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Estimating household water consumption in Jordanian rural households: A case study

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Abstract

Objectives: The study aims to measure the amount and characteristics of end-use water consumption and identify the factors influencing it in Al-Kharj village, Irbid Governorate.

Methods: Primary data were collected through a structured questionnaire survey administered to 146 randomly selected households. Water consumption for each end-use was estimated using a combination of observational techniques and self-reported measures, including flow rate and usage duration. A multiple linear regression model was applied via SPSS to analyze the influencing factors.

Results: The results showed that the average daily per capita water consumption was 66.73 liters, with dishwashing manually being the most consuming activity. Water consumption influenced by household size, the household head's educational level, household income (per month), and total built-up area m². The coefficient of determination (R^2) for the model was 0.623, explaining 62.3% of the variance in per capita consumption.

Conclusions: The study highlighted the need to develop sustainable demand management policies, given the limited available resources. It demonstrated that achieving effective demand management in Jordanian rural areas requires taking into account socio-economic characteristics, and physical characteristics, given their direct impact on daily per capita consumption rates.

Keywords: end-use water; per capita household water consumption; factors; multiple linear regression analysis; Jordan.

تقدير استهلاك المياه المنزلي لدى الأسر الريفية الأردنية: دراسة حالة

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ملخّص

الأهداف: تهدف الدراسة إلى قياس كمية وخصائص استهلاك المياه للاستخدام النهائي وتحديد العوامل المؤثرة عليه في قرية الخرج، محافظة إربد.

المنهجية: جُمعت البيانات الأولية من خلال استبيان مُنظم أُجري على 146 أسرة مُختارة عشوائيًا. قُدِّر استهلاك المياه لكل استخدام نهائي باستخدام مزيج من تقنيات الرصد والقياسات الذاتية، بما في ذلك معدل التدفق ومدة الاستخدام. طُبِّق نموذج انحدار خطي متعدد عبر برنامج SPSS لتحليل العوامل المؤثرة.

النتائج: أظهرت النتائج أن متوسط استهلاك الفرد اليومي من المياه بلغ 66.73 لترًا، وكان غسل الصحون يدويًا النشاط الأكثر استهلاكًا. تأثر استهلاك المياه بحجم الأسرة، والمستوى التعليمي لرب الأسرة، ودخل الأسرة (شهريًا)، وإجمالي المساحة المبنية (م²). بلغ معامل التحديد (R^2) للنموذج 0.623، مُفسِّرًا 62.3% من التباين في استهلاك الفرد.

الاستنتاجات: أبرزت الدراسة ضرورة وضع سياسات مستدامة لإدارة الطلب، في ظل محدودية الموارد المتاحة. وأوضحت أن تحقيق إدارة فعّالة للطلب في المناطق الريفية الأردنية يتطلب مراعاة الخصائص الاجتماعية والاقتصادية والمادية، نظرًا لتأثيرها المباشر على معدلات الاستهلاك اليومي للفرد.

الكلمات الدالة: مياه الاستخدام النهائي، استهلاك الفرد من المياه المنزلية، العوامل، تحليل الانحدار الخطي المتعدد؛، الأردن.

1. Introduction

Water is not only a vital natural resource for sustaining life, but it is also a strategic element and a fundamental driver of economic development (Kılıç, 2020; Mukherjee, 2016). Adequate water supplies are essential for fostering industrial growth, expanding agricultural land, and ensuring the sustainability of ecosystems (Duarte et al., 2013). However, rapid population growth, accelerating urbanization, industrial expansion, and improving living standards have led to an unprecedented surge in demand for water resources (Simukonda et al. 2018; Okello et al., 2015; Schleich & Hillenbrand; 2009). These structural changes have intensified the freshwater scarcity crisis, which now poses a critical global challenge to water and food security in many countries (Gain & Wada, 2014; Davies & Simonovic, 2011; Khawaji et al., 2008).

Water security can be defined as "the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks" (Grasham et al., 2022; Arab et al., 2020). Achieving sustainable development in any country is difficult without ensuring water security, as water is the cornerstone of basic life needs, promoting economic stability, and supporting social development. The meaning of "water scarcity" remains contested. Water scarcity, for example, is not an absolute concept, but rather is linked to specific circumstances. According to Tzanakakis et al. (2020), communities that are actually experiencing water scarcity are those whose basic needs require substantial lifestyle changes to meet them. Only a few nations, including Jordan, fit under this category (Salman and AL-Karablieh, 2006). In 2017, approximately 2.2 billion people, equivalent to 29% of the world's population, were affected by water scarcity (An et al., 2021; WHO, UNICEF, 2019).

As part of integrated efforts to address the challenges of freshwater scarcity, improving water demand management (WDM) is an effective solution. WDM encompasses a variety of incentives, such as pricing, quotas, and subsidies, as well as conservation measures, educational programs, recycling, or awareness-raising. WDM is used as a means to guide customer behaviors toward more sustainable water consumption (Zeitoun et al., 2012). Achieving sustainable consumption through WDM primarily relies on enhancing consumers' awareness of water-saving practices and motivating them to apply this knowledge in their daily behaviors and routines, thereby contributing to the sustainable use of water resources (Sadr et al., 2016). Jørgensen (2010) argues that understanding how water is used and the possible ways to save it is essential to reducing demand and increasing the efficiency of its use. On the other hand, Soufoulis (2005) emphasizes that understanding the cultural context and the complexity of everyday experiences is key to adopting sustainable lifestyles in urban areas. When effectively implemented, WDM can reduce water and energy costs for households and service providers, improve the structure of sewerage networks by reducing peak flows, reducing pollution, enhancing water supply, and extending the life of aging infrastructure (Bello-Dambatta et al., 2010).

