaires. Depending on the village, the households had from several days to a few weeks to answer the questionnaire. The questionnaires were to be performed by the head of the household. Interviews represent households and not individuals. The average answer rate was about 42%. Altogether, 2,570 questionnaires covering 8,493 persons in the area were collected.

The questionnaire had three parts describing socio-economic characteristics of the household, access to drinking water and its perceived quality, and willingness to connect and pay to maintain the access to tap water at home.

The contingent valuation method was used to identify the WTP. The WTP question format that was used was in the form of payment cards, when the range of price options had been offered. In order to use such a form of WTP question, the pilot study showed that whether people give their own amount or offered a range, are similar. Therefore, we believe that the offered price did not influence their decided WTP significantly.

It should be noted that standpipes exist in all villages. Thus, regardless of the private connection people can always use standpipe water. Therefore, the WTP for the standpipe water was included in to the questionnaire.

### 3.2 Data analysis

Initially the survey tried to define general factors that influenced people to connect and pay for the piped system. Therefore, all the respondents were split into two categories: those who would like to connect to the system and pay and those who would not like to connect or may connect but not pay for using tap water from the piped system. Binary logistic regression in the SPSS software was used to find the maximum likelihood estimation of the independent variables (determinants) according to:

$$\ln(WTP) = \ln\left[\frac{\text{Pr}}{(1 - \text{Pr})}\right] = a + bX \quad (1)$$

$$\left[\frac{\text{Pr}}{(1 - \text{Pr})}\right] = e^{a+bX}$$

$$\left[\frac{\text{Pr}}{(1 - \text{Pr})}\right] = e^a (e^b)^X$$

where  $a$  and  $b$  are constants and  $bX$  is consumer index.

During initial data analyses one of the villages was removed from further analysis. The excluded village used to have access to piped water in the past and currently people use different water source and almost no one in the village wants to pay for and use tap water at home. A sensitivity analysis showed that this village significantly affected the regression analysis. Thus, the village needs a separate investigation.

After defining the most significant variables influencing the WTP and connect, further analyses for each separate water user type were conducted to elucidate whether there is a difference between the factors influencing WTP among different water users. In order to estimate the WTP all respondents among different water users were split in to three categories: those who will not pay, those who will pay little amount (below 600 KZT), and those who will pay higher amount (above 600 KZT). Ordered regression in the STATA software was used to estimate the WTP among different water users according to:

$$y^* = \mathbf{x}'\beta + \varepsilon \quad (2)$$

$$y = \begin{cases} 0 & \text{if } y^* \leq 0 \\ 1 & \text{if } 0 \leq y^* \leq 600 \\ 2 & \text{if } 600 \leq y^* \end{cases}$$

where  $x'\beta$  consumer index.

## 4. Results and discussion

### 4.1 Description of the socio-economic characteristics of the households

Table 1 shows the characteristics of the respondents such as sex and age and the household. The living time in the area for a majority of households is more than 10 years assuming that they have been adjusted the water supply. An average household is composed by 2 to 5 persons. Two variables were used to determine the household income: perceived and real income. Our previous research has found that perceived income is a more valid measure of the economic situation of a household since most of the household have either garden or livestock that is a contribution to their food basket, which is not counted. The extremes such as very good and very bad income are very unusual, while most of the people are satisfied with their economic situation.

<b>Table 1. Household characteristics</b>		
<b>Description</b>	<b>Per cent</b>	<b>Mean</b>
<i>Respondent characteristics</i>		
Sex: female=0, male = 1		0.36
Age		47 (SD 14)
<i>Household characteristics</i>		
Living time for the household in the area:		
Less than 5 years	7%	
Between 5 and 10 years	13%	
More than 10 years	80%	
Number of people in household (min.=1 and max. =12, median = 3)		3.5 (SD 1.6)
Family with retired person: 1 = yes, 0 = no		0.3
Family with children up to 18 years old: 1 = yes, 0 = no		0.51
Income perception		
<i>Very good</i>	1%	
<i>Good</i>	16%	
<i>Satisfactory</i>	74%	
<i>Bad</i>	8%	
<i>Very bad</i>	1%	
Income per capita in KZT (min = 500, max = 375,278, median = 24,748)		28,015 (SD18,878)

### 4.2 Access to water and sanitation

Table 2 shows the variety of water supply sources and the sanitation services in the region. The description of the source has been investigated by the author in a related study. From Table 2 we can define six main groups of water users: tap water, standpipe, private

borehole, public borehole, individual well, and open source water users. These six groups were included in the further analyses.

