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Determine Components of Household Water Consumption Per Capita in Rural Communities (Case Study: South Khorasan province, Iran)

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Abstract

The piped water consumption per capita is more than 142 cubic meters per year in Iran that is higher than the consumption per capita of some water-filled European countries such as Belgium and Austria. The use of drinking water for washing dishes, clothes, cars as well as bathing and watering gardens are of the important reasons for piped water high consumption in Iran. However, different lifestyle patterns, water users' facilities, culture and employment types of the majority, as well as very different climatic conditions in rural areas of the country, have caused different water needs. Therefore, it is necessary to determine different components of household water consumption by doing regional and zonal studies separately throughout the country. For this, three water supply complexes of Ali Abad Looleh, Khoor, and Vahdat were selected according to climatic, economic and social conditions among water supply complexes of South Khorasan province. In this study, 128 common water was randomly selected by considering economic - social and household size conditions. Then, to measure every component of water per capita, including drinking, bathing, washing and watering home green space different counters were inserted at homes. Counters were read daily for a week. Results showed that the average water consumption per capita was 99.9 liters a day for the province rural communities. In addition, the contribution of each component of water per capita, including drinking, bathing, washing and watering home green space were 3.6, 15.7, 63.1 and 17.5 liters a day.

Keywords: Water Consumption Per Capita, Household Sector, Villages.

1. Introduction

In the new global attitude, water is considered as an economic-social good and mans' the basic need. Water is a renewable resource, though, its amount is limited. Considering the population growth, industry development, increasing levels of public health and welfare, renewable resources per capita is decreasing (Saleh Nia et al., 2007). According to an estimation, the total amount of available water on the earth is about 1.4 billion cubic meters of which 95% is in oceans that due to the high salinity of the water is not suitable for humans' needs and other uses; about 4% is in the polar caps and the remaining 1% is the entire pure water in the Hydrology cycle involving underground reserves. Of these, only 0.1 % is available as the pure water in rivers and lakes as suitable water for human uses. What is important is the protection and proper use of pure water resources (Ramakrish and Birla, 2003). Due to the limitations of harvestable water resources in the country and the rising increase in its efficiency during recent decades, water has become one of the basic and important goods. However, protection, limitations, creating culture, educational programs, proper utilization, realistic pricing practices and increased use of alternative water sources can reduce the

demand for fresh water (Richard and Marella, 1992).

The annual rainfall in Iran is about 260 mm, which is the equivalent of 415 billion cubic meters of precipitation per year, among which less than 135 billion cubic meters is the renewable resource. There is also about 95 billion cubic meters of water from among this amount (Tajrishi and Abrishamchi, 2006) in the three important sectors of household, industry, and agriculture ((Gleick, 1993; Shiklomanov, 2000; FAO, 2003). According to the international statistics, the consumption amount in these sectors is 75, 25 and 95 percent of the total water demand of 104.6 billion cubic meters, respectively. The domestic water consumption is negligible compared to industrial and agricultural usage, but the cost of supply, transport, and storage of drinking water and household health is very high. On the other hand, the importance of taking it to prevent the outbreak of disease, bathing, and cleanliness is an issue where consumers are willing to pay a high price (Gibbon, 1986). Also, increasing the day to day growth factors, the need for more food, the necessity of the promotion of health and social welfare, industry development and ecosystem protection will increase water demand. Regarding Iran population growth, renewable water resources annual per capita that was 7000 cubic meters in 1957 has reduced to 2000 cubic meters in 1997. It is predicted that the Iran population will become approximately 88.4 million in 2025. With the assumption, drinking water use in Iran cities and villages that is near to 6 billion cubic meters now will become more than 7.8 billion cubic meters (Gleick, 2001).

