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Economics of Water Supply and Household Behavior: the Transition from Self-Supply to Centralized Systems

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ABSTRACT

Access to clean and safe water remains a critical determinant of public health, quality of life, and socio-economic resilience, particularly in emerging economies with unequal infrastructure development. This study aims to identify the key factors that determine consumer behaviour in the water supply sector, taking into account water quality and the level of infrastructure coverage from 2013 to 2023. The research integrates behavioral, infrastructural, and environmental dimensions to understand how access to water infrastructure and source quality influence consumption patterns. Using a mixed-method design, the study combines streamgraph visualization, correlation matrix analysis, and multiple linear regression modeling based on five indicators: quality of centralized water (DW_C), groundwater (DW_G), population connected to centralized systems (AC_P), per capita consumption (WC_PC), and the self-supply population (SA_NP). The results reveal a strong positive correlation between access to centralized systems and per capita water consumption ($r = 0.901$, $p < 0.001$). At the same time, higher groundwater contamination is associated with greater reliance on self-supply ($r = –0.824$, $p = 0.002$). The regression model confirms the significant influence of centralized water quality ($\beta = –0.2679$, $p = 0.023$) and consumption behavior ($\beta = –0.1506$, $p = 0.087$) on reducing the prevalence of self-supply. Visual analysis via Arc Diagrams reveals structural links between infrastructural expansion and behavioral change, suggesting that improved access and sanitary standards influence household preferences. The results highlighted the importance of targeted investments and effective governance mechanisms in reducing dependence on unsafe self-supply, particularly in Kazakhstan's regional disparities, especially in rural areas.

KEYWORDS: Water Supply Systems, Water Quality, Water Management, Consumer Behavior, Economic Efficiency, Economic Development

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1. INTRODUCTION

Access to clean and safe water is the basis for sustainable development, public health, and social justice. Against the backdrop of climate change, population growth, and rapid urbanization, the water supply issue has become a priority for many countries. According to the Food and Agriculture Organization of the United Nations, more than two billion people live in regions with high levels of water stress, and the shortage of drinking water is one of the most pressing global challenges (FAO, 2006). Solving this problem requires a comprehensive approach that includes assessing the availability, quality, reliability, and affordability of water resources.

In global practice, two main types of water supply have emerged: centralized and decentralized. State or municipal structures typically manage centralized systems and include extensive infrastructure facilities, such as treatment plants, main pipelines, and reservoirs. Such systems function most effectively in conditions of high population density and provide a stable water supply in cities (Sapkota et al., 2014). In contrast, decentralized solutions rely on individual sources, including boreholes, rainwater collection, and household filtration systems. These models are typically used in rural and remote areas where the construction of centralized networks is limited by financial or geographical factors (Arora et al., 2015).

In countries with heterogeneous infrastructure and uneven development of territories, such as Kazakhstan, the issue of rational water resource distribution becomes particularly relevant. An arid climate characterizes a significant part of the country's territory, and its water resources are unevenly distributed. In rural areas, many people still rely on private water sources, including untreated boreholes and open water bodies. The lack of quality control in such conditions increases sanitary risks and reduces the overall sustainability of the water supply. At the same time, active urban growth increases the pressure on existing infrastructure and requires new approaches to water system management.

Household water use behavior in Kazakhstan is influenced by physical access to the centralized network and perceptions of the reliability and quality of services provided. The transition from individual water supply to connection to centralized systems depends on several factors, including the sanitary condition of water, the level of infrastructure coverage, and the volumes of actual consumption. In the context of territorial heterogeneity and institutional constraints, a more in-depth assessment of water-use structure and the factors influencing the population's choice of water source is necessary.

This study aims to investigate the impact of sanitary water quality, the level of connection to centralized systems, and individual consumption volumes on the degree of household dependence on self-sufficiency in water in Kazakhstan. The analysis aims to investigate the interaction between infrastructure capabilities, environmental characteristics, and the everyday practices of the population, enabling more informed and balanced management decisions that consider regional differences.

