34th WEDC International Conference, Addis Ababa, Ethiopia, 2009

WATER, SANITATION AND HYGIENE:
SUSTAINABLE DEVELOPMENT AND MULTISECTORAL APPROACHES

Water use vs. socio-economic factors in a water stressed urban area having economic affluence

A. M. Shahalam, S. Al-Shammari & A. Abusam, Kuwait

REVIEWED PAPER 225

The paper presents household water-use data collected from a water use survey in an urban area located in a water stressed region in the Middle East. The purpose of the survey was to investigate the effect and relationships of water shortage, economic effluence and socio-economic attributes of house holds on per capita water use in the area. Results indicated wide variation of water uses in smaller districts of the urban area. In small areas socio-economic factors are significantly related to per capita water use. However, when total urban area is considered, same set of factors do not show any meaningful relationship to per capita water use. Water use in summer is about 2-6 times more than that in winter. Over all per capita water use in the area is recorded to be one the highest in the world.

Introduction

Estimation of domestic water use is one of the most important steps in the planning, design and construction of a new water supply system in an area. Similar estimation is also needed for the extension of existing systems. The estimation usually depends on existing and future population along with expected per capita water use each day. For extension of an existing system, the information gathered from the operating system usually suffices. For new systems, however one relies on available water use records from similar areas elsewhere. It needs prudent judgment of the planner to adopt right kind of data so that the system is designed and constructed with appropriate capacity without over or under provisions.

Consequently there are always desires of concerned people to explore for ways and means that can assist to estimate water demand in water supply systems. Exploring on factors that affect water demand is of one of such approaches. It is proven fact that normally, the socio-economic attributes along with education status of an user, environmental condition of an area, water metering and its cost to users are closely related to amount of potable water use.

A survey was conducted in an existing water supply system with special features of its geographical location, water shortage problem and economic affluence.

Survey

Kuwait is located at the north-east corner of the Arabian Peninsula and has an arid climate with scanty water resources. Kuwait city is the principle urban area. Temperature varies widely from -4 in winter to 51.3°C with a monthly average of nearly 26°C. Mean annual rainfall is about 128mm while the mean evaporation per year is about 4,300mm (MP, 2002). Main domestic water source is desalinated seawater. Water use is metered and charged by the amount of use.

A field survey was conducted on household water uses selecting randomly the houses at various locations in Kuwait city (Shahalam, 2006). Meter readings were recorded at seven days apart through summer and winter months of 2006. The number of surveyed households within a selected district varied from three to 10 depending on its area and population. Socio-economic information about the household was collected by surveyors interviewing the head of household or alternatively interviewing an adult responsible person in the household. These included persons per household, monthly income per household, years of education of the

head of the household and potable water use for gardening. Data were collected during the summer months of July to September and the winter months of November to December.

In total, 142 households were surveyed (70 in the winter and 72 in the summer). Average per capita water use in surveyed households during the summer and winter months in different districts appear in Tables 1 and 2, respectively. Water use rate varied significantly from one season to the other. A comparison of summer and winter water uses in districts indicated that summer to winter per capita water use ratio varied from 2 to 6. Average water use in summer and winter in surveyed locations was 618 and 236 l/p/d respectively. Standard deviations in summer and winter were 194 and 182 l/p/d respectively. Average summer rate was about 2.6 times of that in winter. High value of standard deviation indicated a wide variation in the rate of water use from one district to the other while the magnitude of water use in districts did not change significantly from season to season.

A linear regression analysis was conducted to test the fitness of the relationship of water use with variables such as number of persons per household, monthly income of households, years of education of household head and potable water use for gardening in house-lawns. The form of the relationship that was tested is shown in Equation 1.

$$Y=a1\ X1+ a2\ X2 + a3\ X3 + a4\ X4 \qquad (1)$$

Where Y = Per capita water use, l/p/d, X1 = Persons per household, X2 = Monthly income of a household, X3 = Years of education of household head and X4 = Potable water use for gardening (1=Always, 2=Sometimes and 3=Never). The coefficients a1, a2, a3 and a4 are associated with variables X1, X2, X3 and X4.

Results and discussion

The results of regression analysis appear in Table 3. The coefficient of determination showed the goodness of the relationship. When all areas were combined, the relationship does not fit the data well. Winter and summer water uses had coefficient of determinations of 0.095 and 0.303 respectively. Maximum R value was 0.55 during summer months.The results considering all survey areas together did not show any significant relationship of per capita water use with independent variables. It appeared that the districts had significant differing sensitivity to attributes of users.