Among different uses of water, drinking the water due to health issues and as the basic need of humans as well as the possibility of social tensions incidence because of its shortage is of more sensitivity and priority. In order to determine the consumption pattern of a useful way to manage water demand and improve the efficiency of consumption and to prevent contaminated or destroyed water resources. Indicators like cultural habits, living standard, economic development level, geographical conditions, climate conditions, distribution network pressure, water cost and etc. are known as factors impacting on water consumption per capita in a community (Akbarpour and Azizi, 2009)

Furthermore, increasing growth of water demand in specific climate conditions has exposed the country to the brink of severe shortages and subsequent social and political tensions. To improve this situation requires approaches for the allocation and optimum utilization of available water resources. Considering the semi-arid and dry climate of South Khorasan province and also the growing demand for water that causes lacking, an estimation of consumption patterns in rural communities in the province can be a powerful tool for managing the demand and improving the consumption efficiency. The water that is provided for consumers through much effort, enormous costs and costly quality control are expensive because it is the result of all the measures mentioned. Thus, to identify factors impacting on water consumption pattern and to determine water per capita in villages are of necessities of the present age since in the case of determining water consumption pattern while decreasing operating expenses of water supply projects, more people benefit potable and healthy water.

According to studies conducted by the United Nations in Singapore, water consumption of every citizen for sanitation and health of society was determined at least 99 liters a day (United Nations. 1976). Based on the Third Development Plan, water consumption pattern of each household is 22.5 million cubic meters per month; as a result on average everyone can use 150 liters of water in a day (Plan and Budget Organization & the Department of Energy, 1992). Van Diron (1976) identified water consumption amount for rural areas of developed and under developing countries equal to 300 and 100 liters a day per person (Lpcd), respectively (Rural Water & Waste Water of South Khorasan, 2006).

Saleh Nia et al., (2007) studied tariffs of the potable water sector and the consumption pattern associated with subscribers'statistical community of Nishaboor city during 2001 to 2004 for a period of 2 months per year. Results revealed that the average consumption per capita was 135 liters per day. Javadi (2000) studied public and home green space water use of Yazd province cities in 1995. Results showed that in Yazd the piped water consumption per capita was7.4 liters for public green space uses and 42.1 liters for home green space uses per person. In addition, water consumption per capita of Yazd was obtained 249 liters a day per person. Shajari (1992) in his research estimated the total amount of household water use per capita about 135 liters per day in Shiraz.

Banaei Ghah Farrokhi et al., (2009) in their investigations of water consumption optimization via the research in operations method using linear programming model in Lordeghan realized that the average consumption per capita was 185 liters per day in this town. Using field studies, Maleki nasab et al., (2009) measured the impact of utilizing energy-efficient equipment and valves on household water consumption decrease of Shandiz city located in Razavi Khorasan province during a 9-day period. According to the results, household water consumption was estimated at 171 liters per day. Water Forum Research Institute of America (1999) conducted studies under the title of comprehensive studies of household water uses in 12 different cities of United States for 1108 subscribers, in other words about 100 subscribers for every city. According to the results, the average use of each subscriber was estimated at 69.3 gallons per day. Executive institution of Yarra water (2004) in Melbourne, Australia conducted studies under the title of measuring household subscribers' use for 480 household subscribers. According to these studies, the average daily consumption of any subscriber was about 622 liters and 169 liters a day per person.

Ghasemi et al., (2008) examined and evaluated the consumption and waste of household water per capita by preparing and completing questionnaires and interviewing with Zabol citizens. They found out that the highest level of consumption was in the bathing sector with a per capita of 34.5 liters and the highest amount of household water waste was associated with air conditioning and ventilation systems sector that was about 8.5 times more than the standard rate of Iran.

Fahiminia et al., (2015) The study In 15 Rural areas of Qom, average domestic consumption per capita, average general uses per capita, average industrial and commercial per capita and total consumption per capita were 173, 4.6, 3 and 180.6 Liters per capita per day (LPCD) respectively. Semsar Yazdi et al., (2017) the study aimed to estimate the per capita consumption of drinking water in the city of Ardakan, Yazd Province, through field studies and a survey of the inhabitants who collected their required drinking water from public water distributors. The data were statistically analyzed and the per capita consumption of drinking water in this area was determined as 4 liters per day.

Given that water consumption pattern in Iranian villages has not been studied yet, the present research aimed to determine different components of household water use per capita in rural communities of South Khorasan province in order to take an effective step for an explanation of executive approaches to manage and preserve available water resources of the country.