2. LITERATURE REVIEW

Several studies have highlighted the negative impacts of water scarcity, particularly in water-stressed countries. In particular, it has been demonstrated that a lack of access to safe water has a profound impact on health, human development, and socioeconomic status. Improved water supply and sanitation are recognized as crucial to reducing mortality and enhancing health, particularly among children (Tarrass & Benjelloun, 2011; Zhang, 2012). Hutton and Chase (2016) note that investments in water infrastructure can significantly improve public health, reduce health care costs, and increase economic well-being. Access to safe water and improved sanitation are thus integral to achieving the Sustainable Development Goals, including reducing poverty and improving quality of life.

Additionally, water supply improvements impact labor productivity and economic growth, particularly in agriculture (Meeks, 2017). Continuous monitoring of drinking water quality is crucial for enhancing public health and necessitates the development of effective health protection strategies, particularly in countries vulnerable to frequent natural disasters (Li & Wu, 2019). Water disasters such as floods and droughts increase epidemiological risks, with poor and marginalized populations being the most vulnerable (Lee et al., 2020). Zhang et al. (2020) emphasize that water scarcity and poor water management can hinder the development of countries, resulting in economic and social consequences, particularly in the absence of innovative solutions and improved water management. Water crises can lead to social and economic problems, including poverty, migration, and deterioration of living conditions (Israilova et al., 2023). In this regard, water management should consider not only economic but also social factors to minimize negative impacts and increase resilience to water crises.

Some studies focus on water management strategies, including infrastructure planning, policy measures, legal barriers, and innovative approaches to water supply and sanitation. Kayser et al. (2013) proposed a system of indicators for assessing water services across different countries and concluded that the lack of an integrated approach to evaluating water supply can lead to an underestimation of problems and inefficient resource allocation. Thus, a system of indicators reflecting all aspects of water supply helps to effectively plan and manage water resources, improving access to safe water and reducing health risks. Socioeconomic aspects, including living standards and social inclusion of the population, as well as effective policy and governance, are crucial for successful water supply planning. Asefa et al. (2014) emphasized that to ensure a sustainable water supply, it is necessary to consider a complex set of factors, including the social and economic needs of the population, as well as to develop effective political and management strategies. Increasing the water supply can stimulate economic growth, but it is also necessary to consider environmental impacts, such as deterioration of water quality. Therefore, for balanced growth, it is necessary to apply a strategic approach that takes into account not only economic but also environmental aspects (Ke et al., 2016). Fletcher et al. (2017) emphasized that for water supply sustainability, it is essential to develop flexible infrastructure that can adapt to future changes in water system design, thereby reducing capital costs and enhancing resilience to unpredictable fluctuations in water resources. Cipolletta et al. (2021) emphasized the significance of small-scale water supply systems as local, decentralized infrastructure that provides water supply and sanitation on a smaller scale, most often in rural or remote areas. However, small-scale water supply systems, despite significant potential to address water scarcity issues, face legislative barriers. On the contrary, Makanda et al. (2022) emphasized the conservation of natural resources and the importance of protecting aquatic ecosystems, including groundwater and surface water, for sustainable water management. More attention should be paid to the protection of aquatic ecosystems and the prevention of pollution, which implies a more traditional and centralized approach to managing water resources. Zhang and Oki (2023) recommend revising water pricing policies as an essential part of sustainable water resources management. Current water prices do not accurately reflect the actual cost of water resources and fail to create sufficient incentives for efficient water use, particularly in water-intensive sectors like agriculture. Revising water prices can be a crucial tool for improving water efficiency, reducing the inefficient use of water resources, and encouraging the adoption of technologies that reduce water consumption. Thus, the introduction of economic instruments to ensure the sustainability of water resources, especially in agricultural areas where water is the primary resource for production, is significant. Thus, countries with large territories and high water needs can focus on economic instruments, such as water pricing, to encourage the rational use of water resources. In contrast, countries with smaller volumes of water resources and more controlled systems can focus on environmental and innovative solutions that are more adapted to the specifics of the water supply and ecosystem.