Regarding household water demand management, effective water resource planning requires estimating water consumption and usage patterns. Household water demand depends on a variety of factors. The most common factors used in studies include socio-demographic data, such as gender, household size, marital status, etc., as well as economic indicators, such as income, household economic class, etc. Housing characteristics, such as property size, number of floors, number of rooms, garden area, etc., are also taken into account. Furthermore, the efficiency of water-using appliances, such as dishwashing machine, laundry machine, type of tap, type of toilet, etc., are influential factors, along with environmental characteristics, including hydrological factors, water reliability and quality, climate, etc. Consumer attitudes and behaviors are key factors that influence water demand (Ibrahim et al., 2021; Fan et al., 2013; Slavíková et al. 2013; Duarte et al. 2013; Nauges & Strand, 2007; and Syme et al., 2004). To better understand household water demand, we need to analyze the daily end-uses of water. "End use" refers to sites in the house where water is consumed within the home, such as toilets flushing, showers, bath, washing machines, etc. While water end-use behaviors refer to the details of the activities people engage in to consume water in their daily lives (Shan et al., 2015). According to Salman and AL-Karablieh (2006), per capita's household water consumption includes the quantity of water used in daily activities such as personal hygiene, flushing toilets, washing clothes and dishwashing, drinking and cooking, as well as other household uses such as watering gardens.

If urgent action is not taken to address water-related problems, Jordan faces a severe water crisis within the next decade. The country is already considered one of the most water-resource-deficient countries in the world (USAID, 2018).

According to Altz-Stamm (2012); Al-Kharabsheh (2020), Jordan, like other developing countries, faces significant obstacles in securing water supplies, which are often linked to economic, social, and political factors. For example, the influx of Syrian refugees into Jordan since 2011 has placed a significant strain on its already limited and stressed water resources (Müller et al. 2016; Namrouqa, 2013; Klassert et al. 2015). Rapid development in urban and rural areas has also contributed to an increased demand for water, as the number of houses with gardens has increased, along with the number of cars and household appliances that consuming water. From a natural perspective, Jordan's water scarcity is largely due to low rainfall rates and limited surface and groundwater resources (Al-Hadidi and Al-Kharabsheh, 2015). However, these natural limitations are now compounded by demographic, economic, and infrastructural pressures. These challenges have made existing water supply systems insufficient to meet local demand (Salman & Al-Karablieh, 2006), leading to frequent bottlenecks in water supply and dissatisfaction among the population, especially in rural areas.

To the authors' knowledge, there is no study on household water consumption. Relevant literature has discussed per capita water consumption for all sectors such as the annual report for 2020 prepared by the Ministry of Water and Irrigation, the report estimated per capita water consumption at a maximum of 125 m^3 per year (MWI 2020). Although several studies have examined per capita domestic water consumption in Jordan (e.g., Salman and Al-Karablieh (2006); Alnsour and Ijam (2023); and Klassert et al. (2018), none have conducted a comprehensive analysis of detailed household water consumption patterns at the level of specific end uses, or the factors influencing this consumption, particularly in small rural villages. This study is distinguished by its application of rigorous and innovative approaches to monitoring daily water use behaviors and their determinants, rather than relying on aggregated data and general estimates common in previous literature. This gap hinders a deeper understanding of water consumption dynamics in rural contexts, where water constraints and cultural and social factors differ from those prevailing in urban areas. Hence, the need for focused research that employs micro-level analytical methods to examine household water consumption patterns in rural areas of Jordan is highlighted, with the aim of supporting more targeted and sustainable water demand management policies. Another point, this study draws on theoretical literature on the socio-economic and physical determinants of household water consumption, employing these concepts within an applied framework in a specific rural context in Jordan. By integrating the adopted theoretical frameworks within a systematic methodological approach, the study aims to generate context-specific evidence that can be used to improve water demand management policies in rural areas.

As a result, this study stands out as the first to apply novel approach and techniques to focus on household water consumption for one of Jordan's smallest rural villages. Rural villages constitute approximately 9.7% of the total population, compared to 90.3% for urban areas (DOS, 2022). "Rural" includes localities of (5000) or less population as defined in the 2015 census (DOS, 2022).

This study is expected to help decision-makers develop more efficient and sustainable plans for future water supply systems, as well as in determining efficient policies for the allocation of scarce water resources among competing uses. From an academic perspective, it will provide important additions to research on household water consumption, given that the available literature on this topic in developing countries, including Jordan, is still limited (Nauges and Whittington, 2010), and especially in Jordan. As a case study of households in Kharaj village, one of Jordan's smallest rural villages, the current study was carried out. The following were the study's objectives:

(i) Estimate the amount and characteristics of end-use water consumption,

(ii) Identify the factors influencing the amount and characteristics of end-use water consumption.

2. Materials and methods

2.1 Study area

Kharaj is a small rural village among seven villages in the Al-Wasatiya sub-district of the Irbid governorate. Kharaj is located in northern Jordan, precisely 20 km northwest of Irbid city (see Figure 1). Its population is about 4,713 people, with 959 households (DOS, 2023). The population density in Kharaj is 1,440 people per km^2. The study site is part of the Irbid governorate; the ground relief of the study area is completely flat and situated on a plateau at around 340 m.a.s.l.