2. Materials and Methods

2.1 Characteristics of the study area

Iran and particularly South Khorasan province is a semi-arid and dry region so that the rainfall level is half of the national average. However, Iran with a rainfall average of 250 mm has one-third of the global average value (860 mm). Particularly, this problem has become a basic dilemma due to the uneven distribution of rainfall in different areas. In addition, vegetation poverty and the prone to erosion have ever been of great attention and importance from two perspectives of erosion control, sediments, risks containment and elimination and costs caused by possible

floods. South Khorasan with an area extension of about 150800 square kilometers (nearly 9.27 percent of the country total area) is located in the east of Iran. According to the latest national divisions, the province includes 11 cities, 25 sections, 28 towns, 41 rural districts, and 3555 villages. The province population is 732192 people of which 414173 people belong to the urban population (56%) and 318019 people belong to the rural population (44%) (Azizi et al., 2012). Among 86 water supply complexes, three complexes of Ali Abad Looleh, khoor and Vahdat were selected. Ali Abad Looleh water supply complex is located on the east and southeast of Birjand city, 6 km far from the city center. Its villages are mostly located in foothill areas of Bagheran rural district of the central section. Khoor water supply complex is on the west of Khossf city and 85 km far from the city center. Its villages are located in the rural district and section of Khoosf. Vahdat water supply complex is located on the north and east north of Birjand and 100 km far from the city center. 8 villages are located in mountainous areas of Shakhen rural district of the central section of Birjand and 9 remaining villages are located in mountainous of Efin rural district of Zohan section of Zirkooh city. Figure (1) displays the geographical location of the study area.

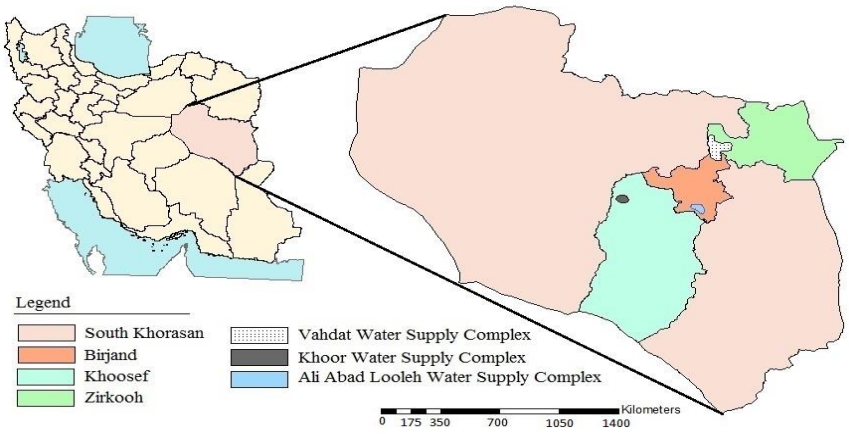

Fig.1. The geographical location of the study area in South Khorasan province

2.2. Methods and tools for data collection

Water consumption per capita in Iran cities is not completely clear. This is far more evident in villages. Indeed, due to the lack of comprehensive and required data, to have a clear and exact estimation of rural uses sorted by consumption type is not possible. Dependence of water consumption rate on various variables makes it difficult to express a definitive figure for water consumption per capita in the form of general instruction. A village geographical location is a major determinant variable of water use rate. To have archeological and spectacular sites, tourist attractions, good revenue, residents‘ high culture and proximity to the city are factors of water use increase in rural communities. The following stages were done to collect the required data in the present research:

2.2.1. Selection of water supply complexes

Among the province water supply complexes and considering factors of population, climate conditions, cultural-economic aspects, and the distance aspect, Ali Abad Looleh complex was selected because of proximity to the city as well as similarity of its cultural, social and economic aspects to urban communities. Khoor water supply complex was selected because of the proximity to the Lut Desert, warm and dry weather in summer, cold and dry weather in winter and is suitable for keeping livestock. Vahdat water supply complex was selected because of mountainous cold water and is suitable for farming.

2.2.2. Estimation of household water consumption per capita

In the studied water supply complexes, household water per capita was estimated separately for 4 sectors of potation, bathing, washing and livestock use water.

1. Potable water per capita

To measure the potable water per capita for drinking a counter was inserted in the place of subscribers‘ drinking water harvesting pipe. By daily reading of counters, potable water per capita for Ali Abad Looleh, Khoor and Vahdat complexes was estimated separately. The final result is presented in table (1).