In terms of sanitation, almost 90% use pit latrines outside their house. The majority of people realizes the importance of water supply for their household.

<b>Table 2. Access to water and sanitation</b>	
<b>Description</b>	<b>Per cent</b>
<b><i>Access to water</i></b>	
<i>Tap piped water</i>	5.5%
<i>Standpipe</i>	18.1%
<i>Individual borehole</i>	50.5%
<i>Public borehole</i>	5.9%
<i>Individual well</i>	10.7%
<i>Public well</i>	1.0%
<i>Bottled water</i>	0.3%
<i>Delivered water</i>	1.3%
<i>Open source (river, lake)</i>	5.7%
<i>CBM</i>	0.2%
<i>Other</i>	0.8%
<b><i>Access to sanitation</i></b>	
<i>No toilet</i>	4.7%
<i>Toilet outside home</i>	89.5%
<i>Toilet at home, without access to piped sewer system</i>	4.7%
<i>Toilet at home, with access to piped sewer system</i>	1.1%
<b><i>Importance of the water supply to household</i></b>	
<i>Absolutely not important</i>	4.6%
<i>Not important</i>	10.3%
<i>Between important and not important</i>	7.7%
<i>Important</i>	41.7%
<i>Very important</i>	35.7%

#### 4.3 WTP to maintain standpipe and piped water at home

Table 3 shows the WTP to maintain standpipe and piped water at home. While the majority think that water supply is important for their household, more than 27% would not pay for the piped water at home and about 40% would not pay for using standpipe water. About 74% would not pay connection fee for the provision of piped water to their home. The majority of 70% believe that piped water is the responsibility of the government or local mayor, and only 13% believe it should be the local water users' responsibility.

<b>Table 3. Willingness to pay to maintain standpipe and piped water at home</b>		
<b>Description</b>	<b>Per cent</b>	<b>Mean</b>

<b><i>Willingness to pay to maintain standpipe water</i></b>	
<i>Will not use</i>	31.3%
<i>Will pay "Zero"</i>	8.6%
<i>100-250</i>	24.5%
<i>251-400</i>	12.0%
<i>401-550</i>	13.1%
<i>551-700</i>	4.6%
<i>701-850</i>	1.6%
<i>851-1000</i>	3.7%
<i>More</i>	0.5%
<b><i>Willingness to pay to maintain piped water at home</i></b>	
<i>Will not use</i>	20.1%
<i>Will pay "Zero"</i>	7.5%
<i>100-300</i>	32.2%
<i>301-600</i>	16.6%
<i>601-900</i>	8.0%
<i>901-1200</i>	9.8%
<i>1201-1500</i>	2.7%
<i>1501-1800</i>	0.8%
<i>1801-2100</i>	1.6%
<i>More</i>	0.6%
<b><i>Willingness to pay the connection fee (40 000 KZT): yes =0, no=1</i></b>	0.74
<b><i>Responsibility for the maintenance of standpipe water</i></b>	
<i>Local mayor (municipality)</i>	70.3%
<i>Private organization</i>	13.9%
<i>Local citizens' board</i>	12.6%
<i>Other</i>	3.1%
<b><i>Responsibility for the maintenance of piped water at home</i></b>	
<i>Local mayor (municipality)</i>	69.7%
<i>Private organization</i>	13.8%
<i>Local citizens' board</i>	13.6%
<i>Other</i>	2.9%

#### 4.4 Willingness to connect to piped water supply

Table 4 shows results from the binary regression analysis (Eqn. (1)) for the willingness to connect to and pay for maintenance of the piped water supply. As seen from the table, the most statistically significant variables were present water source, perceived quality, perceived reliability of the source, time-spent to collect water, additional household treatment of drinking water, household size, and current expenses for drinking water. Among these, public borehole users (0.536) and income perception (0.532) received highest significance. After these, a strong significance was found for sanitation at home (0.440) and open source water users (0.368).

