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Working Paper

Navigating WASH challenges in rural areas: Peer effects and infrastructure

ADBI Working Paper, No. 1428

Provided in Cooperation with:

Asian Development Bank Institute (ADBI), Tokyo

Suggested Citation: Kapsalyamova, Zhanna; Karymshakov, Kamalbek; Azhgaliyeva, Dina (2024) : Navigating WASH challenges in rural areas: Peer effects and infrastructure, ADBI Working Paper, No. 1428, Asian Development Bank Institute (ADBI), Tokyo, <https://doi.org/10.56506/EBJO6248>

This Version is available at:

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ADB Working Paper Series

**NAVIGATING WASH CHALLENGES IN
RURAL AREAS: PEER EFFECTS AND
INFRASTRUCTURE**

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and Dina Azhgaliyeva

No. 1428
February 2024

Asian Development Bank Institute

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Suggested citation:

Kapsalyamova, Z., K. Karymshakov, and D. Azhgaliyeva. 2024. Navigating WASH Challenges in Rural Areas: Peer Effects and Infrastructure. ADBI Working Paper 1428. Tokyo: Asian Development Bank Institute. Available: <https://doi.org/10.56506/EBJO6248>

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Abstract

Despite the well-documented benefits of improved sanitation and washing facilities, a considerable number of people, even in middle-income countries, still lack access to modern sanitation and home-based bathing facilities. This paper leverages household budget survey data from two Central Asian countries to investigate the barriers to improved adoption of sanitation and washing facilities. The study finds that in Kazakhstan, households with higher incomes generally have better sanitation facilities. Households led by married individuals have better facilities in both Kazakhstan and the Kyrgyz Republic. The average adoption rate in a sub-province also contributes to an increased household-level sanitation and washing facilities uptake. This suggests that peer influences represent an important mechanism underlying household behavior. The role of infrastructure is significant. Access to piped water increases the probability of adoption of modern sanitation and washing facilities in both countries. Primary barriers to the adoption of better sanitation and washing facilities by rural households include the lack of necessary infrastructure (piped water and centralized sewerage).

Keywords: WASH, sanitation, Central Asia, rural households, structural estimation

JEL Classification: I12, O12, O18, J16

1 Introduction

The lack of safe sanitation and domestic bathing facilities constitutes a global challenge that is pertinent to many middle-income countries. This shortfall poses significant risks to public health, environmental sustainability, and overall well-being. In rural areas, there is a lack of basic infrastructure, including septic tanks, centralized sewerage, and domestic washing¹ facilities. Our paper aims to uncover the barriers hindering wider adoption of safe and improved sanitation and washing amenities in Kazakhstan and the Kyrgyz Republic, two Central Asian countries with distinctive challenges and characteristics.

Kazakhstan and the Kyrgyz Republic have experienced rapid economic growth in recent years. However, financial limitations and insufficient infrastructure impede rural populations' access to improved sanitation² and hygiene facilities. In 2015, in Kazakhstan 89% of rural population relied on pit latrines³, with only 7% having access to toilets with septic tanks (WHO/UNICEF (2017)). In the Kyrgyz Republic, an even higher percentage, 98% of the rural populace use pit latrines. Furthermore, rural households in Kazakhstan and the Kyrgyz Republic typically source their water from shallow wells, often located near outdoor latrines (Snegireva (1999); Nurgalieva et al. (2002); Bekturganov et al. (2016)). This proximity poses significant health risks due to potential contamination. Access to sewer connections and the use of septic tanks remain limited in rural areas (Burunciuc (2019)). These conditions exacerbate environmental pollution and public health risks, resulting in annual costs estimated at around \$2 billion/year (Burunciuc (2019)).

The studies extensively document the adverse health consequences associated with the absence of inadequate sanitation and contaminated water sources (Bekturganov et al. (2016)). Water, Sanitation, and Hygiene (WASH) initiatives have been recognized for their positive impact on health (Brouwer et al. (2023)), employment, education, and women's empowerment (Dickin et al. (2021)). For instance, improved hygiene through centralized sewerage systems or septic tanks reduces human and insect contact with human waste, a benefit not provided by unsanitary pit

¹In the rest of the paper, the terms 'bathing' and 'washing' will be used interchangeably.

²Sanitation services refer to the management of excreta from the facilities used by individuals, through emptying and transport of excreta for treatment and eventual discharge or reuse. Improved sanitation facilities are those designed to hygienically separate excreta from human contact (JMP (2023)).

³A type of toilet that collects human waste in a hole in the ground.

latrines (Figure 1).

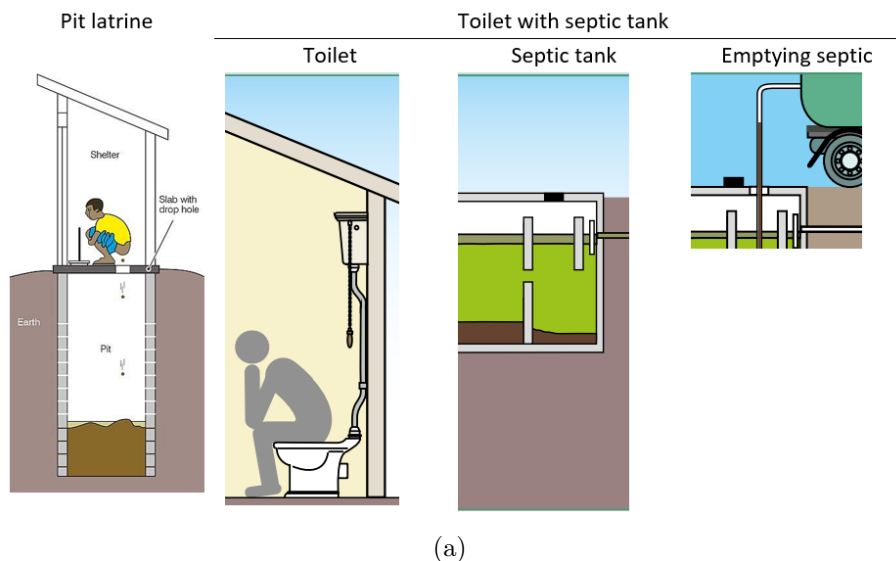


Figure 1: Types of toilets: pit latrine and toilet with septic tank

Note: In this paper open defecation is excluded as Kazakhstan and the Kyrgyz Republic reached 0% of open defecation.