2. Bathing per capita

The used water per capita for bathing was estimated by reading the counter inserted on the bathing pipe before and after an individual goes to the bathroom. According to the villagers‘ comment, each person goes to the bathroom every 4 days. Bathing per capita for the studied complexes is shown by table (2).

Table1. Potable water per capita for the studied complexes

Water supply complex	Potable water per capita (Liters Per Capita per Day)
Ali Abad Looleh	3.2
Khoor	3.9
Vahdat	3.7
The Average of total per capita	3.6

Table 2. Bathing per capita for the studied complexes

Water supply complex	Water for bath per person	Bathing per capita (Lpcd)
Ali Abad Looleh	59.8	15
Khoor	65.8	16.4
Vahdat	62.8	15.7
The Average of total per capita		15.7

3. Washing per capita

Washing per capita includes the water used for laundry, doing dishes, lavatory, toilet and house cleaning. To estimate the washing per capita, at first, some households with the family size of 2 to 7 persons were selected from every complex. Then, to provide a more exact estimation those households were selected that they didn’t have home green space, their potable water was not supplied by a resources other than the water supply network (for example aqueducts or fountains) and they didn’t keep livestock at home; thus, the water available in the house was used only for bathing and washing. Next, the volume of water consumed by each household was measured daily for a week by reading the counter and the consumption type was recorded on the associated family’s form. Afterward, through the statistics of days when no water was used for bathing, the washing per capita was estimated. The related results for every complex are presented in table (3).

Table 3. Washing per capita for the studied complexes

Water supply complex	Washing water per capita (Lpcd)
Ali Abad Looleh	63.6
Khoor	63.8
Vahdat	62
The Average of total per capita	63.1

4. Estimation of consumption per capita for (home) green space water

In order to determine water consumption per capita for green space in rural communities of the studied complexes at first, some villages were selected from every complex. Then, some subscribers were selected randomly. Next, every family's green space area was measured and through dividing the area by the number of family members, green space per capita for each home and consequently for each village and the complex was determined. Green space per capita for each complex is displayed by table (4).

Furthermore, to obtain the rate of needed water for irrigating per square meter of green space, homes with green spaces were selected. Then, one meter of the available green space was selected and the used water volume for irrigation was obtained. According to the tests conducted in different homes, to irrigate per square meter of a green space approximately 50 liters water was consumed. With questions and answers and comments of villagers, it was cleared that on average they irrigate the home green space every 5 days. As a result, water consumption per capita for one square meter of green space was 10 liters a day.

Table 4. Green space per capita for the studied complexes

Water supply complex	Potable water per capita (Lpcd)	The average of green space per capita (m^2)
Ali Abad Looleh	2.04	20.4
Khoor	1.34	13.4
Vahdat	1.88	18.8
The Average of total per capita	1.75	17.5

5. Estimation of the water consumed by livestock

To estimate water consumption per capita for livestock only homes with livestock were selected. Then, livestock consumption per capita was determined by reading the counter. Table (5) shows the related results.

Table 5. Livestock water consumption per capita for the studied complexes

Animal	The average of livestock water consumption per capita (Lcpd)
sheep	14.4
caw	29.4
camel	27.4

3. Results and Discussion

3.1 Determination of household water per capita components

The piped potable water consumption per capita in Iran cities is more than 142 cubic meters per day that is higher than consumption per capita of some water filled European countries like Belgium and Austria. The use of drinking water for washing dishes, clothes, cars as well as bathing and watering gardens are of important reasons for piped water high consumption in Iran. Therefore, to determine a consumption pattern is a useful approach for managing water demand, reducing and improving the use of efficiency and preventing water sources from being contaminated or destroyed. For this, the present study was conducted on water supply complexes of Ali Abad Looleh, khoor and Vahdat in South Khorasan Province in order to identify water consumption per capita in rural communities. In addition, home water consumption per capita components were identified for rural communities. The results are presented in Tables (6) to (9). According to the above tables, taking into account the items of drinking water, bathing, washing, and home green space, Per capita consumption of Ali Abad Looleh, Khoor, and Vahdat Water Supply Complexes and average per capita villages are 102.2, 97.5, 100.3 and 99.9 liters per day per person, respectively.