Compared to tap water users individual borehole water users have lower willingness to connect and pay for tap water from the piped system. The water quality variable shows that the

change in perceived water quality from good to bad increases the willingness to connect and pay for piped water supply.

The reliability of the water source can be interpreted as if water from the source can provide constant access and giving the same quality and quantity of water. The change in perceived reliability from reliable to not reliable increases the WTP.

The time spent variable shows that if you spend less time to collect water the less you are willing to pay for the piped water (and consequently, if spending more time you are more willing to pay).

The additional household treatment of drinking water variable shows that those who do not use the water directly from the source and use additional treatment have higher willingness to pay for piped water.

The variable for water expenses shows that if the current water users at present spend money to obtain drinking water they are willing to pay for the piped water supply.

Access to sanitation and perception of the household financial situation does not show a significant influence on the willingness to connect to the piped water system.

As seen from the above, it is obvious that a water supply source can be described from many different viewpoints and various perceived characteristics. As well, the socioeconomic situation of the user influences how water is perceived and the WTP to be

**Table 4. Results for the binary regression analysis (Eqn. (1)) for the WTP for connection and maintenance of the piped water supply.**

Variable in Eqn. (1)		b	Significance	Exp(b)
<b>Water source</b>	<i>tap water</i>		<b>0.000</b>	
	<i>open source</i>	-0.457	0.368	0.633
	<i>individual borehole</i>	-1.005	<b>0.003</b>	0.366
	<i>public borehole</i>	0.346	0.536	1.413
	<i>individual well</i>	0.810	<b>0.060</b>	2.248
	<i>standpipe water</i>	0.546	0.188	1.726
<b>Water quality</b>	<i>from good to bad</i>	0.510	<b>0.002</b>	1.666
<b>Reliability</b>	<i>from reliable to not reliable</i>	0.705	<b>0.000</b>	2.024
<b>Time spent</b>	<i>from much time to less time</i>	-0.459	<b>0.001</b>	0.632
<b>Household treatment</b>	<i>no treatment</i>		<b>0.000</b>	
	<i>settling</i>	0.405	<b>0.014</b>	1.499
	<i>other</i>	1.662	<b>0.001</b>	5.269
<b>Household size</b>		0.152	<b>0.002</b>	1.164
<b>Income perception</b>		-0.025	0.532	0.976
<b>Water expenses</b>		0.347	<b>0.015</b>	1.415

<b>Sanitation</b>	<i>at home</i>		0.440	
	<i>no toilet</i>	-0.382	0.220	0.683
	<i>outside toilet</i>	-0.459	0.264	0.632
<b>Constant</b>		-0.196	0.788	0.822
<b>Number of observations: 1,408</b>	<b>R square: 0.345</b>	<b>Sign.: 0.0</b>		

connected. Thus, to involve the user in the decision process, it is important to understand and quantify factors that determine the WTP. Different water users may have a similar or different driver for the WTP.

#### 4.5 Determinants for WTP

Ordered regression according to Eqn. (2) was used to determine the WTP for piped water supply depending on different water user type according to Table 5. The perceived water quality was the variable that all water users found to be relevant. Obviously, if you are not satisfied with the water quality you are willing to pay more for a better quality water.

Perceived reliability of the water source indicates whether the consumers believe that the water service access is reliable or if water uptake from the source is secure. If your current water source is not reliable you are willing to pay more for the piped water. The only exception is the current tap water users that had a negative relationship. Consumers who believe that the water source is not reliable (e.g., water service given hourly or water having a brownish colour) would like to pay less. This indicates that there are problems with the current trust towards tap water from the piped system.