Different approaches to water resource management influence risk perception and decision-making about water supply. The culture of water supply management in different regions has a significant impact on the choice of water sources, particularly in areas with insufficient centralized water supply. Koehler et al. (2018) identified that effective water resource management requires considering the cultural characteristics of local communities, as well as developing governance models that account for the risks and values associated with water resources. Since water is not only a physical resource but also a social one, access to it depends on the country's political and economic situation. Gunda et al. (2019) emphasized that water security requires the integration of environmental, economic, and social factors. Therefore, an integrated approach to water resource management is crucial, which should consider not only the physical availability of water but also the ability of society to manage this resource effectively. In rural and remote areas, where centralized water supplies are either absent or underdeveloped, self-sufficiency in water is paramount. However, legal and institutional recognition of self-sufficiency as a crucial component of water supply is necessary. However, Grönwall and Danert (2020) noted that such systems face risks related to water quality, pollution, and inadequate monitoring. Successful community water systems depend on local ownership, funding, and technical expertise. This means that the long-term sustainability of such systems requires active participation of residents and continuous external support, including training and financial resources (Machado et al., 2022). Despite the availability of centralized water supply, many households continue to use private water sources, such as wells and groundwater, due to concerns about the quality of centralized water and the system's unreliability. Genter et al. (2022) note that to ensure the sustainability of urban water supply, both centralized and decentralized systems need to be considered, supporting their complementarity.

The issue of access to drinking water in rural areas of Kazakhstan has been accompanied by institutional and infrastructural imbalances over the past decades. Tussupova et al. (2016) recorded a high level of willingness of rural households to connect to the centralized system. Low coverage and inadequate sanitation infrastructure made such connections ineffective. As a result, the physical presence of the network does not ensure its daily use. Following this, Karatayev et al. (2017) drew attention to the strategic priorities of water policy, in which technical expansion prevailed over institutional flexibility, which limited the adaptation of systems to the behavioral practices of the population. Thus, weak institutional coherence became a barrier between project goals and real conditions. This gap was further confirmed by Zhupankhan et al. (2018), who noted a misalignment between basin-level governance and existing regulatory mechanisms, especially in the limited participation of local users. The study by Issanova et al. (2018) introduced spatial differentiation, revealing that water resources and the degree of anthropogenic transformation of water basins were extremely uneven, which exacerbated differences in access between regions and undermined the universality of technical solutions. Against this background, Omarova et al. (2019) demonstrated that even with the formal availability of centralized water supply, a significant proportion of households continued to use alternative sources, which was explained not by habit but by doubts about water quality, supply instability, and high costs.

The institutional, regional, and behavioral contradictions identified in the literature indicate the need for a multidimensional approach to analyzing water use in Kazakhstan.

Despite the presence of centralized systems, the use remains selective, and self-sufficiency continues to play a significant role in households.

Existing studies have demonstrated a gap between technical water availability and actual consumption patterns; however, they have not integrated behavioral, sanitary, and infrastructural determinants of water source choice in a single empirical study. This study aims to fill this gap. The hypothesis is formulated: the level of water self-sufficiency is determined not only by the coverage of centralized water supply but also by the perceived water quality, system stability, and economic behavior of households, including the level of registered consumption.

3. METHODOLOGY

The study employed a combination of statistical analyses and visual assessments to investigate the relationship between access to water infrastructure, water source quality, and household consumption patterns in Kazakhstan. Data were collected from the Bureau of National Statistics of the Republic of Kazakhstan, covering the period from 2013 to 2023. The assessment followed a step-by-step structure, progressing from a graphical representation of variable linkages to a quantitative evaluation of interdependence, thereby ensuring internal consistency in testing the stated hypothesis.

At the first stage, descriptive trends were examined using a streamgraph visualization. This allowed for a comprehensive overview of five key indicators across eleven years. This dynamic assessment formed the empirical foundation for developing a hypothesis regarding the determinants of water consumption behavior. Specifically, it was posited that the volume of water consumed per capita (WC_PC) is not an isolated indicator, but is shaped by several interrelated factors: the extent of access to centralized water supply systems (AC_P), the proportion of the population relying on self-supply (SA_NP), and the quality of available water sources, including both groundwater (DW_G) and centralized supplies (DW_C). The observed temporal trends in these indicators suggested meaningful interdependencies that warranted further statistical validation.

The variables included in the analysis are presented in Table 1.