While the literature underscores the positive impact of WASH initiatives, it also highlights challenges in their promotion, especially when facing with limited public budgets. For instance, limited investment in sanitation is often linked to disease-related external factors, inequalities in distribution within families, coordination failures, and behavioural biases (Rijsberman and Zwane (2012)). Addressing these challenges requires increased funding, infrastructure improvement, and development of cost-effective technologies. Wastewater treatment plants and vacuum trucks used for septic tank emptying are costly and energy-intensive. The current practice of manually cleaning latrines and septic tanks introduces environmental risks.

Under the SDG Target 6.2 “Sanitation and hygiene” countries aim to achieve access to adequate and equitable sanitation (safely managed sanitation service) and hygiene for all by 2030. The target is measured with Indicator 6.2.1 “Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water“. Sanitation facilities, such as individual pit latrines, septic tanks, and facilities exceeding the standards set by the sanitation ladder (Figure 2) are classified as safely managed sanitation. In Central Asia, the indicators of SDG 6.2.1(a) and (b) show high coverage. For instance, Kazakhstan has achieved

100% coverage⁴, the Kyrgyz Republic has 93% coverage⁵, and other countries in the region report over 75% coverage. However, pit latrines, even when classified as 'safely managed', may not be inherently safe or modern. Such facilities lack effective waste containment, hygienic separation from human contact, and safe waste treatment.

The infrastructure necessary for modern sanitation (e.g., piped water and centralized sewage infrastructure) in Central Asia is outdated, mostly dating back to the Soviet times. Moreover, access to piped water and centralized sewage, especially in rural areas is limited. Only 60% of households have piped water inside of the house (35.1% have piped water system installed outside) in rural Kazakhstan and 24% of households have piped water inside of the house (27% have piped water system installed outside) in the rural Kyrgyz Republic. Only 6% of households have a centralized sewerage system in rural Kazakhstan. As a result, only 41% of rural households have modern sanitation with mainly septic tanks in Kazakhstan. There is also a huge gap in sanitation between urban and rural areas. That resembles the situation in other Central Asian countries, for instance in Uzbekistan only a quarter of all households had access to a centralized sewerage system⁶.

Kazakhstan's government has pledged to connect all villages across the country to the water distribution network by 2026. 51% of the water grid is deemed to be substandard. Access to safe drinking water remains a challenge, despite substantial investments made for this purpose over the last years.

⁴<https://www.sdg6data.org/en/country-or-area/Kazakhstan>

⁵<https://www.sdg6data.org/en/country-or-area/Kyrgyzstan>

⁶In rural Uzbekistan most households use taps in their yards (97%), but also use pumps in the yard (27%) and rivers, lakes and ponds (26%). 20% have toilets inside of the home in Uzbekistan according to the World Bank survey (2015)

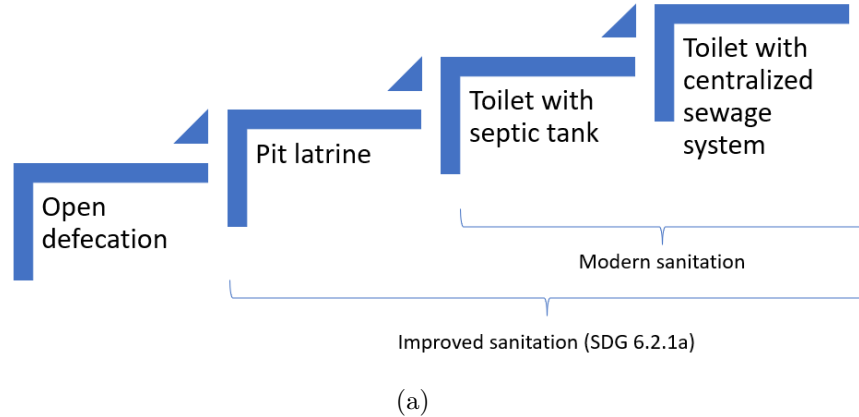


Figure 2: Sanitation ladder

The primary sources of funding for water supply and sanitation in Central Asia are governments and international assistance, with households contributing significantly only in Azerbaijan and the Kyrgyz Republic (ADB (2020)). While 95% of the rural respondents in Kazakhstan express willingness to connect to the piped water system (Tussupova et al. (2015)) and more than 90% of the consumers are willing to pay for better water quality and regular water supply (Tussupova et al. (2015)), limited investments hinder infrastructure improvements.

There is a gap in comprehensive studies addressing sanitation and hygiene challenges specific to Central Asian countries, as the focus of most studies is on African and other developing countries. To fill this void in the literature, we use the household budget survey data for Kazakhstan and the Kyrgyz Republic to uncover the determinants of the adoption of sanitation and washing facilities by rural households.