However when the districts were considered individually, the relationship showed meaningful significance. It had very good fit in winter and summer seasons and could be statistically utilized to estimate water use in the surveyed areas. The magnitude of a coefficient value showed the sensitivity of its associated variable on water use. The higher the value of the coefficient, the higher was the sensitivity of associated variable on the water use. For example, if one considers winter data, water use per person is more sensitive and responsive to number of persons in a household at Sabha Al-Salem (-55.42) than that observed at Khaldiah (+5.66).

In general on a sensitivity scale, the number of persons in a household (a1) and water use for gardening have the most significant effects on per capita water use. Education level of household head had minimum sensitivity on water use rate. The negative sign associated with a coefficient indicated that increasing the value of its associated variable would decrease the water use rate.

It is interesting to note that same variable-affect even show opposite effect on water use in certain districts. The variable sensitivity significantly changes even from one season to other. Normally metering and water charge are considered to be deterrents to high water consumption. However in Kuwait where both metering and water-charging are practiced, the effects are not reflected in the water use as the area has one of the highest domestic water consumption rates in the world.

It is imperative from the results that the socio-economic factors are more effectively related with per capita water use in smaller districts due to probably the presence of homogeneity in household characteristics.

In Kuwait it appeared that for large urban areas incorporating several smaller areas of diversified socio-economic and demographic characteristics, the estimation of water use should follow the scheme of discrete determination of water uses in small zonal districts and then combine the results for larger areas or follow trends of past average water use in the existing city or similar cities in the region.

Conclusion

The following conclusions might be drawn from the results of the survey of household water uses in Kuwait city area located in a region of water stressed area but enjoying economic affluence.

- In small urban areas, the socio-economic factors such as persons per households, monthly income of households, number of years of education of head of household and household portable water use for gardening show strong statistical relationship with household per capita water use.
- For large urban areas which comprise of several smaller areas of diversified socio-economic and demographic characteristics, per capita domestic water use does not show significant relationships to same set of variables found to be very important in discrete small areas.

Table 1. Daily average per capita water use during summer months

Case Location	Number of Households	Ave (l/p/d)
Khaldiya	9	493
Rehab	8	537
Ardiya	7	859
Firdous	9	598
Nuzha	3	637
Adan	10	333
Salmiya	3	1004
Kaifan	8	455
Adailiya	8	617
Andalus	7	647

Table 2. Daily average per capita water use during winter months

Case Location	Number of Households	Ave (l/p/d)
Khaldiya	5	140
Rehab	3	98
Ardiya	3	144
Firdous	3	145
Sabah Al-salem	10	422
Adan	3	142
Gadisiya	9	431
Gossour	10	610
Surah	6	111

Yarmouk	3	113
Khaitan	3	96
Shamiya	3	126
Shuwaikh	2	195
Mishref	4	135
Bayan	3	135

Table 3. Relationship coefficients and coefficient of determination in water use in equation (1)

Location	a1	a2	a3	a4	R2*
All surveyed areas:					
Winter	13.22	-0.099	11.536	64.446	0.095
Summer	-43.57	0.268	32.317	52.448	0.303
Individual Areas: Winter data:					
Sabha Al-Salem	-55.42	0.244	14.567	192.135	0.486
Khaldiah	5.66	0.099	-12.498	48.992	0.424
Gadisya	-6.91	0.099	9.118	98.183	0.541
Gossour	-50.18	0.384	25.926	74.701	0.492
Surah	-4.96	0.051	2.069	14.534	0.863
Mushref	-4.50	-0.287	51.636	-93.546	1
Summer data:					
Adan	-24.51	0.055	6.572	163.604	0.912
Kaifan	15.25	0.212	-44.711	285.054	0.955
Adiliya	-504.34	7.050	6.610	-2716.010	0.957
Khalidiya	12.43	-0.347	63.619	13.324	0.417
Andalus	-27.37	0.050	52.075	55.248	1
Rehab	-41.74	-0.036	54.269	134.889	0.887
Ardiya	-83.23	-0.469	152.149	36.811	0.675
Firdous	-22.97	-0.222	52.160	191.291	0.433

Acknowledgements
The authors would like to extend thanks to the Kuwait Foundation for Advancement of Sciences and Kuwait Institute for Scientific Research for financing the survey project.

References
MP (Ministry of Planning), (2002) Annual Statistical Abstract: Kuwait.
Shahalam, A.B. et al., (2006). Present and Future Wastewater Quantities and Reuse Demand in Kuwait. Final Report No. 8954.Kuwait Institute for Scientific Research: Kuwait.

Contact details

Dr. Abulbasher Shahalam :
Water Resources Division, Kuwait Inst. For Scientific Research
Tel: (965)24672223
Fax: (965)24672223
Email: salam@safat.edu.kw