TABLE 1. Variables used in the analysis

No.	Indicator description	Code	Unit of measurement
1	Share of non-standard samples in centralized water	DW_C	% of tested water samples
2	Share of non-standard samples in groundwater	DW_G	% of tested water samples
3	The population is connected to a centralized supply	AC_P	Share of total population (%)
4	Water consumption per capita	WC_PC	Cubic meters per person/year
5	The population relying on self-supply	SA_NP	Million persons

Note: compiled by authors based on the Bureau of National Statistics (2024)

In particular, the consistent growth of WC_PC alongside increases in AC_P, and the simultaneous decline in SA_NP, indicated a potentially structured dynamic in the evolution of water access and use. The following specific hypotheses were proposed:

H1: Water consumption per capita (WC_PC) increases with a higher share of the population connected to a centralized water supply (AC_P).

H2: The prevalence of self-supply practices (SA_NP) decreases as AC_P increases and WC_PC rises.

H3: The use of self-supply is positively associated with the deterioration of groundwater quality (DW_G).

H4: The quality of centralized water (DW_C) has an inverse effect on reliance on self-supply (SA_NP).

H5: The sanitary quality of water sources (DW_C and DW_G) influences overall consumption behavior and the perceived reliability of supply systems.

All data were sourced from open-access publications of the Bureau of National Statistics of the Republic of Kazakhstan. The dataset was checked for completeness, and no missing values were detected during the observation period. Since all variables were expressed in compatible units and scales, no normalization or transformation procedures (e.g., logarithmization) were applied. The sample consisted of eleven annual observations ($N = 11$), which imposes certain limitations on generalizability and statistical power. Nonetheless, the dataset was deemed sufficient for identifying directional patterns and testing bivariate associations using correlation and regression techniques.

To formally test the proposed hypotheses, statistical procedures were conducted using IBM SPSS Statistics. Pearson correlation analysis was applied to assess the direction and strength of linear relationships between variables, followed by the estimation of a multiple linear regression model. In this specification, per capita water consumption (WC_PC) was treated as the dependent variable. In contrast, the share of population connected to centralized supply (AC_P), the size of the self-supplying population (SA_NP), groundwater quality (DW_G), and centralized water quality (DW_C) served as independent variables. Statistical significance was assessed at thresholds of $p < 0.05$ (statistically significant) and $p < 0.10$ (marginally significant). The regression model demonstrated strong explanatory power, with a coefficient of determination (R^2) of 0.894, indicating that approximately 89.4% of the variation in WC_PC was explained by the combined influence of the selected variables. Among them, the quality of centralized water (DW_C) demonstrated a statistically significant inverse relationship with the level of self-supply ($p = 0.023$). At the same time, the volume of consumption per capita (WC_PC) showed a marginal effect ($p = 0.087$). Other predictors did not reach the defined significance thresholds.

The analysis was based on an annual time series of eleven observations ($N = 11$), which imposes limitations on statistical inference. Adjusted R^2, residual diagnostics, and tests for outliers were not conducted due to the limited degrees of freedom. These methodological constraints should be taken into account when interpreting the results.

To enhance the interpretive depth of the analysis and capture relational patterns that may not be evident through numerical methods alone, the statistical procedures were supplemented with a visual structural component. Specifically, a structural visualization was constructed in the form of an Arc Diagram, which allowed for the mapping of aggregated connections between the selected indicators over the entire observation period. This technique offered insight into the relative intensity and configuration of inter-variable linkages, reflecting underlying behavioral or infrastructural dependencies. For example, the visualization revealed powerful associations between AC_P and WC_PC, suggesting that infrastructural expansion is systematically associated with shifts in consumption patterns. At the same time, the proximity between DW_G and SA_NP in the diagram highlighted the role of environmental quality in shaping reliance on self-supplied water sources.

Taken together, the integrated methodological design, combining statistical validation with relational visualization, facilitated the construction of a logically coherent and analytically layered framework for hypothesis testing. This approach enabled the detection of not only direct statistical associations but also latent structural dynamics, thereby facilitating a more comprehensive understanding of how water accessibility, quality, and usage intersect within the broader context of public well-being and infrastructure-driven development.

4. RESULTS AND DISCUSSION

Water supply and drinking water quality issues play a key role in ensuring sustainable development and public well-being. Assessing the relationships between the quality characteristics of water sources, consumption levels, and infrastructure availability allows us to identify hidden dependencies that require consideration in water resources policy. This section presents the results of a visual analysis that reflects both the dynamics of changes and the structure of internal relationships between the leading water indicators in Kazakhstan for the period 2013–2023.