Our study applies a static model to examine household choices regarding the adoption of these facilities, taking into account the interdependence of decisions within sub-provinces and the role of externalities or peer effects, factors often overlooked in similar studies. The study by Gautam (2023) is one of the first studies to apply this methodology to sanitation adoption in India. We apply a two-stage pseudo-likelihood estimator, following Gautam (2023) and Aguirregabiria and Mira (2002) to the adoption of sanitation facilities in Kazakhstan and bathing facilities in the Kyrgyz Republic. We also study the potential impact of income and infrastructure improvements in Kazakhstan and infrastructure improvement in the Kyrgyz Republic using counterfactual scenarios.

To account for the unique features of the data and the specific conditions of each

country, we use two distinct metrics to evaluate WASH practices in Kazakhstan and the Kyrgyz Republic. In Kazakhstan, our dependent variable is whether a household uses a pit latrine or septic tank. In the Kyrgyz Republic, where over 98% of rural households depend on pit latrines, we employ a different criterion: examining whether a household has in-house bathing facilities or relies on external amenities (Figure 3). This tailored approach allows us to address the nuanced aspects of WASH conditions in rural areas.

We contribute to the literature in the following respects. First, we provide empirical evidence on understanding determinants of household demand for sanitation and washing facilities in Kazakhstan and the Kyrgyz Republic, thereby uncovering the barriers to the improvement of these amenities. Second, we employ the nested pseudo-likelihood method by [Aguirregabiria and Mira \(2002\)](#) to identify the role of externalities in the demand for improved sanitation and washing facilities. The studies focusing on externalities in WASH contexts are scarce ([Gautam \(2023\)](#)).

The remainder of the paper is structured as follows. Section 2 describes the data. Section 3 presents the methodology. Section 4 discusses the results and Section 5 concludes the paper.

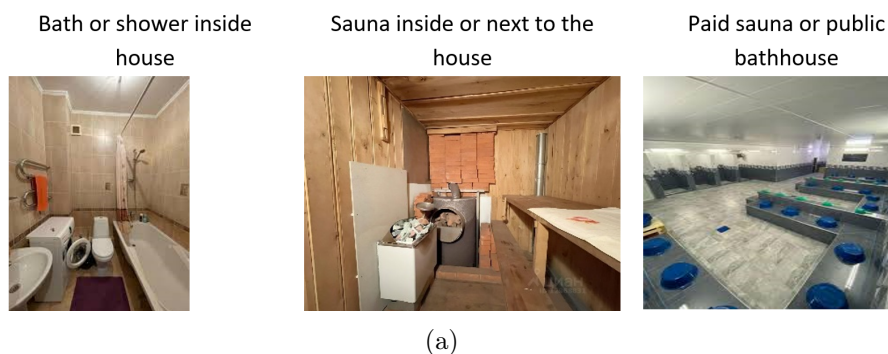


Figure 3: Bathing options

2 Data

2.1 Kazakhstan

The study uses the nationally representative annual household budget surveys (HBS) for Kazakhstan for 2021 conducted by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. This survey involves a total of 12,000 households from all regions of the country. Our focus is

on rural households, therefore our sample reduces to 4,992 households from over 120 settlements⁷.

The selection of households for the survey follows a two-stage probabilistic sampling method, which involves stratification and random selection procedures. The population is stratified based on territorial divisions, encompassing urban and rural areas, resulting in 30 distinct strata. From each stratum, 30 households are randomly selected as primary sampling units (PSUs). The households to be visited for the survey are then chosen with equal probability from the eligible households within each PSU.

Personal interviews are conducted with household members every quarter. These interviews collect additional information about demographic details and other relevant factors associated with the dwelling conditions of the households. The dataset offers a comprehensive and representative depiction of household characteristics and consumption patterns in Kazakhstan during the specified survey period.

2.2 The Kyrgyz Republic

We also use data from the Kyrgyz Integrated Household Survey (KIHS), which is conducted by the National Statistical Committee of Kyrgyz Republic. The survey is nationally representative, and the sample is drawn using a two-stage stratified random sampling approach. The survey is representative at the national, rural/urban, and regional (oblast) levels.

For our research, we use household-level data for 2021. The KIHS surveys about 5,000 households each year. In our study we focus on the rural sample. This rural sample consists of 1,917 observations collected from 180 settlements⁸ across the country. In the survey, the main respondent is typically the household head or a knowledgeable member of the household. The survey covers a wide range of dimensions, including the household roster, income, expenditure, consumption patterns, employment status, and household assets.

2.3 Variables

2.3.1 Dependent variables

For Kazakhstan, the dependent variable is the household availability of the sanitation facility, which is divided into two categories: (i) centralized sewerage system or septic

⁷Some observations are dropped due to missing data on employment.

⁸In the rest of the paper, the terms 'settlements', 'regions', and 'sub-provinces' are used interchangeably.

tank and (ii) pit latrine. For the Kyrgyz Republic, we use the variable of hygiene indicating if a household has its own facility at home for taking a bath or shower.

2.3.2 Independent variables

We are interested in understanding the impact of household disposable income per capita and the average level of sanitation among others in a sub-province, excluding household i . Income is calculated by considering various sources, including hired labour, self-employment, entrepreneurship, and social transfers. Social transfers are further categorized into category-based and income-based social transfers. We also include two sets of control variables.