Table 6. Water consumption per capita in Ali Abad Looleh complex

Type of Demand	Consumption (Lcpd)
Potation per capita; potable and drinking water (e.g. tea)	3.2
Bathing per capita; the water consumed for bathing per person is 59.8 liters and each person goes to the bathroom every 4 days	15
Washing per capita including doing dishes, laundry, lavatory, toilet, cleaning the house	63.6
Home green space water per capita	20.4
Household water consumption per capita	102.2

Table 7. Water consumption per capita in khoor complex

Type of Demand	Consumption (Lcpd)
Potation per capita; potable and drinking water (e.g. tea)	3.9
Bathing per capita; the water consumed for bathing per person is 65.8 liters and each person goes to the bathroom every 4 days	16.4
Washing per capita including doing dishes, laundry, lavatory, toilet, cleaning the house	63.8
Home green space water per capita	13.4
Household water consumption per capita	97.5

Table 8. Water consumption per capita in Vahdat complex

Type of Demand	Consumption (Lcpd)
Potation per capita; potable and drinking water (e.g. tea)	3.7
Bathing per capita; the water consumed for bathing per person is 62.8 liters and each person goes to the bathroom every 4 days	15.7
Washing per capita including doing dishes, laundry, lavatory, toilet, cleaning the house	62
Home green space water per capita	18.9
Household water consumption per capita	100.3

Table 9. Water consumption per capita in rural communities

Type of Demand	Consumption (Lcpd)
Potation per capita; potable and drinking water (e.g. tea)	3.6
Bathing per capita; the water consumed for bathing per person is 62.8 liters and each person goes to the bathroom every 4 days	15.7
Washing per capita including doing dishes, laundry, lavatory, toilet, cleaning the house	63.1
Home green space water per capita	17.5
Household water consumption per capita	99.9

The analysis of data gathered from different components of water per capita in the studied water supply complexes indicated that 17 percent of the household water per capita in rural communities is used for irrigating home green spaces. Figure (2) shows that the share of each of the various components of rural water per capita, including drinking water, bathing, washing, and home green space, is 4, 16, 63 and 17 percent of the total per capita water consumption, respectively. Also, home green space water per capita is higher than bathing and drinking water which is one of the human vital needs.

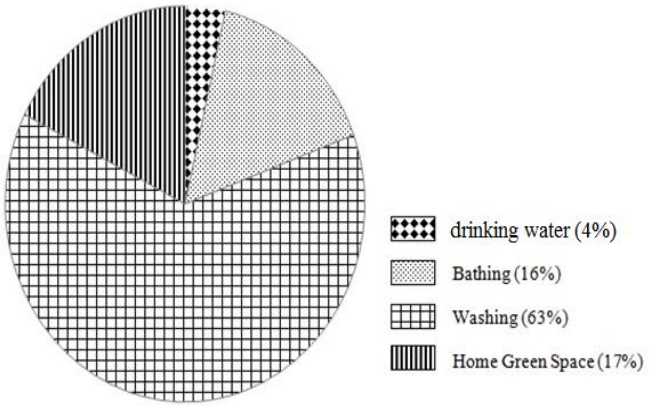

Fig. 2. Different components of household water per capita in rural communities

3.2 Factors impacting on household consumption per capita

3.2.1 Cultural and economic status

The consumption rate of any community depends on its people cultural and economic status. Low-income or unemployed communities consume less water. In many impoverished areas of cities, it has been observed that due to the harsh living conditions habitants avoid creating home green spaces. In the current research, families of Ali Abad Looleh water supply complex benefit a good cultural and economic status because of proximity to the city. Vahdat complex families have a moderate status because of a suitable geographical location for farming and Khoor complex households' status is poor because of the limited employment opportunities and recreational facilities, drought and located in a desert location. Figure (3) indicates changes in household water consumption per capita according to the cultural and economic status.