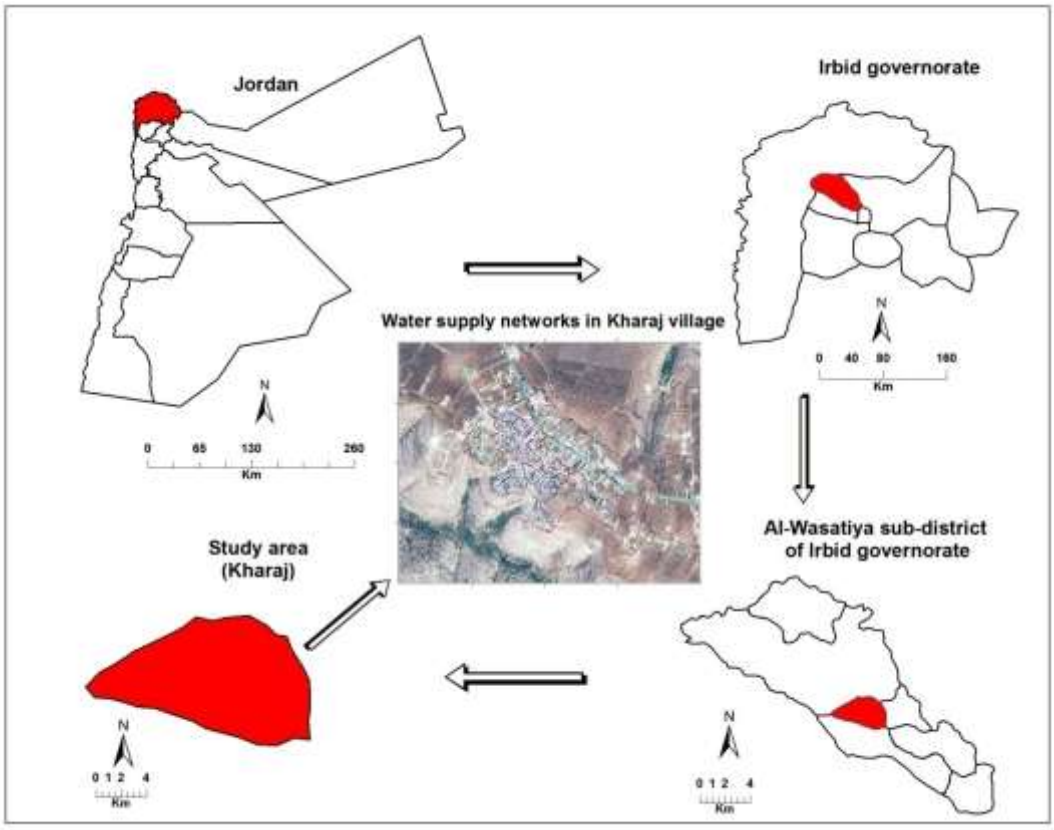


Figure 1. Study area

2.2 Water management in Kharaj

As in other villages of the Irbid governorate, all houses are connected to a water distribution network, and water is supplied to the kharaj houses according to a weekly schedule set by the Yarmouk Water Company (YWC). According to the villagers' respondents, the author who belongs to the village, and the results of a study conducted by the German Agency on water supply management for several villages, including Kharaj (Gesellschaft für Internationale Zusammenarbeit, 2017), the main problems associated with the water situation in the village are firstly the water shortage, particularly during the summer months, when water is sometimes supplied for 24 hours (one day of the week), and sometimes it is only available for a few hours. Secondly, the unequal distribution and use of water (low water pressure), which can be attributed to a variety of factors, including differences in the height of houses, the location of houses in relation to the main water line, or illegal extraction and pumping by some households. The water supply's irregularity is the third major problem. Because the water supply schedule is constantly changing, people are unable to prepare to fill their tanks when the water arrives. Leakages are the fourth problem associated with the village's water infrastructure.

To cope with the ongoing water shortage, many households in the village rely on underground cisterns, known as rainwater reservoirs, as an additional source of water. However, this option is too expensive for some households. This water resource is usually used for cooking and drinking. Additionally, some resort to purchasing water from private vendors as an alternative or supplementary source to their water supply. On average, these households request water trucks twice a month during the hot summer season.

People often complain to the municipality or water company when they encounter problems with water supply. However, these problems may take some time to resolve as water company staff are busy receiving many complaints. In some cases, personal water problems in the village are dealt with and resolved through personal relationships and connections with those responsible for maintaining the infrastructure.

2.3 Data collection instrument

The required data was collected used a structured questionnaire, which was adopted from previous research conducted elsewhere (Alharshaa et al. 2022; Ibrahim et al. 2021; Hussien et al. 2016). The survey was conducted between 15 December 2023, and 15 January 2024 (the data collection period reflects the phase of the beginning winter season). As the first author is from this small village, she was able to supervise a team of researchers also from this village to collect data and conduct face-to-face interviews with respondents, and get this number of responses this month. Actually, there is no other (more reliable) way to obtain WDM data or to understand consumer cultural behavior than a house-to-house survey.

Before starting the fieldwork, the author piloted a method for measuring water consumption, which involved calculating the rate of water flow and duration of use, using a clock and a bucket for collecting water for each end-use. Four highly educated villagers, carefully selected, separately tested the method to ensure its accuracy and effectiveness. Based on the results and estimations of the authors and the four persons, and with reference to some sources (e.g. Gleick, 1996; Yolles, 1993) the author decided acceptable ranges of flow rate and duration for all end uses of water, which the village participants could not exceed. To verify the accuracy of household heads' estimates, they were asked about the amount of household water consumption shown on the meters connected to the water distribution network or shown in the water bill, then the amount of water consumption shown on the meters was compared with the average water consumption estimated by the household heads.

The survey questions were designed to be divided into two main sections containing multiple-choice questions. The first section focused on collecting socio-economic information about the respondents, such as gender, age, education level, household size and monthly income, in addition to data related to physical housing characteristics, such as household type, home ownership, total built-up area, number of rooms, number of kitchens and toilets, and garden area. The second section of the questionnaire covers information related to household water consumption, including frequency, duration of end-use, and water flow rate for each end-use.