The first set includes household head characteristics, such as age, gender, education level, marital status, and labor status⁹:

1. Age of the household head, which is a continuous variable.
2. The gender of the household head. The gender variable takes a value of one for females and zero for males. Gender is included due to the heterogeneous effect of gender on sanitation benefits. [Wang and Shen \(2022\)](#) show that unsanitary pit latrines disproportionately burden women, and improved sanitation facilities have greater benefits for women in terms of reducing domestic housework.
3. Education level of the household head. We generate three major education groups: incomplete secondary education, secondary education, and tertiary education. More educated household heads are likely to have better sanitation ([Coffey et al. \(2017\)](#)), potentially due to their heightened awareness of health risks associated with inadequate sanitation.
4. Primary activity status of the household head, which captures employment and non-employment categories. We use three categories: employed, self-employed, unemployed, and out of the labour force.
5. Marital status of the household head, which categorizes individuals as married or single.

We also consider the dwelling characteristics, which include:

⁹To identify a primary breadwinner within a household, we use the information provided by the household members. Household Budget Survey (HBS) questionnaire allows a respondent to self-identify as the primary breadwinner. However, experts from the Bureau of National Statistics caution that the selection of breadwinners may be influenced by factors such as age hierarchy or gender preferences, even though the questionnaire instructs respondents to consider income level.

1. The number of rooms in the apartment or house and house ownership.
2. Living space, recorded as a numerical variable in square meters. We apply the natural logarithm to the living space.
3. Availability of a piped water system indoors, availability of piped water system outdoors within a yard, and other water sources.
4. Sewerage system, classified differently for Kazakhstan into central sewerage and other sewerage systems but omitted for analysis in the Kyrgyz Republic since most rural households in the Kyrgyz Republic do not have central sewage and rely on local sewage facilities at home.

We also include whether a household has a transport vehicle, mobile phone, land ownership, and other relevant variables.

2.4 Summary statistics

Table 1 presents a summary statistics related to rural households in Kazakhstan. 42% of households have either septic tanks or a centralized sewerage system. Female-headed households account for 46% of the sample. The average age of household heads is 53 years. A significant portion, about 70% of households, are single. 76% of household heads have secondary education. 98% of households own their housing amenities. 58% of household heads are employed, 8.6% are self-employed, and the remaining 33% are either unemployed, out of the labor force, or retired. 17% of households reside in two-room apartments, 48% in three-room apartments, and 34% in accommodations with more than three rooms.

Only 11% of households have mobile phones. 57% of households have access to an indoor piped water system, and 15% have a piped water system installed outside of their homes. A significant proportion, 40% relies on other types of water access. A mere 6% of households have access to centralized sewerage system. 98% of households have transport vehicles. 78% of households own private land, with 6% having rented land.

Table 1: Summary Statistics, Kazakhstan

Variable	N	Mean	Standard deviation	Min	Max
Sanitation (0=pit latrine, 1=septic tank or centralized system)	4992	0.42	0.49	0.00	1.00
Total income per capita, log	4992	13.24	0.50	10.33	15.35
Mean sanitation of others, excl. i household in region r	4992	0.42	0.32	0.00	1.00
Female	4992	0.46	0.50	0.00	1.00
Age	4992	53.41	13.48	20.00	91.00
Education	4992	2.10	0.48	1.00	3.00
Employment status	4992	1.75	0.92	1.00	3.00
Marital Status	4992	3.51	0.83	1.00	4.00
Availability of mobile phone	4992	0.11	0.32	0.00	1.00
Size of living space, in log	4992	3.91	0.43	2.30	5.55
Number of rooms	4992	3.29	0.86	2.00	5.00
House ownership	4992	1.02	0.12	1.00	2.00
Access to piped water inside the house	4992	0.57	0.50	0.00	1.00
Access to piped water outside of the house	4992	0.15	0.36	0.00	1.00
Access to other water sources	4992	0.40	0.49	0.00	1.00
Access to centralized sewerage system	4992	0.06	0.24	0.00	1.00
Availability of transport vehicle	4992	0.98	0.15	0.00	1.00
Number of available land plots	4992	1.10	0.78	0.00	8.00
Area of land, in ha	4992	141.48	817.15	0.00	27666.00
Private land	4992	0.78	0.41	0.00	1.00
Rented land	4992	0.06	0.24	0.00	1.00

Table 2: Summary Statistics, Kyrgyz Republic

Variable	N	Mean	Standard deviation	Min	Max
Household has own facility at home for washing (=1 if yes)	1917	0.36	0.48	0.00	1.00
Total income per capita, log	1917	10.87	0.85	4.45	14.29
Mean sanitation of others, excl. i household in region r	1917	0.36	0.21	0.10	0.84
Female	1917	0.33	0.47	0.00	1.00
Age	1917	56.67	12.88	16.00	97.00
Secondary education	1917	0.80	0.40	0.00	1.00
Tertiary education	1917	0.10	0.30	0.00	1.00
Self-employed	1917	0.20	0.40	0.00	1.00
Unemployed or out of labor force	1917	0.42	0.49	0.00	1.00
Marital status (=1 married)	1917	0.69	0.46	0.00	1.00
Size of living space (in sq. meters), log	1917	5.00	0.38	3.26	6.08
Number of rooms, 3	1917	0.26	0.44	0.00	1.00
Number of rooms, 4	1917	0.37	0.48	0.00	1.00
Number of rooms, 5	1917	0.17	0.38	0.00	1.00
Piped water at home	1917	0.81	0.39	0.00	1.00
Piped water in yard of home	1917	0.29	0.45	0.00	1.00
Transport vehicle	1917	0.37	0.48	0.00	1.00
Area of land	1917	1645.62	2060.19	100.00	63000.00
Number of land plots	1917	1.02	0.14	1.00	2.00

Table 2 presents descriptive statistics for the Kyrgyz Republic. About 35% of rural households have their own bathing facilities, which aligns with the community-level average counterpart. 33% of households are female-headed and the average age of household heads is 57 years. 68% of household heads are married and 41% are unemployed or out of the labor force. 37% and 17% of households have 4 and more rooms in their house, respectively. 24% have piped water within their houses, and

more than 27% have access to outdoor piped water system, located outside in the yard. The remaining, over 47% of rural households, rely on water sources other than indoor or outdoor piped water. This is a significant indicator, as it highlights the deficiency of basic infrastructure required for bathing at home.