**Table 5. Results for ordered regression according to Eqn. (2) to determine the WTP for piped water supply depending on different water user type.**

WTP ordered	<i>Tap water</i>	<i>Standpipe</i>	<i>Ind.borehole</i>	<i>Public borehole</i>	<i>Ind.well</i>	<i>Open source</i>
<i>Water quality bad</i>	4,11 **	-1,32 *	0,65 *	1,64	0,22	4,18 ***
<i>Water quality OK</i>	3,69 ***	-0,55	0,62 ***	2,11 **	0,68 *	2,65 *
<i>Water quality good</i>	0	0	0	0	0	0
<i>Not reliable</i>	-4,85 **	1,88 ***	1,61 ***	-0,18	-1,94	-0,43
<i>Not often reliable</i>	-3,11 **	1,95 ***	1,05 ***	0,99	-1,03 ***	-0,54
<i>Reliable</i>	0	0	0	0	0	0
<i>Much time spent</i>	-2,61	0,59	1,09 ***	0,86	0,48	0,69
<i>Less time spent</i>	-2,24 ***	1,79 ***	0,57 ***	0,10	1,27 ***	2,05
<i>No time spent</i>	0	0	0	0	0	0
<i>Other treatment</i>	-0,84	0,98 **	0,56 ***	0,71	-0,22	-1,31 **
<i>Settling down</i>	0,98	0,26	0,76 ***	0,91	-0,11	-0,87
<i>No treatment</i>	0	0	0	0	0	0
<i>Income perception good</i>	-1,39	-0,20	0,81 ***	0,009	0,64	2,95 ***
<i>Income perception satisfied</i>	-3,02 **	0,43	0,45 *	0,66	1,30	0,25
<i>Income perception bad</i>	0	0	0	0	0	0
<i>Household size</i>	0,10	-0,014	-0,023	0,21	0,019	0,28
<i>Water expenses</i>	0,0005	0,0002	0,00007 *	-0,0003	0,001	0,0002
<i>number of observations</i>	93	291	838	88	179	82
<i>significance</i>	0	0	0	0	0	0
<i>r square</i>	0,29	0,16	0,15	0,18	0,09	0,24
<i>/cut1</i>	-4,47	0,57	2,00	1,74	-0,30	2,96
<i>/cut2</i>	4,79	4,65	5,58	7,04	2,92	6,41

For the time spent to collect water there is a positive trend for all water users except for the current tap water users. This means that the more time they spend to collect water the less they want to pay for a similar system with 24 hour access to potable water.

The variable for additional household treatment is less clear since sub-variables were merged into one group corresponding to no treatment. Settling represented a small proportion, and all other types of treatment that merged into the second largest group. Individual borehole water users would be willing to pay more if they use additional household treatment before water intake.

The variable income perception was chosen due to the fact that this might better reflect the purchasing ability. Recent research has shown that those who perceive that they have a good income would likely pay more. As seen from the table, particularly open source and individual borehole water users would like to pay more if they perceive their income as good. There is a negative trend for tap water users. The better they perceive their economic situation, the less no willingness they have to pay for improved water system.

The two variables household size and water expenses are in general not statistically significant.

As seen from the table, different water users value different factors that influence the WTP for piped water. For current tap water users, it appears that they have lost some trust in the current water source. The time spent to collect water and income perception are other main factors affecting the WTP. Improved trust in the piped water system may increase the WTP for piped water. One interesting variable that is significant is the perceived household financial situation. With improved financial situation there is a less WTP but it can be also associated with perceived bad quality of the water.

For open source water users, the income perception is one of the most influential variables for WTP. In general, if consumers can afford they are willing to pay. Water treatment variables have a negative relationship meaning that if the household has installed some treatment technique then they are less willing to pay.

For individual borehole water users, variables indicate logical relationships. The worse the quality of water, less reliable, much time spent, using additional household treatment, higher income perception, higher current water expenses, the more they want to pay for the piped water. There is a similar situation with the public borehole water users.

Standpipe water users are more or less similar to borehole water users with only a difference in the perception of water quality.

We may conclude that although some of the variables, especially perceived water quality, are common for all the different water users, there are still differences in their relationship in regards to WTP. Therefore, whenever planning piped water supply systems in rural areas we have to understand the local needs and the willingness to access drinking water service.

#### 4.6 Water management solutions



The UN Sustainable Development Goals (SDGs) promote water and sanitation for health (WASH) for all. Its agenda is full coverage with access to safe drinking water and safe management of excreta disposal. These goals do not discriminate between the different water sources and sanitation services unless the access is safe and the excreta is disposed. Thus, the management of drinking water supply and wastewater and safe management of excreta disposal are crucial.