Figure 1 presents a Streamgraph visualization showing the dynamics of five key indicators: centralized water quality (DW_C), groundwater (DW_G), proportion of population with access to public water supply (AC_P), per capita water consumption (WC_PC), and self-sufficiency (SA_NP).

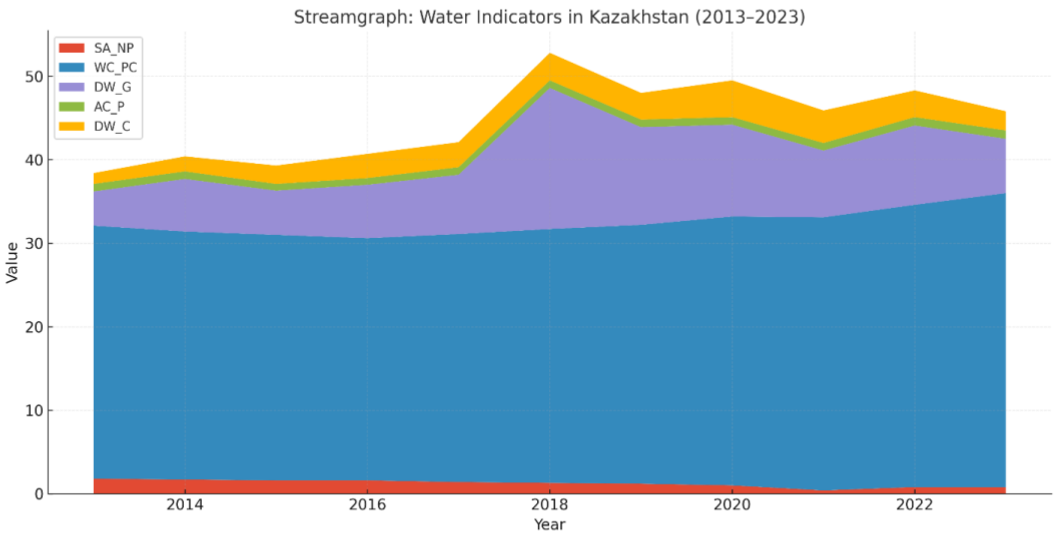

FIGURE 1. Dynamics of water indicators in Kazakhstan for 2013–2023 (Streamgraph)

The graph analysis reveals a steady increase in the WC_PC indicator, indicating a rise in individual water consumption. The peak of groundwater pollution (DW_G) in 2018 is especially pronounced, after which a gradual decrease is noted. The DW_C indicator remains stably low, which may indicate the relative quality of centralized water compared to groundwater sources. At the same time, SA_NP shows a steady decrease, which correlates with the growth of AC_P, indicating an expansion of municipal water supply coverage and a decrease in the share of the population using alternative sources.

Additional analytical insight into the relationships between water indicators is provided by the arc diagram, which visualises the directional relationships between variables based on aggregated data for the entire analysis period for 2013–2023 (Figure 2).

The most pronounced relationships are found between water consumption per capita (WC_PC) and the level of connection to public water supply (AC_P). Both indicators increased during the analyzed period: consumption increased from 30.3 cubic meters in 2013 to 35.2 cubic meters in 2023, while the share of the connected population increased from 89.4% to 96%. This relationship indicates the dependence of water use behavior on infrastructural conditions: the expansion of coverage by centralized systems is accompanied by an increase in consumption, which is directly related to the level of household comfort, sanitary safety, and, in a broader context, to the quality of life.