2.4 Sample size

. The total number of households in Kharaj village is approximately 959 (DOS, 2023). From this population, a simple random sampling method was used to select 146 respondents, representing approximately 15% of the total households. The sample frame was based on a comprehensive list of households in the village, obtained from the village headman (mukhtar). The respondents include the household heads (HHH). Respondents were asked to consent voluntarily before they were allowed to participate in the study. As mentioned, the interviews were directed to HHH (Table 1). However, since the first author and team are from the village, they were able to meet the husband and wife, and sometimes the entire family, on most visits, and obtained relevant information from all of them.

2.5 Statistical modeling for end-use water consumption

Although end-use household water consumption has been quantified, water consumption modeling is necessary to identify the factors affecting the average water consumption of the selected households. To create the prediction model, four variables that are most common in relevant studies were selected and included in the model. Table 1 lists every variable along with its type.

We used Correlation analysis to identify the independent variables that predict the amount of water consumption. After identifying potentially independent variables, we used linear regression analysis to examine the relationship between average household water consumption and four main variables: three reflecting the socio-economic characteristics of the household head, and one related to physical housing characteristics. The linear regression model was chosen due to its simplicity and high reliability in interpreting the relationship between the variables. This methodology was based on previous studies that used similar models to analyze water consumption in various contexts, as reported in (Alharsha et al., 2022; Ibrahim et al., 2021; Aho et al., 2017). The mathematical model used in this study is expressed by the following equation(Gujarati & Porter,2009), which illustrates how the independent variables affect average household water consumption.

$$Y=\alpha+\beta 1X1+\beta 2X2+\cdots+\beta nXn+\varepsilon$$

- **Y** represents per capita water consumption, which is the dependent variable in the model.
- α is the intercept, representing the expected value of water consumption when all independent variables are zero.
- β (1, 2, . . ., n − 1, n) are the regression coefficients, indicating the change in water consumption for each unit change in the independent variables.
- X (1, 2, . . ., n − 1, n) represent the independent variables, which include factors affecting water consumption such as household size, the household head's educational level, income, and the physical housing characteristics.
- ε is the random error term, accounting for unmeasured or random factors that may influence water consumption but are not included in the model.

This model aims in this study to explain the relationship between individual water consumption and its influencing factors, helping to provide more accurate estimates for water policy variables and making informed decisions regarding water resource management.

Table 1. Statistical model variables and their type.

Variable	Description of measurement	Variable type	Reference
Dependent variables			
Water consumption	Water consumption liter/cap/day	Continuous	
Explanatory variable			
Area of house	Total built-up area of house (m^2)	Continuous	(Hussien et al ,2016).
Education level	0= No formal education, 1= Primary, 2= Basic, 3= Secondary, 4= tertiary	Factor	(Aho, 2016); (Fan et al., 2013); and (Reniko, 2020).
Household size	Total number of individuals who live together and share meals in the same household.	Continuous	(Aho, 2016); Alharsha et al., 2020); (Sadr et al., 2016); (Fan et al., 2013); (Hussien et al ,2016); and (Reniko, 2020).
Household income	Total monthly income of the household (in Jordanian Dinars), with an exchange rate of 1 USD = 0.71 JOD.	Continuous	(Ana and Mazzega, 2017); (Oageng and Mmopelwa, 2014); (Hussien et al., 2016) (Ibrahim et al., 2021); (Baigorri et al., 2022); (Fan et al., 2013); and (Zevi, et al., 2022).

2.6 Data Analysis

Data extracted were analyzed using IBM SPSS Statistics (V23). The analysis included calculating basic descriptive statistics related to the average water consumption for each end-use. In addition, correlation analysis models were developed between the average water consumption and three variables related to the socio-economic characteristics of the household head, in addition to one variable related to physical housing characteristics, using stepwise multiple linear regression analysis. Correlation analysis was conducted as an initial step before applying regression analysis to examine the relationship between average water consumption and the relevant independent variables. To achieve this, Pearson's correlation coefficient was used to analyze the relationship between variables that have numerical (scale) values. This

coefficient measures the strength and direction of the linear relationship between scale variables, helping to determine the extent to which each independent variable influences water consumption. For nominal and ordinal variables, Point-Biserial correlation was used. This statistical method is appropriate for examining the relationship between categorical variables and numerical variables like average water consumption. The use of these statistical techniques helped identify independent variables that significantly correlate with water consumption, allowing for the selection of the most influential variables to be included in the regression analysis. This made it possible to estimate the main factors influencing household water use with greater accuracy. To evaluate the statistical significance of the results, several indices were used, including standard criteria, coefficient of determination (R^2), F-test, and t-tests.

3. Results and discussion

3.1 Description of participating households

It was found that the majority (89.1%) of household heads were male. The survey results revealed that the most represented age group among respondents was between 31-40 years, constituting 37% of the total sample, while no responses were recorded from the age group 18-30 years. The reason for the absence of respondents in this age group is that the formation of families takes place after this group due to the late age of marriage in the area study and Jordan in general. As for the level of education, the majority of household heads were educated; 52.2% had a university education, 23.9% had a secondary education, 17.4% had a basic education, and 6.5% had a primary education. This is an indication that the majority of the interviewed household heads are literate enough to understand the questions in the questionnaire and provide accurate answers. The average monthly income of households is 615 JD. The average Kharaj household consisted of 4.65 people. Most of the respondents (80.4%) lived in houses and (19.6%) in apartments. Regarding the home ownership distribution in the sample, the results showed that (93.5%) owned and (6.5%) rented. The number of rooms ranged between 4-6. The survey results showed that the number of toilets in each house ranged between one and three toilets, most households have 2 toilets (67.4%). Total built-up area ranges between 40 and 200 m² with about 90.43 m² as a garden area. Most households who own cars have 1 car (52.17%). Table (2) shows a detailed summary of the basic characteristics of the households included in the survey.