Although water on premises is one of the safe access types to drinking water, still certain water users would not like to connect to the piped system. There are different drivers for them not to connect and one of the major drivers is satisfaction with the current water source, which should not be neglected. If the private borehole water user is satisfied with the present water source it should be properly managed. Consequently, the wastewater should be treated and the excreta disposed in a safe way. This system will require a proper management and monitoring as well as involvement of local water users and their responsibility for the well-functioning water and wastewater system and excreta disposal. The hygiene promotion is a must in such cases.

The study showed that almost 90% of all respondents have private pit latrines outside in the yard. According to the SDGs if a pit latrine is not shared and the excreta disposal is safely managed the household has safe access to sanitation. Proper management includes a monitoring system as well as a hygiene behaviour promotion and a main responsibility from the water user side.

For the current tap water user it is important to improve the trust to the system, since those who had lower reliability to the system, less satisfaction with the water quality, and spent time to collect water for various reasons can still use this water if it is properly managed. In this case, the wastewater system should be well functioning offering either local in-household treatment such as septic tank, safe pit-latrines or a proper sewer collection system. Obviously open source water users need to have an access to safe water sources. Thus, the water provided to them should be affordable in price and of a decent quality.

## **5. Conclusion and recommendations**

The current study investigated the determinants of WTP for the piped water supply among different water users in rural Kazakhstan. It should be noted that local villagers use water from different sources and at least three quarters of the respondents are willing to connect and use water from the piped water supply. However, general defined determinants for WTP should be carefully considered as regards each particular water user. Thus, the survey established determinants of the WTP among the different water users.

Perceived water quality is a variable that is relevant for all water users. The less people are satisfied with the current water source the more they are willing to pay. Other variables are also significant but differently correlated with the WTP among different water users. These are perceived reliability and the time-spent to collect water from the source, in-household treatment of water, and income perception. The variable water expenses is significant only for the private borehole water users.

Current tap water users behave somewhat differently as compared to other groups. When the other groups perceive the water source as less reliable and spend more time to collect water then they have greater WTP for the piped water. The same relationship for the current tap water users is a smaller WTP.

The SDGs recommend having a sustainable drinking water supply management and a safe excreta disposal management. Although, water on premises is considered to be a safe system if properly managed, still some water users are reluctant to pay for the system and are satisfied with their current water supply and sanitation services. In this case, a proper management for the drinking water and wastewater and safe management of the excreta disposal should be supplied. This can also mean to supply in-household treatment of greywater using septic tanks or other eco-friendly treatment techniques, and eco-friendly pit latrines with safe excreta disposal. Local systems, however, mean a greater responsibility from the water user side and consequently their environmental awareness and improved hygiene behaviour.

Based on the findings it is recommended that local water users' opinion as regard the willingness to connect and pay for the piped water system should be taken into consideration. This can help not only to define the reasons why people want to or do not want to connect and pay for the piped system, but also help to improve current drinking water and sanitation management systems in a more efficient way. The improved hygiene behaviour and environmental awareness are pre-requisites for any water intervention and peoples' involvement is very crucial. Thus, the findings are of particular importance for policy-makers, water managers, engineers, and public health specialists.

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Appendix 1.

<b>Table. Perceived characteristics of water source</b>		
<b>Description</b>	<b>Percentage</b>	<b>Mean</b>
<b><i>Perceived water quality</i></b>		
<i>Good</i>	24.5%	
<i>Satisfactory</i>	62.0%	
<i>Bad</i>	13.5%	
<b><i>Water reliability</i></b>		
<i>Reliable</i>	32.0%	
<i>Not often reliable</i>	49.0%	
<i>Not reliable</i>	19.0%	
<b><i>Time spent to collect water</i></b>		
<i>Much</i>	15.5%	
<i>Little</i>	61.0%	
<i>No time spent</i>	23.5%	
<b><i>Household water treatment</i></b>		
<i>Nothing</i>	45.0%	
<i>Water filter</i>	11.0%	
<i>Boiling</i>	37.0%	
<i>Settling</i>	6.7%	
<i>Other</i>	0.3%	
Monthly expenses to obtain water in KZT (min. = 50, max = 10,000, median = 500 , N= 725)		1,053 (SD 1,430)