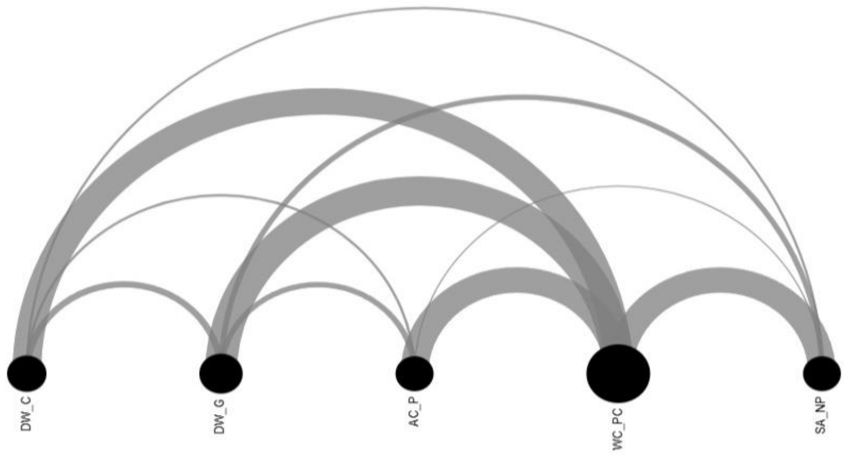

FIGURE 2. Structural relationships between water indicators (Arc Diagram)

A noticeable structural relationship exists between groundwater pollution (DW_G) and the level of self-sufficiency (SA_NP), emphasizing that the deterioration of alternative water sources can limit the possibility of a safe individual water supply. Thus, the level of groundwater pollution in 2018 reached a peak of 16.9%, which was accompanied by a decrease in self-sufficiency from 1.8 million people in 2013 to 0.8 million in 2023. This dynamic is especially relevant for rural areas, where centralized networks are underdeveloped, and access to high-quality water determines the basic conditions of life and health. Weak links with the participation of the quality of centralized water (DW_C), the values of which fluctuated between 1.3% and 4.4% of samples with deviations from standards, may indicate the stability of this indicator and, as a result, its limited impact on the population's behavior. Thus, the arc diagram reflects stable links between the indicators of access, quality, and nature of water consumption, which form the basis of infrastructural provision and sanitary well-being.

Further analysis includes a quantitative test of the relationships between variables based on the correlation matrix, which will clarify and statistically substantiate the identified visual patterns (Figure 3).

The results of the correlation analysis confirmed the key relationships between the variables previously visualized using the arc diagram. The highest and statistically significant correlation was found between water consumption per capita (WC_PC) and the level of connection to public water supply (AC_P), where the Pearson coefficient was $r = 0.901$ at a significance level of $p < 0.001$. Therefore, there is a clear relationship between the expansion of water supply infrastructure and the increase in individual consumption, which is visually reflected in the structure of the arc diagram through the most intense arc.

A strong inverse correlation is observed between self-sufficiency of the population with water (SA_NP) and the indicators AC_P ($r = -0.818$, $p = 0.002$) and WC_PC ($r = -0.824$, $p = 0.002$), which demonstrates the effect of crowding out alternative forms of water supply as centralized systems develop. The decrease in self-sufficiency is accompanied by an increase in the recorded volume of consumption, reflecting the transition to more reliable and stable water supply sources. Structurally, these relationships are presented in the arc diagram through close relationships between the corresponding variables.

The correlation between groundwater quality (DW_G) and centralized water quality (DW_C) also proved to be significant (r =