3 Methodology

Similar to [Gautam \(2023\)](#) we use a static model to study household choice regarding adoption of a WASH facility. In this model, a household’s decision to adopt a facility can affect the well-being of other households, creating a sense of interdependence in sanitation adoption choices within a given settlement.

3.1 Model overview

In line with [Gautam \(2023\)](#), we define a household as a decision-making unit making discrete choices regarding sanitation or washing facilities adoption. The utility function for household i in region r is expressed as: $u_{ir}(c_{ir}, d_{ir}, d_{-ir})$ where c_{ir} represents the consumption of a composite private good, d_{ir} is households’ own adoption of WASH facility, d_{-ir} is the average level of adoption in the region r , excluding household i .

The household’s budget constraint is defined as:

$$c_{ir} + d_{ir} \leq y_{ir} \tag{1}$$

As in [Gautam \(2023\)](#) utility function is linear and takes the form:

$$u_{ir}(c_{ir}, d_{ir}, d_{-ir}) = \gamma d_{ir} d_{-ir} + A_{ir}(d_{-ir}) + B_{ir}(d_{ir}) + C_{ir}(c_{ir}, d_{ir}) \tag{2}$$

where $C_{ir}(c_{ir}, d_{ir})$ denotes the utility from consumption, $B_{ir}(d_{ir})$ denotes private utility from the household’s demand of sanitation or washing facility. d_{-ir} highlights the interdependence of households’ decisions concerning the adoption. Private taste shocks follow a Type 1 extreme value distribution and are unique to a household. These shocks are observable by a respective household and not by others.

3.2 Estimation

Following [Gautam \(2023\)](#) we use a two-stage estimation procedure using the [Hotz and Miller \(1993\)](#) conditional choice probability estimator that is applied within the framework of incomplete information games. The first stage focuses on estimating

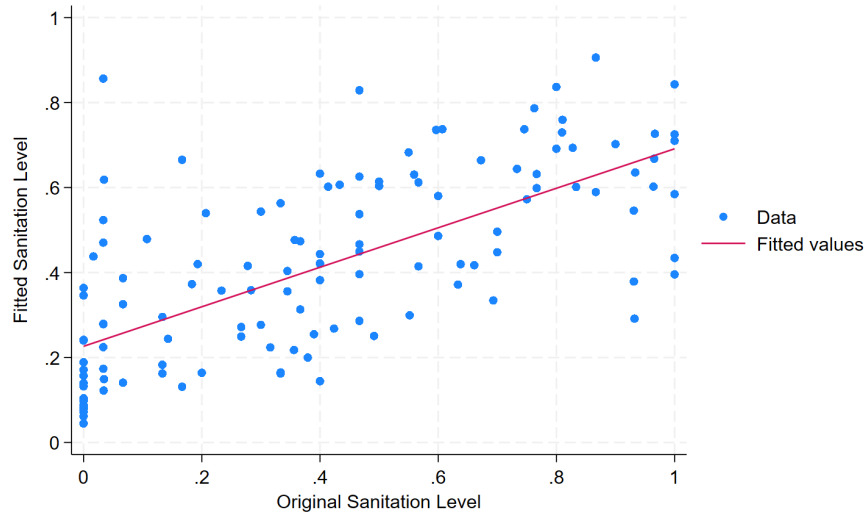
conditional choice probabilities at the household level, directly from the data using a simple frequency estimator (Gautam (2023)). In the second stage, structural parameters are estimated using a nested pseudo-likelihood estimator following Aguirregabiria and Mira (2002). Robust standard errors are constructed using a bootstrap procedure.

4 Results

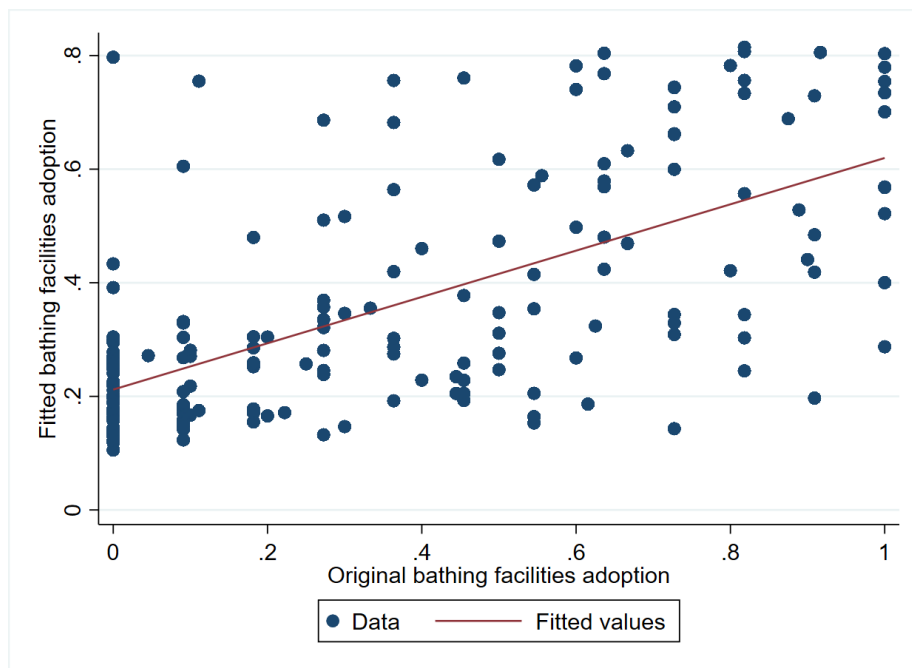
In this section, we present the empirical findings. First, we show the extent to which the model accurately predicts the level of a WASH facility adoption. Second, we discuss the structural estimates of the model. Third, we present the results from our counterfactual scenarios.