Table 2. Description of the surveyed households

Variables	Category	F	%
Gender of the household head	Male	130	89.1
	Female	16	10.9
Age of the household head	18–30	0	0
	31–45	54	37
	46–60	51	34.8
	>60	41	28.2
Education level of the household head	No formal education	0	0
	Primary level	9	6.5
	Basic level	25	17.4
	Secondary level	35	23.9
	Tertiary level	76	52.2
Monthly household income (JD)	<500	67	45.65
	501-1000	64	43.48
	1001-1500	10	6.52
	> 1500	5	4.35
Household	1–3	2	1.39

Variables	Category	F	%
size	4–6	105	71.74
	>6	16	10.87
Household type	Houses	117	80.4
	Apartments	29	19.6
Household home ownership	Owned	136	93.5
	Rented	10	6.5
Number of rooms	1–3	16	10.87
	4–6	118	80.43
	>6	12	8.7
Number of Toilets	1	19	13
	2	98	67.4
	3	29	19.6
	>3	0	0
Total built-up area m² of house	<50	3	2.18
	51-100	0	0
	101-150	70	47.82
	>150	73	50
Garden area m²	0	29	19.6
	1-50	26	17.39
	51-100	41	28.26
	101-150	26	17.39
	>150	26	17.39
Number of Cars	0	54	36.97
	1	76	52.17
	2	16	10.9
	>2	0	0

3.2 Average daily per capita of end-use water consumption

The reality shows that water is consumed at varying frequencies, either daily, or weekly. To extract the amount of end-use water consumption, at first, data on some types of uses were converted into daily water consumption for household and per capita; average daily water consumption per household member for end-use was found by dividing the total household water consumption by the total number of household members. The daily per capita water consumption for various household activities was estimated based on the frequency of use, the duration of each activity, and the water flow rate set by household heads.

The average water consumption in Kharaj village ranges between 31.79 and 113.54 liters per capita per day, while the average during the winter season was 66.73 liter/cap/day. This consumption is higher than consumption rates in some rural areas in least developed countries, such as Boro village in Ngamiland Province, Botswana, which has a daily consumption rate of 20.6 liter/cap/day (Oageng & Mmopelwa, 2014); 20–40 liter/cap/day in rural areas of Africa (Wallingford, 2003). In contrast, this consumption is equivalent to the consumption rates reported in other studies of rural water consumption, for example, 71.3 liter/cap/day in the Wei River Basin, China (Fan et al., 2013). However, water consumption in Kharaj village is much lower compared to urban areas, for example, 255 liter/cap/day in Sirte in Libya in the winter season (Alharsha, al., 2022); 320 liter/cap/day in Riyadh in Kingdom of Saudi Arabia (Al-Zahrani & Baig, 2011); 138 liter/cap/day

in Portugal (Jorge et al., 2015), 183 and 215 liter/cap/day for standalone households and apartments, respectively Jaipur, India (Sadr et al, 3016) and 161.26 liter/cap/day for Bandung Metropolitan in Indonesia (Zevi et al, 2022).

3.3 Characteristics of end-use water consumption

The top three water-consuming activities are dishwashing manually at 25.15%, followed by toilet flushing at 19%, and hand wash basin taps at 15.90%. High water consumption for manual dishwashing is due to the fact that most households are accustomed to eating three meals a day spread throughout the day, which increases the amount of water used daily for this purpose. The increased water consumption form flushing toilets is due to households' tendency to install pour-flush toilets instead of pit latrines, which has led to increased water use for this purpose. Meanwhile, the high-water consumption from hand wash basin taps can be explained by the need to perform ablution (wudu) before the five daily prayers, which is a mandatory requirement. House washing activities, including washing room, balconies, driveways, toilets and kitchens floors contributed 6.03% of total water consumption. In contrast, the lowest water consumption rates were for watering garden and vehicle washing at 3%. This is due to the lack of garden watering during the winter in Kharj village, in addition to the fact that vehicle washing at home is not common, as households tend to wash their vehicle at the car washing facility, which has become widespread in the nearby villages within the district to which the village belongs. The proportions for each water end-use are shown in Figure 2.