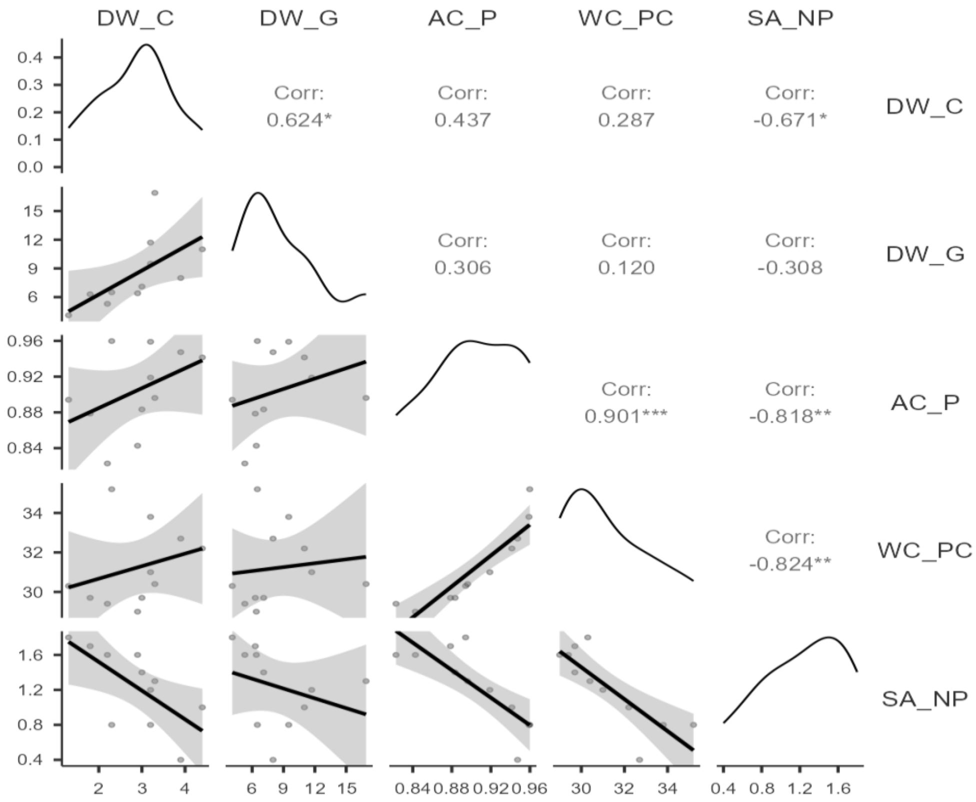

FIGURE 3. Correlation analysis matrix

0.624, p = 0.040), which may indicate the presence of common natural or technological factors influencing the state of water resources. At the same time, DW_G did not demonstrate a statistically significant relationship with consumption (WC_PC) or connection to infrastructure (AC_P), which indicates its indirect influence. At the same time, the negative correlation between DW_G and SA_NP according to the Spearman coefficient (ρ = -0.644, p = 0.033) indicates a decrease in the attractiveness of polluted groundwater sources as a means of self-sufficiency in water supply.

The centralized water quality indicator (DW_C) exhibits limited relationships with other variables, with a moderate correlation with DW_G and AC_P, but no significant relationships with WC_PC and SA_NP, which confirms its relative stability and weak influence on the behavioral aspects of water use. These findings are consistent with the structure of the arc diagram, where DW_C is presented on the periphery of the relationships.

The set of correlation results provides empirical support for confirming the hypothesis on the determination of water consumption per capita through a system of infrastructural, sanitary, and behavioral factors, reflecting the transformation of water use in the context of improving quality of life. The results of model evaluation, to validate the strength and reliability of the regression model, showed the following.

The coefficients R and R^2 indicate a high degree of model fit, with $R^2 = 0.894$ showing that the model successfully explains a substantial proportion of the variation in self-supply levels. This reinforces the idea that a combination of access to centralized water systems, self-supply practices, and the quality of available water sources indeed influences water consumption. To clarify the contribution of each independent indicator to the formation of SA_NP values and to assess the statistical significance of the corresponding coefficients, the table below shows the results of model evaluation with standard errors, t-statistics, and p-values (Table 2).

TABLE 2. Model coefficients

Predictor	Estimate	SE	t	p
Intercept	6.5971	1.2855	5.13205	0.002
DW_C	-0.2679	0.0886	-3.02286	0.023
DW_G	0.0140	0.0216	0.65034	0.540
AC_P	-0.0126	0.024	-0.00371	0.997
WC_PC	-0.1506	0.0737	-2.04425	0.087

Note: compiled by authors

The most significant factor is the quality of centralized water (DW_C), with $\beta = -0.2679$ ($p = 0.023$), indicating an inverse relationship: as the proportion of samples with deviations from standards increases, the proportion of the population relying on self-sufficiency decreases. This may reflect mistrust of the centralized source as a trigger for returning to alternative forms of water supply or, conversely, the influence of stable quality of centralized water as a factor in abandoning individual systems. A significant but marginal factor in terms of significance is the volume of water consumption per capita (WC_PC), with $\beta = -0.1506$ ($p = 0.087$). The inverse relationship is interpreted as a consequence of the population's transition from unrecorded consumption within self-sufficiency to recorded consumption through centralized networks, consistent with the previously established negative correlations between SA_NP, WC_PC, and AC_P. The coefficients for groundwater quality (DW_G) and the level of connection to the centralized system (AC_P) were statistically insignificant. This may indicate a more complex, indirect relationship between these variables and population behavior or insufficient variability in the series of observations. The model confirmed the importance of the sanitary quality of centralized water and the volume of consumption as key factors influencing the prevalence of self-sufficiency in water. The results complement the findings made earlier during visual and correlation analysis and emphasize the importance of a comprehensive assessment of behavioral, infrastructural, and environmental determinants of water use.