4.1 Fitness of the model

The model fit assesses how well the model predicts the level of a WASH facility's adoption. Figure 4 presents the relationship between the original mean adoption level in a sub-province as suggested by the data and the predicted adoption level in Kazakhstan and the Kyrgyz Republic. The correlation coefficient between the original and the fitted levels is 69% in Kazakhstan and 64% in the Kyrgyz Republic. Overall, the fitness of the model closely aligns with the observed data.



(a)



(b)

Figure 4: Observed versus fitted adoption levels across settlements in (a) Kazakhstan and (b) the Kyrgyz Republic

4.2 Regression results

Tables 3 and 4 present the estimates of structural parameters for Kazakhstan and the Kyrgyz Republic. In Kazakhstan, households with higher incomes tend to have improved sanitation facilities. The effect of income on the adoption of improved sanitation is statistically significant, which aligns with the expectation that higher income enables accommodation of improved sanitation facilities, illustrating the important role of income in sanitation improvement.

In contrast, in the Kyrgyz Republic, the effect of income is negative and statistically significant. This negative income effect indicates that income may not play significant influence over the provision of washing facilities. Instead, the availability of piped water within the home is an important determinant of this type of WASH facility. Improved washing conditions within the household may not materialize in situations where piped water access within the home is unavailable. This underscores the significance of piped water access over income in shaping household WASH outcomes in the Kyrgyz Republic.

The peer effects and network externalities, as captured by the mean adoption levels of others from the same region, is positive and statistically significant in both Kazakhstan and the Kyrgyz Republic. These findings underscore the significance of spillover effects generated by enhanced sanitation and washing facilities adoption. A higher adoption rate of modern or improved facilities within a region corresponds to an improvement in household-level sanitation and bathing facility uptake. This could happen due social pressure, reciprocity, learning from others, etc. This result is consistent with existing literature, which provide empirical evidence of peer effects on better sanitation (Pakhtigian et al. (2022); Mukhopadhyay (2020)).

Households led by married household heads tend to exhibit better sanitation and washing facilities in Kazakhstan and the Kyrgyz Republic, respectively, which is consistent with the literature (Wang and Shen (2022)). This may be attributed to the responsibilities associated with raising children. The presence of children within households necessitates a heightened awareness of hygiene and sanitation. Therefore, married household heads may prioritize and invest in better sanitation and washing facilities to ensure a clean and safe environment for their families.

Although the effect of education is positive, it is not statistically significant in Kazakhstan and the Kyrgyz Republic. This finding is in contrast to the broader literature, which typically predicts a positive impact of education on sanitation (Angoua et al. (2018)). The literature asserts that the positive effect of education is due to the hypothesis that more educated household heads have a better understanding of the adverse health effects of poor sanitation. Also, educated individuals may have better employment prospects and financial resources to invest in improved sanitation

facilities (Angoua et al. (2018)).

The model also accounts for heterogeneity, taking into account the presence of mobile phones and transport vehicles in relation to improved sanitation or washing facilities adoption. The estimates for Kazakhstan are positive and statistically significant. The availability of transport vehicles also has a positive effect on washing facilities adoption in the Kyrgyz Republic. Interestingly, the effect of the number of land plots and the area of land has a negative and statistically significant impact on the improved sanitation adoption in Kazakhstan. In Kazakhstan, that may indicate that households heavily engaged in agriculture, as suggested by larger land areas or more land plots, might be less incentivized to invest in improved sanitation facilities.

Conversely, in the Kyrgyz Republic, the effect of the number of land plots is positive and statistically significant. In the Kyrgyz Republic, the decision to construct a bathing facility may likely be influenced by the size of the land owned by households or number of land plots. Households with larger land holdings may have more resources and physical space to accommodate such facilities.

In both Kazakhstan and the Kyrgyz Republic, infrastructure plays a crucial role, demonstrating a positive and statistically significant impact. Households residing in homes equipped with piped water (both within and outside the home) and centralized sewerage systems are more likely to have better sanitation and bathing facilities. This result is in line with expectations, particularly the finding that having a flush toilet (with a septic tank) is contingent on water access.