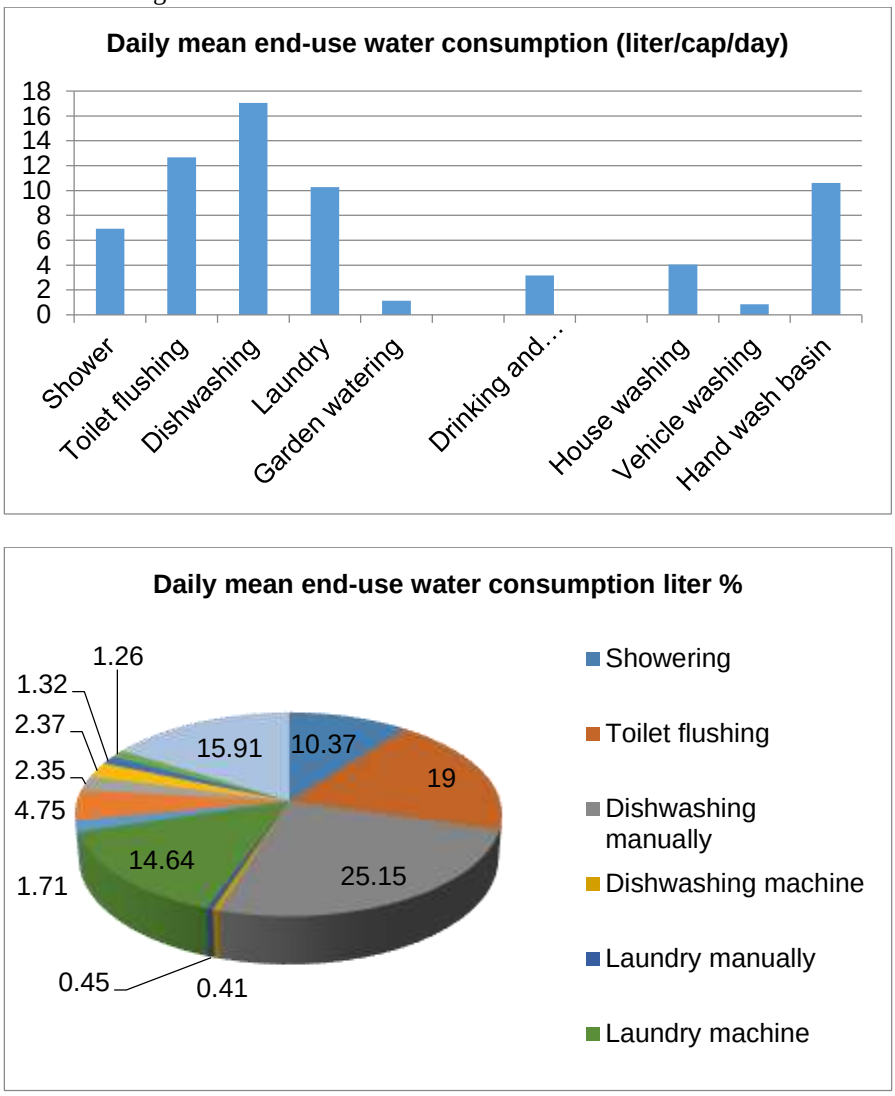


Figure 2. Household end-use water consumption proportion for each activity

3.4 Factors influencing end-use water consumption

This section reviews the factors that influence average end-use water consumption, focusing on the aspects or variables listed in Table 1.

3.4.1 Household size

The results shown in Figure 3 showed a positive effect of household size on average water consumption, as water consumption increases with the increase in the number of family members. Pearson coefficient was applied to evaluate the empirical relationship between the household size and water consumption, and the study revealed a moderate positive correlation between them ($r = 0.625$, $p < 0.01$).

Household size is considered an influential factor in water consumption, as it reflects the number of individuals living together and sharing household resources, including water. Previous studies have examined the impact of this variable, indicating two contrasting trends in the relationship between them. Some studies, such as Manga et al. (2022), Alharsha et al. (2022), and Sadr.et al. (2016), have shown a positive relationship, with larger households leading to increased water consumption. In contrast, other studies have reported a negative relationship, such as (Daniel et al., 2020; Aho et al., 2016; Miezah et al., 2015; Makki, et al., 2015; and Nauges & Thomas, 2000). These studies have attributed the decrease in water consumption to economies of scale and improved efficiency in household appliances.

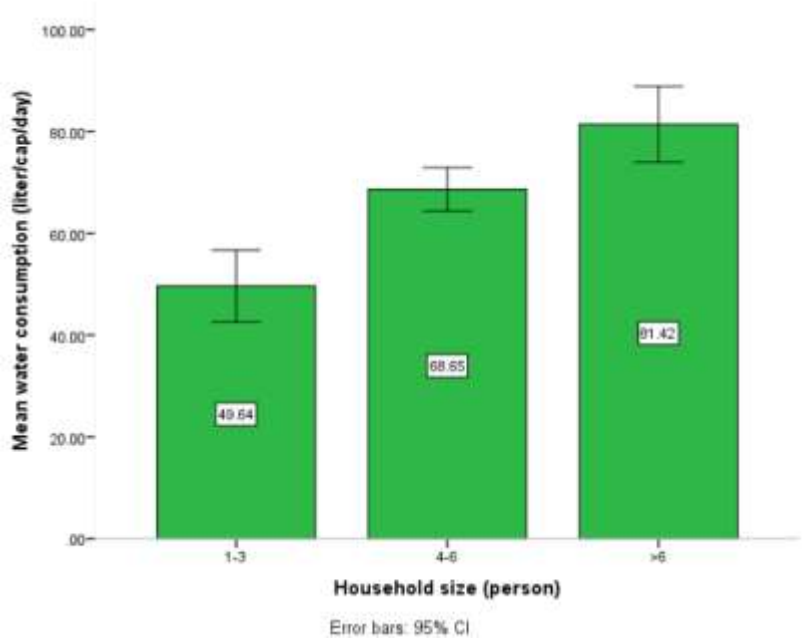


Figure 3. The relationship between end-use water consumption (liter/cap/day) and household size

3.4.2 Household income

Figure 4 highlights the positive effect of household income on average water consumption, with the amount of water consumed increasing as household income increases. To determine the relationship, Pearson's correlation analysis was applied, which showed a moderate positive correlation between the two variables, with a correlation coefficient of ($r = 0.531$, $p < 0.01$).

Household income level is a major factor that directly affects total water consumption. High-income households show the highest average water consumption, while low-income households have the lowest average consumption. This may be due to low water prices, which encourage high-income households to adopt irresponsible consumption behaviors and overuse. Additionally, a lack of awareness of water's value may further reinforce this consumption pattern (Jorgensen et al., 2009). Higher incomes help to acquire more advanced and efficient equipment, but may be accompanied by a reluctance to change habits, such as running the washing machine before waiting for it to be fully filled (Shan et al., 2015). In contrast,

low-income households show a lower tendency to purchase new equipment due to costs, but they adopt economical behaviors, such as running the washing machine only when it's full, which is supported by numerous studies (Morales & Maia, 2021; Potter et al., 2022; Sant'Ana & Mazzega, 2018; Hussien, et al., 2016; Oageng & Mmopelwa, 2014; and Arouna & Dabbert, 2010). However, some studies suggest a negative effect of income level on water consumption, with higher incomes increasing environmental awareness and reducing overconsumption. This hypothesis is supported by Philippsen et al. (2017.