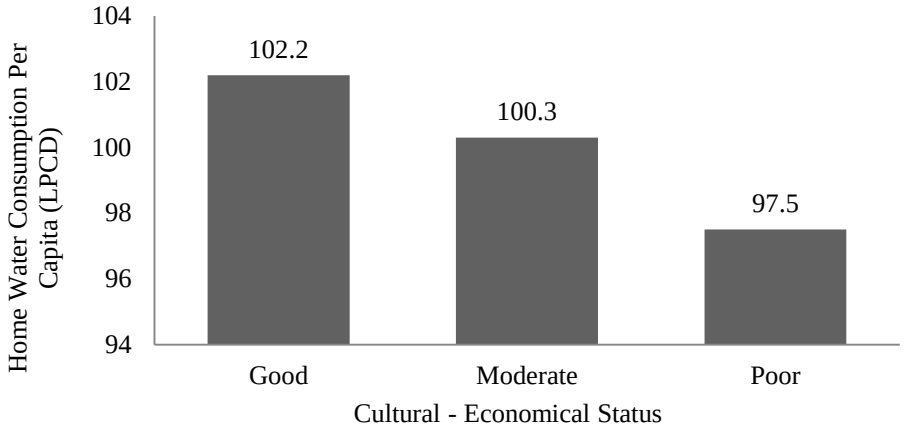

Fig. 3. The ratio of fluctuations of household water consumption per capita related to the cultural and economic status

3.2.2 Family size

Demographics such as family size and composition of age and gender impact on water consumption. Water consumption rate rises by increasing the number of households' per capita or the region population. As shown by the figure (4), the analysis of data collected from water consumption pattern in the studied water supply complexes revealed that water consumption pattern ascends through the increase of family size by 5 individuals and begins to descend due to the more increase of the family size.

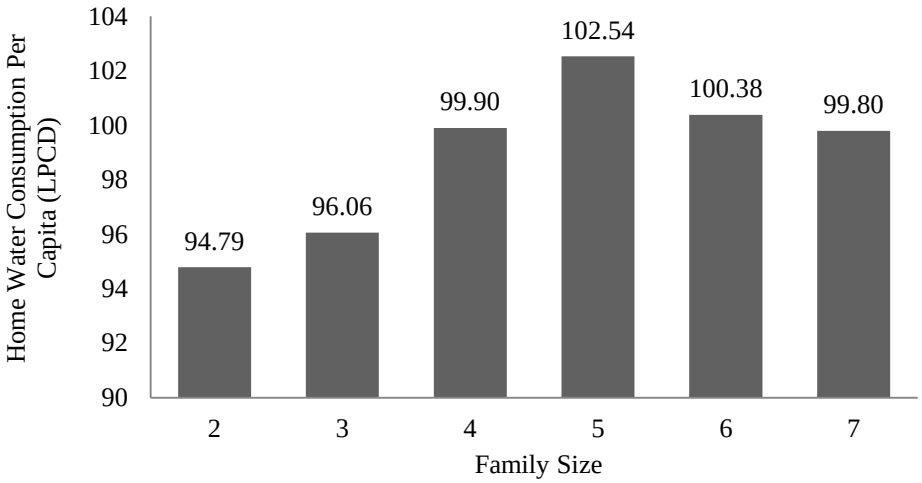

Fig. 4. The ratio of fluctuations of home water consumption per capita related to the family size

3.2.3 Holidays

Water consumption per capita fluctuates during a week. Totally, in holidays water consumption per capita is higher than other days since most of the family members are home and go to the bathroom or clean the house. Through the examination of household water per capita weekly fluctuations in the studied water supply complexes it was realized that Fridays with the used water per capita of 97.2 liters and Saturdays with the consumption per capita of 62.6 liters have Highest and lowest consumption per capita. Figure (5) shows household water per capita fluctuations in the studied water supply complexes.

