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COMPARISON OF SEASONAL DOMESTIC WATER USE AND THE IMPACT OF HOUSEHOLD CHARACTERISTICS ON PER CAPITA WATER CONSUMPTION IN SIRTE, LIBYA

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EXTENDED ABSTRACT

INTRODUCTION

In many countries, water demands are increasing due to population growth, urbanization, industrialization and improving living standards [1, 2]. These factors, which are more pronounced in developing countries, increase water demand beyond the existing infrastructure capacity and decrease local authorities' ability to adequately provide water supply and sanitation services [1]. Additionally, limited water resources and climate uncertainties magnify the water scarcity problems. These problems require effective and efficient usage of the available fresh water resources [3]. To address this, it is important to have information on domestic water demand which relies on the knowledge of the daily indoor water end-uses (bath, shower, toilet flushing, washing hand basin, cooking, dishwashing, laundry and house washing) and outdoor water end-uses (watering garden, yard cleaning, vehicle washing and swimming pool). This knowledge is lacking in many developing countries. The paper, basing on the questionnaire survey data for 380 households in Sirte city, Libya, uses 25 IBM statistics models to investigate the seasonal variation in per capita water consumption and the impact of household characteristics on per capita water consumption in the city. Additionally, the paper uses regression techniques to predict the future water demand for the study area in summer season.

METHODS AND MATERIALS

STUDY AREA

The city of Sirte in the north of Libya between 31º 12' 32.11'' North and 16º 35' 19.18' East with population of around 70,000. It's climate is classified as arid affected by the Mediterranean Sea in the north and the desert in the south. The water source for the city is from Man-Made River Project (MMRP).

METHOD

For the survey, 400 questionnaires were distributed in December 2017 to students and staff of Sirte University in Libya as household representatives. The survey contained 67 multiple choice questions designed to extract information about demographic characteristics (number of children, females, males and elder), physical characteristics (number of rooms, kitchens, toilets, floors, built-up area, garden area and income) and household water consumption characteristics of the participants for each indoor and outdoor end-use. Of the distributed questionnaires, 380 replies were received. To capture the seasonal variability of water consumption, the survey was repeated in July 2018. The survey was distributed to the same participants as in the winter to ensure consistency. Data analysis was done using 25 IBM statistics methods to observe the seasonal variability of water end-uses. Then, the best fit model between multiple linear (STEPWISE) and evolutionary polynomial (EPR) regression was used to predict the future water demand for the study area in summer season.

RESULTS AND DISCUSSION

SESONAL AVERAGE PER CAPITA WATER CONSUMPTION

Figure 1 shows a comparison of the frequency distributions of per capita household water consumptions in summer and winter. The figure shows that the number of households with consumption greater than 240 l/p/d increased to 361 with percentage of 95% in summer season compered to winter season (187, 49%). The figure also shows that the majority of households have relatively lower consumptions in winter and the winter frequency distribution is skewed towards left.

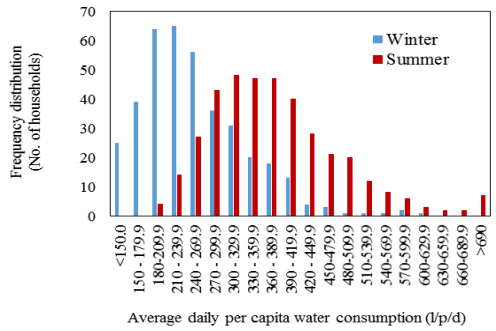

Figure 1. seasonal variability of per capita average consumption

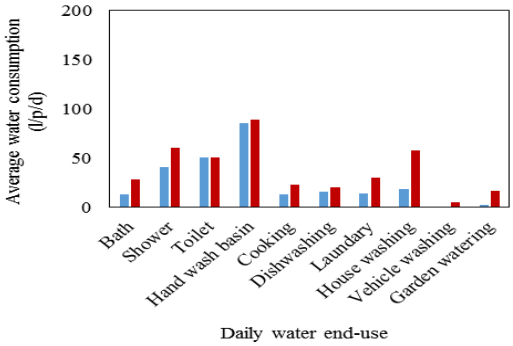

Figure 2. Seasonal water end-use

The similarities and differences for end-use water consumption in winter and summer are shown in Figure 2. While there is no difference with respect to toilet water use, there is slight difference for hand wash basin and there are significant differences for all the other end uses. A formal t-test analysis (Table 1) confirmed this as shown below.

Table 1. Seasonal statistical comparison of water end-uses

Water end-use	Average water consumption (l/p/d)		Mean different (Winter-Summer)	t value	Significant (2-tailed) (p)
	Winter	Summer			
Bath	13	28	-14.86	-10.662	0.000*
Shower	41	60	-19.18	-10.687	0.000*
Toilet flushing	51	50	0.49	0.434	0.665**
Hand wash basin	86	89	-2.93	-1.135	0.257**
Cooking	13	23	-10.08	-33.517	0.000*
Dishwashing	16	20	-4.64	-10.247	0.000*
Laundry	14	30	-16.08	-28.852	0.000*
House washing	18	58	-39.43	-25.458	0.000*
Vehicle washing	1	5	-4.14	-11.993	0.000*
Garden watering	2	17	-14.32	-8.782	0.000*
Total water consumption	255	380	-	-	-

* = significant different between winter and summer
** = not significant different between winter and summer

A regression model was developed to estimate per capita water consumption as a function of demographic and physical characteristics, using STEPWISE multiple linear and evolutionary polynomial regression techniques. Of these, STEPWISE multiple linear and EPR based regression approach appears to be producing better fit to the observed data. Further investigations are in progress.

CONCLUSION

The study found some significant seasonal variability of household end-use water consumption characteristics in Sirte city in Libya which results in the average per capita water consumptions of 255 l/p/d and 380 l/p/d in winter and summer, respectively. These per capita water consumption figures are relatively on the higher side and do indicate considerable scope for the deployment of water saving devices and initiation of education campaigns for water efficiency promotion and waste minimisation. The developed models can be used to predict any future demand as a function of changes in water use or household characteristics and support water resources management policy formulation.

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