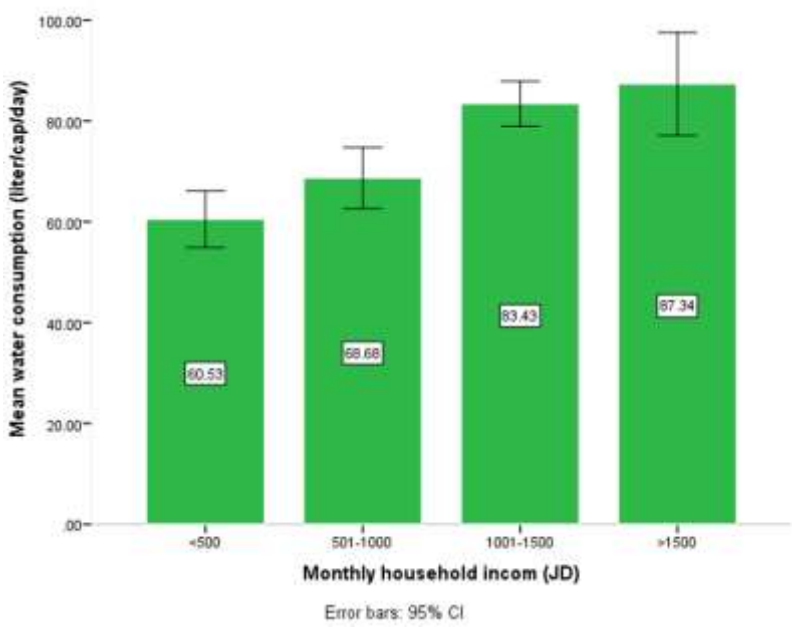


Figure 4. The relationship between end-use water consumption (liter/cap/day) and monthly household income

3.4.3 Total built-up area

Figure 5. showed a positive effect of built-up area on average water consumption, with larger houses tending to consume more water overall than smaller houses. A Pearson correlation analysis was applied to determine the relationship between these variables. The results showed a moderate positive correlation between them, with a correlation coefficient of ($r = 0.648$, $p < 0.01$).

It is well known that living in a small house helps reduce costs, as reducing the spaces between the walls of the house leads to reducing the consumption of water, electricity and gas, due to reducing the number of household appliances required and their operating costs. Also, Smaller houses require less water to clean than larger houses, resulting in lower overall water consumption. The relationship revealed by this study between built-up area and water consumption is consistent with previous studies, such as Alharsha et al. (2022); Souza & Kalbusch (2017); and Makwiza& Jacobs (2016).

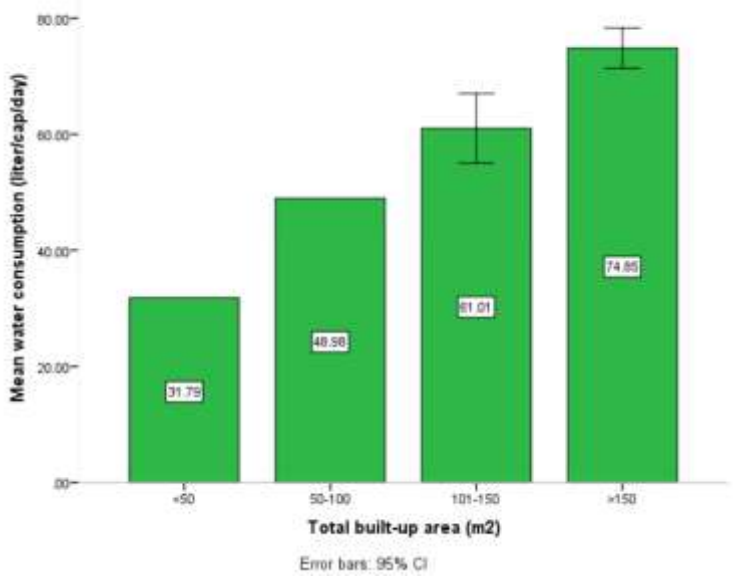


Figure 5. The relationship between end-use water consumption (liter/cap/day) and built-up area m²

3.4.4 Education level

Figure 6 shows a positive effect of household educational level on average water consumption, meaning that the higher the educational level of household members, the higher their daily water consumption. To determine this relationship, a Point-Biserial correlation analysis was applied. The results showed a moderate positive correlation between them, with a correlation coefficient of ($r = 0.534$, $p < 0.01$).

This variable can be explained within the framework of human capital theory, which suggests that education and investment in it contribute positively to economic growth (Wang & Liu, 2016). According to proponents of this theory, individuals with higher educational levels have better job opportunities and higher incomes, which increases their ability to afford water and leads to higher water consumption (Zevi et al., 2022). Several studies have explored the effect of education level on water consumption, with studies such as Zevi et al. (2022), Aho et al. (2015), Villar-Navascués & Pérez-Morales (2018), and Fan et al. (2013) showing a positive relationship between education level of the HHH and increased water consumption. However, other studies have shown a negative relationship between the two variables, suggesting that households with higher educational levels may consume less water due to their awareness of the importance of conserving water resources (Gregory & Di Leo, 2003; Oliver, 2003).