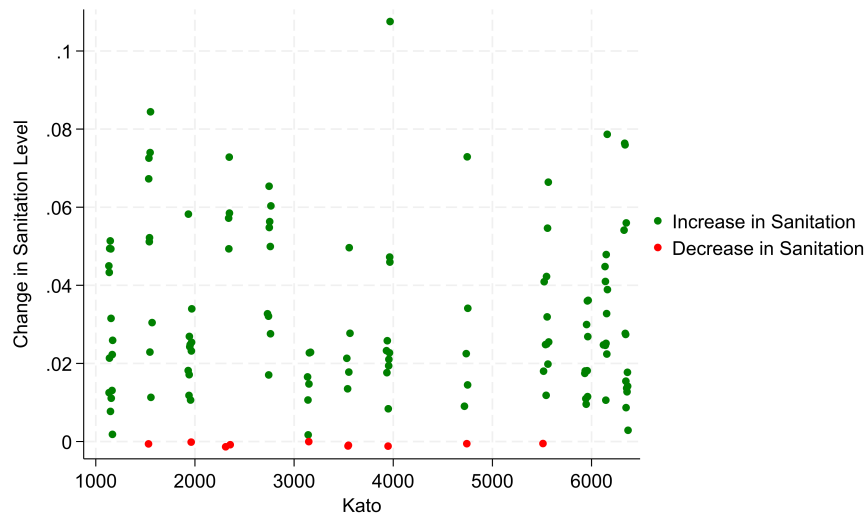
Overall, the results point to several barriers to the adoption of improved sanitation, such as septic tanks or centralized sewerage systems, in Kazakhstan and of domestic bathing facilities in the Kyrgyz Republic. These barriers include low income and inadequate access to infrastructure, specifically piped water at home and centralized sewerage in Kazakhstan. In the Kyrgyz Republic, the primary barriers are similarly related to infrastructure, notably the absence of piped water at home and centralized sewerage. This underscores the critical need for infrastructure development as a means to enhance the overall quality of WASH practices among rural households in both countries.

4.3 Counterfactuals

We conducted two counterfactual scenarios to explore the potential impact of income and infrastructure improvements in both Kazakhstan and the Kyrgyz Republic. In the first scenario, we raised the income of households with poor sanitation to the average income level of the sub-province in Kazakhstan only. The second scenario focused on enabling piped water at home for households with pit latrines in Kaza-

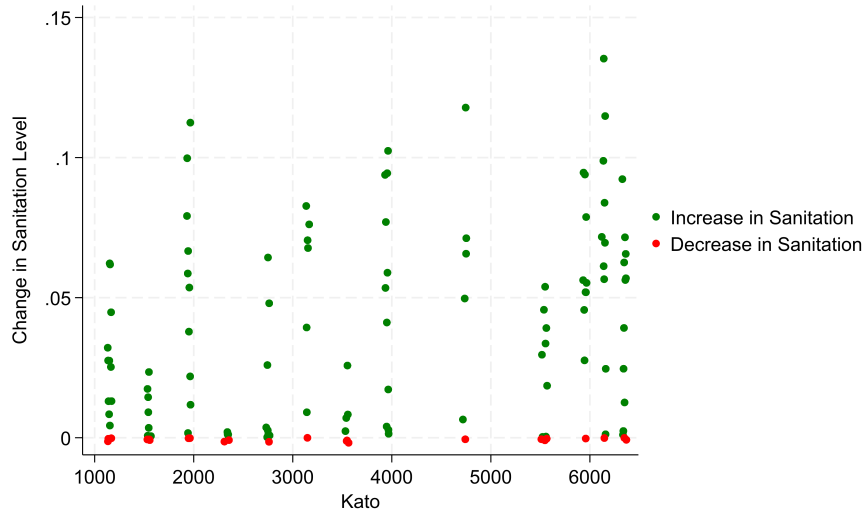
khstan and households with no bathing facilities in the Kyrgyz Republic.

Figure 5 presents the effects of income rise in Kazakhstan. In Kazakhstan, the average probability of adopting improved sanitation increases by 3 percentage points. These results are heterogeneous across regions, with some regions experiencing an up to 8 percentage point increase in improved sanitation adoption.

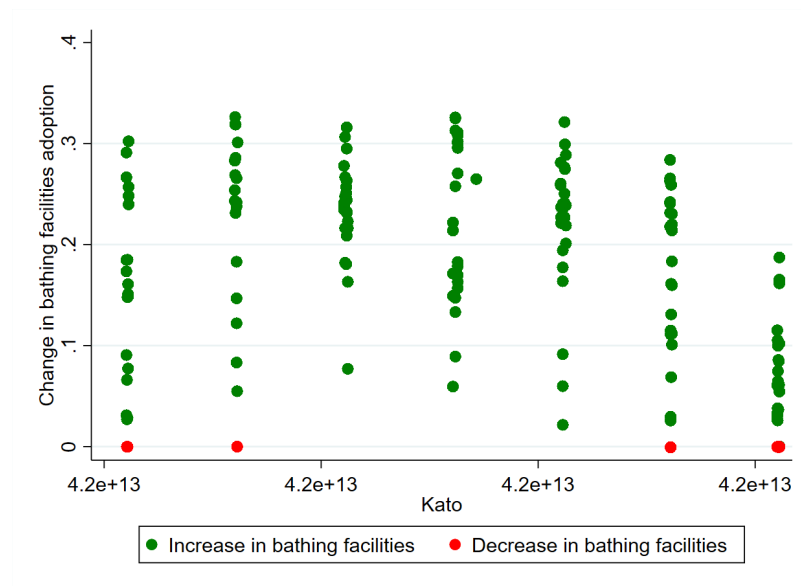


(a)

Figure 5: Effect of income rise on sanitation adoption in Kazakhstan
Note: KATO defines a code for a sub-province, derived from the classifier of administrative-territorial objects.



(a)



(b)

Figure 6: Effects of improved water infrastructure in (a) Kazakhstan and (b) the Kyrgyz Republic

Note: KATO defines a code for a sub-province, derived from the classifier of administrative-territorial objects.

Figure 6 illustrates the impact of improving access to piped water on the adoption of septic tanks in Kazakhstan and adoption of bathing facilities in the Kyrgyz Republic. We observed a 3.3 percentage point increase in adoption on average in Kazakhstan, but this effect varied across regions. Some regions experienced a substantial 15 percentage point increase in adoption. In the Kyrgyz Republic that amounts to 17 percentage improvement on average.