From 2013 to 2023, Kazakhstan's annual per capita water consumption increased from 30.3 to 35.2 cubic meters per person. The dynamics reflect the effects of infrastructure expansion and changing water use patterns at the household level. The increase in consumption indicates a partial restoration of trust in centralized water supply systems, especially in rural and semi-rural areas where individual sources previously predominated. Expanded access has provided greater stability in meeting the population's sanitation and household needs, including cooking, personal hygiene, and home maintenance. Implementing state programs aimed at modernizing the utility sector has led to increased coverage; however, persistent inequalities in service quality across regions signal structural constraints.

Sanitary indicators of centralized water indicate an imbalance between physical access and the safety of the resources provided. In 2018, 16.9% of the water samples collected did not meet the established sanitary standards, despite ongoing system expansion. In 2020, annual water consumption reached a peak of 32.2 m^3 per person, coinciding with the highest consumption level during the study period. The discrepancy between infrastructure expansion and quality indicators indicates the inadequacy of the current control system, especially in non-urbanized areas. Households living in such areas continue to use alternative or backup sources, including wells, filtered bottled water, and seasonal deliveries. Using parallel water supply systems increases household expenses and limits the potential of centralized networks to achieve sanitary safety. In large cities, where stable sanitary control indicators characterize centralized water supply systems, most of the population relies solely on the connected network. Comparison with international examples allows us to expand the assessment of systemic sustainability. In Germany and France, the daily water consumption level reaches 120-150 liters per person, reflecting the full institutional integration of water supply into daily life. In countries with a high rate of urbanization, such as India and Brazil, the average daily consumption level in large cities is 90-100 liters per person. Regardless of income and technical limitations, a stable relationship exists between the completeness of coverage and the rejection of individual sources. The total amount of water used in such systems becomes an indicator not only of redundancy but also of the trust and sustainability of distribution and regulation mechanisms. In Kazakhstan, the increase in water consumption is accompanied by institutional challenges. The lack of a unified approach to sanitary monitoring, limited coverage of high-quality services in non-urbanized areas, and inconsistencies in administrative mechanisms between levels of governance hinder further sector development. The results confirm the need to shift the emphasis from the physical expansion of infrastructure to ensuring the reliability, sanitary safety, and manageability of systems. The formation of an integrated model in which quality control, regulatory responsibility, and accessibility act in conjunction is a key condition for increasing the efficiency of water use and improving the quality of life of the population.

Thus, the study's results confirm the importance of investing in water supply infrastructure, as improving water quality and expanding access to centralized systems contribute not only to increased water consumption but also to an improvement in quality of life. The economic benefits of expanding water supply infrastructure include reduced health care costs, increased labor productivity, and improved social stability.

5. CONCLUSIONS

The analysis of the factors influencing water consumption and self-supply behaviors in Kazakhstan considered the infrastructure, water quality, and behavioral factors. Water consumption per capita is significantly affected by access to centralized water supply systems, the extent of self-supply, and the quality of groundwater and centralized water sources. The study reveals that improved water quality and increased access to infrastructure reduce reliance on self-supply, which is beneficial for public health and water safety.

The results align with similar trends observed in other countries. Countries with developed economies and increased access to centralized water supply systems tend to have higher per capita water consumption, reflecting improved living conditions and better public health standards. Conversely, limited access to water infrastructure forces the population to rely more on alternative water sources, often leading to higher health risks. The case of Kazakhstan mirrors these patterns, underscoring a critical need to expand and improve water infrastructure.

Further research should consider incorporating socio-economic factors, public awareness, and water pricing to provide a more specific analysis of water consumption behaviors. Additionally, qualitative methods, such as surveys or interviews with local communities, could offer valuable insights into how water access and quality issues are perceived at the household level.

AUTHOR CONTRIBUTION

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Visualization: Askar A. Adamov.
Writing review and editing research: Gulnara B. Tuleshova, Raushan B. Azbergenova.

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