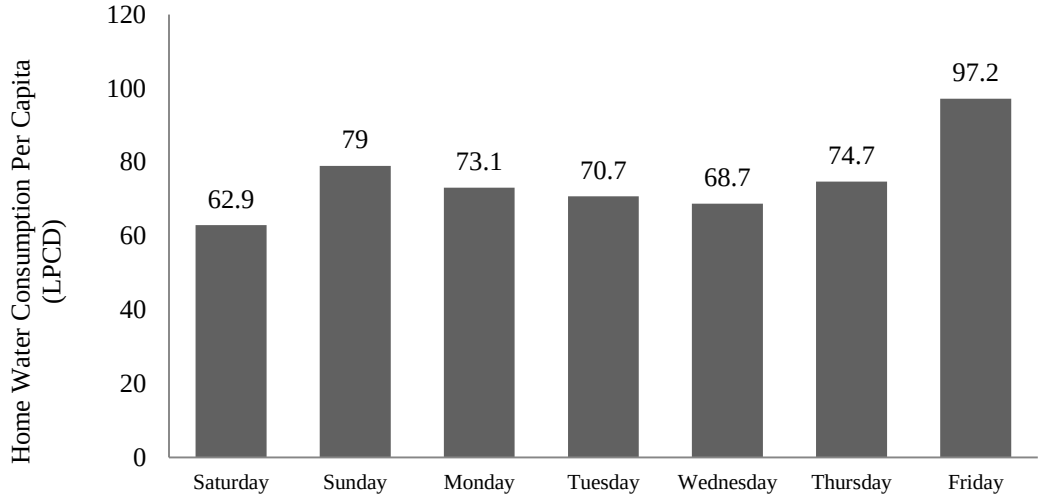

Fig. 5. The ratio of fluctuations of home water consumption per capita compared to the Days of Week

3.2.4 Climate conditions

Water consumption in various climate conditions is different due to the temperature difference, humidity, and rainfall rate. In general, water consumption in warm and dry desert areas is higher than temperate, humid and cold areas. As shown in Figure (6), Khoor complex is located in the vicinity of the Lut Desert. It is warm and dry in summer and cold and dry in winter and its water per capita is less than other complexes; hence, other conditions make more influence on household water per capita compared to climate conditions.

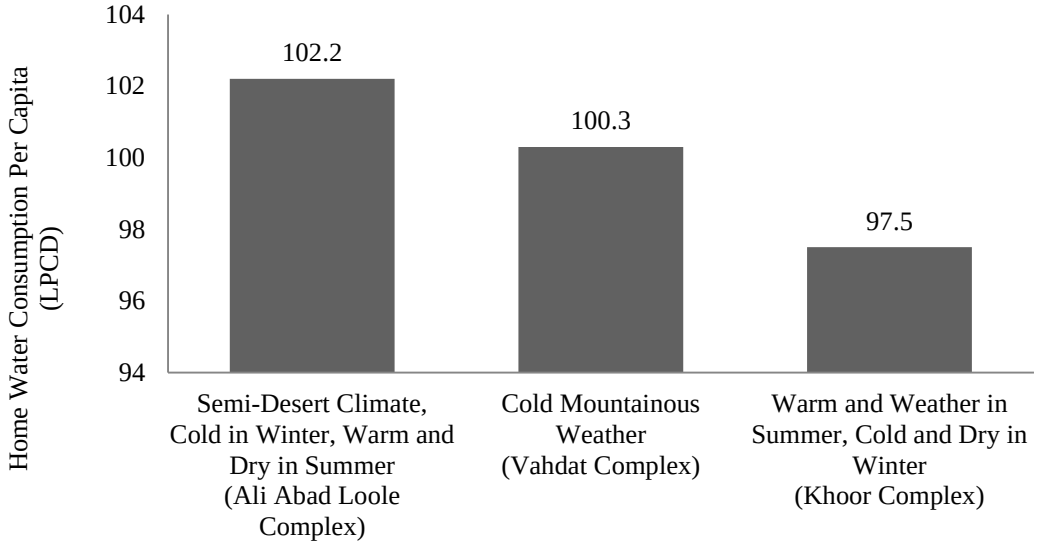

Fig. 6. The ratio of fluctuations of home water consumption per capita related to climate conditions

4. Discussion and conclusion

Water consumption per capita for rural communities of South Khorasan was investigated in this research. Results showed that consumption per capita for water supply complexes of Ali Abad Looleh, Khoor and Vahdat was 102.2, 97.5 and 100.3 liters per day, respectively. Moreover, the average of water per capita for rural communities of the province was 99.9 liters per day. The resulted Figures may play a specific role in designing water supply projects of the province villages and preserving water resources. In addition, the contribution of any water per capita components including potation, bathing, washing and watering home green space were 3.6, 15.7, 63.1 and 17.5 liters, respectively. Finally, weekly fluctuations indicated that Fridays with 97.2 liters a day per person had the most and Saturdays with 62.9 liters a day per person had the least consumption rate.

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