Although the results across these two counterfactuals are not directly comparable, the findings suggest a more pronounced effect of infrastructure improvements on WASH facilities in both countries. That points toward the need for government intervention and investment in WASH infrastructure to improve rural living conditions.

5 Conclusions and policy implications

This study applies a two-stage pseudo-likelihood estimator to estimate the structural parameters related to sanitation adoption in rural Kazakhstan and washing facility adoption in the rural Kyrgyz Republic using household budget surveys from both countries. Households living in rural regions lack modern sanitation. 60% of households have piped water in rural Kazakhstan and 51% in the Kyrgyz Republic. Only 6% of households have centralized sewerage system in Kazakhstan. As a result, only 41% of households have modern sanitation in rural Kazakhstan and only 36% of households have their own facilities for bathing in the rural Kyrgyz Republic.

Our findings demonstrate the positive and significant effect of income on improved sanitation adoption in rural Kazakhstan, highlighting the role of financial resources in enhancing sanitation practices. Conversely in Kyrgyz Republic, we find a negative and significant effect on the adoption of bathing facilities, indicating that income alone may not be sufficient to drive improvements in this regard. We also find that households with married household heads have better sanitation and washing practices.

A higher adoption rate by neighbours within a sub-province corresponds to increased household-level sanitation and washing facilities uptake. This could be due to a better infrastructure available in the region and due to peer effects.

Importantly infrastructure plays a significant role in sanitation and washing outcomes. Households residing in homes with access to piped water at home and centralized sewerage are more likely to have modern facilities. This underscores the pivotal role of infrastructure in promoting better WASH practices.

This implies that the main barriers to the adoption of improved WASH in Kazakhstan are limited income and inadequate access to infrastructure, specifically piped

water and centralized sewerage. In Kyrgyz Republic, the primary barrier is a lack of infrastructure.

It is important to recognize the challenges faced by rural households in addressing basic needs, in the context of WASH facilities. Therefore, government intervention is imperative to improve living conditions and promote better WASH practices in rural areas.

Kazakhstan and the Kyrgyz Republic is facing aging water and sewage infrastructure deficiencies, which impede the adoption of sanitation and washing facilities among rural households. Policymakers can promote modern WASH facilities by providing connections to piped water and centralized sewage systems in rural areas. Additionally, the region is vulnerable to climate change risks, including more severe and frequent droughts, which could further strain piped water supply systems.

To address these challenges and advance WASH practices, future research should focus on comprehensive and long-term planning efforts, considering the unique needs and circumstances of rural communities in these countries. Safe sewage treatment is also an important aspect of sanitation, yet this topic falls out of the scope of this paper. In this study, we tested the impact of access to infrastructure, e.g. piped water system. However, it is vital to recognize the potential issues related to water supply interruptions and low water pressure, which we did not address in our study due to the absence of related questions in the Household Budget Survey (HBS).

6 Appendix: Regression tables

Table 3: Estimation Results for Kazakhstan

Variable	Coefficient	Std. Err.
Total income per capita, log	0.970***	(0.082)
Mean sanitation of others, excl. i household in region r	2.159***	(0.198)
Household heads' characteristics		
Gender: 1-Female, 0- Male	0.087	(0.085)
Age	-0.012***	(0.004)
Secondary education	0.209	(0.145)
Tertiary education	0.215	(0.172)
Self-employed	-0.225	(0.138)
OLF, Retired, Unemployed	0.076	(0.097)
Married	0.166***	(0.048)
Mobile phone	2.087***	(0.140)
Transport vehicle	0.511**	(0.240)
Dwelling characteristics		
Living space, log	-0.066	(0.119)
Number of rooms, 3	0.349***	(0.127)
Number of rooms, 4	0.612***	(0.154)
Number of rooms, 5	0.839***	(0.210)
House rented	-0.008	(0.328)
Piped water at home	0.468***	(0.136)
Piped water outside of the house	0.677***	(0.123)
Other sources of water	-0.614***	(0.128)
Centralized sewerage	3.138***	(0.411)
Other		
Number of land plots	-0.199***	(0.060)
Area of land	-0.0002**	(0.000)
Private land	-0.331***	(0.110)
Rented land	0.220	(0.253)
Constant	22	-14.969***
Observations	4,992	
Pseudo R2	0.284	
p value (chi2)	0	

Notes: Base categories: incomplete secondary education, employed, house owned. The second stage uses the bootstrapped procedure to construct standard errors (250 reps). Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Estimation results for Kyrgyz Republic

Variable	Coefficient	Std. Err.
Total income per capita, log	-0.133*	(0.071)
Mean sanitation of others, excluding i household in region r	2.447***	(0.423)
Household head characteristics		
Female	0.186	(0.175)
Age	0.008	(0.005)
Secondary education	0.129	(0.191)
Tertiary education	0.339	(0.265)
Self-employed	-0.174	(0.184)
Unemployed, OLF	0.100	(0.158)
Marital Status	0.437**	(0.181)
Living space, log	0.074	(0.172)
Dwelling characteristics		
Number of rooms, 3	-0.008	(0.164)
Number of rooms, 4	-0.248	(0.163)
Number of rooms, 5	0.099	(0.207)
Piped water at home	1.412***	(0.216)
Piped water outside of the house	0.444***	(0.140)
Transport vehicle	0.580***	(0.115)
Area of land	-0.000	(0.000)
Number of land plots	0.948**	(0.382)
Constant	-2.996**	(1.199)
Observations	1,917	
Pseudo R2	0.186	
p value (chi2)	0	

Notes: Base categories: incomplete secondary education, employed. The second stage uses the bootstrapped procedure to construct standard errors (250 reps). Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

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