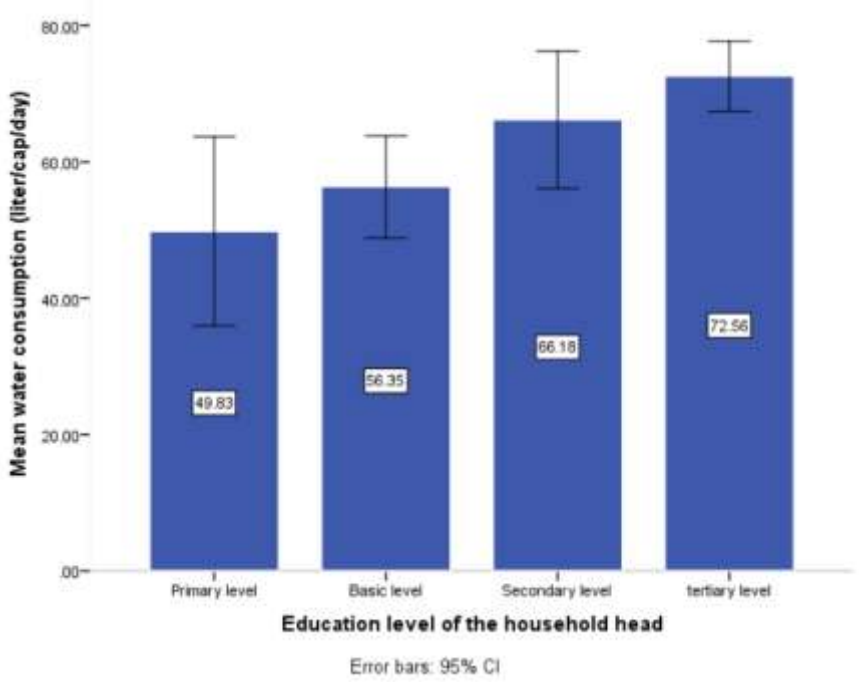


Figure 6. The relationship between end-use water consumption (liter/cap/day) and education level

3.5 Multiple Linear Regression Analysis for factors affecting end-use water consumption

In the previous part of the study, correlation analysis techniques were applied to examine the relationships between different variables and determine their strength and direction. This included using Pearson's coefficient to measure the strength of the correlation between quantitative variables. This analysis helps determine the extent of covariance between two variables and the direction of the relationship between them, whether positive or negative. In addition, Point-biserial correlation analysis was used to assess the relationship between variables comprising dichotomous (binary) data, which contributes to understanding the potential effects of categorical variables on other variables in the study. The analysis revealed a statistically significant correlation between water consumption and three variables related to the socio-economic characteristics of the household head, in addition to one variable related to physical characteristics of the house. In this part of the study, a stepwise multiple linear regression model was used to examine the factors affecting water consumption. This model is characterized by its ability to accurately predict when the coefficient of determination (R2) value exceeds the threshold of 0.35, as indicated by Mendenhall et al. (1990). The analysis results showed that the R2 value reached 0.623, reflecting the model's ability to explain 62.3% of the variance in per capita water consumption, based on the independent variables included in the analysis. This indicates that the model is capable of providing a clear quantitative insight into the factors affecting individual water consumption levels. Furthermore, the results of the t-test showed that all variables were statistically significant, indicating a substantial impact of these variables on the dependent variable. The F value also confirmed the statistical significance of the model, reaching 16.940 at a significance level of $p < 0.01$, enhancing the reliability of the results derived from the analysis. The exact details of the model are provided in Table 3.

Table 3. Multiple linear regression analysis of the water consumption

Model	Unstandardized coefficients		Standardized coefficients	*t*	Sig.
	B	**Std. error**	**Beta**		
(Constant)	10.30	7.500		1.431	.160
Household size	6.293	.3.430	.240	1..835	.074*
Education level	4.036	1.529	.278	2.640	.012**
Monthly household income	3.474	2.126	.195	1.634	.080*
Total built-up area m²	7.311	2.517	.341	2.904	.006***

N = 146; F = 16.940; R^2 =.623

4. Conclusion

This study analyzed household water consumption in kharaj village, Jordan, with the aim of understanding consumption patterns and the factors influencing it. The results showed that the average water consumption was 66.73 liter/cap/day or (24 cubic meters per year), reflecting the limited water resources available to rural households in the region, compared to rates recorded in countries with abundant water. The result also showed that the most water-using activity is dishwashing manually, demonstrating that this habit contributes significantly to total daily water consumption in homes. This rate is high compared to developed countries. A multiple linear regression analysis was performed, showing that the statistical model used explains 62.3% of the variance in per capita water consumption. The F test confirmed the significance of the model, as the results showed that the included variables play a combined role in determining individual water consumption in kharaj.

The study emphasized the importance of rationalizing water consumption and emphasized the need to develop demand management strategies, especially in light of the limited available resources. Among the most prominent proposed solutions is rescheduling per capita water allocations to prioritize basic domestic uses, while exploring the potential for reallocating water to other sectors such as agriculture and industry. To achieve this, the researchers propose developing sustainable alternatives and solutions, including: improving water use efficiency in the agricultural sector by adopting modern irrigation systems such as drip irrigation and using treated wastewater for irrigation; increasing reliance on desalination to provide additional sources of drinking water, especially in areas suffering from scarce groundwater resources; and enhancing water efficiency in the industrial sector by adopting technologies that reduce water consumption and improve reuse.

Also, the current findings provide practical insights for policymakers interested in improving water use efficiency in rural areas. These findings can guide the design of effective household-level interventions, such as awareness campaigns targeting inefficient consumption patterns (such as manual dishwashing), and income-related financial incentives for water conservation. These interventions are particularly important in areas with chronic water scarcity, such as rural northern Jordan.

In expanding the scope of future research, the study recommends conducting in-depth research that includes: comparing water consumption in urban and rural areas to understand the differences between these two patterns and the impact of infrastructure on consumption rates; and studying the impact of social beliefs and behaviors on water consumption decisions to understand the role of culture and environmental awareness in water resource management. Analyzing seasonal variations in water consumption, with the aim of developing more efficient water policies that take into account climate change and seasonal demand patterns. Estimating water consumption in the other sectors will provide a comprehensive picture of total per capita water consumption in Jordan, helping to formulate effective policies to achieve water security at the national level. These recommendations reflect the need for a comprehensive vision for water resource management, ensuring a balance between meeting the basic needs of the population, supporting economic development, and protecting water resources for future generations.

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