ANALYSIS OF PER CAPITA HOUSEHOLD WATER DEMAND FOR THE CITY OF RIYADH, SAUDI ARABIA

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الخلاصـــة :

لايوجد دراسة جادة وفعلية لتقدير معدل استهلاك الفرد من المياه لأيٍّ من مدن المملكة العربية السعودية . وتهدف هذه الدراسة الى حساب معدل استهلاك الفرد من المياه عن طريق المسح الميداني في مدينة الرياض وعلى مدى تأثير العوامل الاجتماعية والاقتصادية والمحلية على استهلاك المياه . لذا تَـمَّ اختيار (١٩٥) عينة عشوائيا وتم تقسيمها الى ثلاث مجموعات حسب نوعية المبنى ، والمستوى الاقتصادي للساكن ، والعوامل الاجتماعية والعادات . وقُـسِّم المسح الميداني الى جزئين : مسح استبياني ، ومسح لقراءة عدادات المياه وذلك في الفترة من مايو ١٩٨٣ م حتى نهاية يونيو ١٩٨٤ م ، وقد جمعت المعلومات اللازمة للتمكن من دراسة مدى تأثير العوامل التالية : الفصول الاربعة ، وأيام الاسبوع ، وعطلة نهاية الاسبوع ، وعدد القاطنين ، والجنسية ، ومستوى الدخل ، ونوعية ومساحة المنزل .

تـمَّ تحليل المعلومات ونتائج المعدلات الوسطى والقصوى والدنيا لاستهلاك الفرد من المياه وكذلك تفصيل لكل العوامل السابق ذكرها ومدى تأثيرها على معدل الاستهلاك . ولقد تبيَّن من هذه الدراسة أن المعدل الوسطي لاستهلاك الفرد من المياه يبلغ (٣١٠) لتراً في اليوم ؛ وهذا المقدار مطابق للاستهلاك المنزلي الحالي لمدينة الرياض . هذا وقد وجد بأن العوامل الأكثر تأثيرا على استهلاك المياه هي : عدد القاطنين في المسكن ، ونوعية ومساحة المسكن ، ومستوى الدخل . في النهاية تم اقتراح نموذج رياضي يمكن بواسطته تقدير معدل استهلاك الفرد للمياه .

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ABSTRACT

No comprehensive study of actual per capita water demand is available for any city of the Kingdom of Saudi Arabia. This study is focused on the survey and determination of actual per capita household water consumption for the city of Riyadh and its interdependence on some physical and socio-economic factors. 195 randomly selected households were classified among three groups according to household type, income level, and social and cultural factors. Field survey and water meter measurements for the households were conducted from May 1983 to June 1984. The factors that were considered in this study included: season, weekdays, week-end days, number of household residents, nationality, income level, type and area of household. The results of the average, maximum, and minimum per capita household water consumption as well as the effects of the above mentioned factors were evaluated. The daily average domestic water consumption of 310 lpcd found in this study compared favorably with the present consumption in 1988. The number of residents, type and area of households, and income level were found to be the most significant factors in determining the average consumption. Finally a forecasting model was also suggested.

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INTRODUCTION

The city of Riyadh, the capital of the Kingdom of Saudi Arabia has grown from an area of 1 km^2 before 1940 with a population of a few thousands up to an urbanized area of 750 km^2 in 1985 with a population of 1.3 millions [1]. Most of this growth took place only during the last 15 years. This vast growth required planning for water sources and distribution networks. Due to insufficient information on per capita water consumption rates in Saudi Arabia, each consultant tried to use his experience in his own country (*e.g.*, Europe or North America) in forecasting the water consumption for Riyadh. The estimates showed a variation of overall comsumption between 240–350 lpcd in 1985 and between 335–445 litres/capita/day (lpcd) in year 2000. The domestic consumption was estimated around 162 lpcd for the year 1985 and about 255 lpcd for the year 2000 [2, 3, 4, 5]. This study is focused on the determination of actual (by field survey) per capita household water consumption for Riyadh City and its interdependency on physical and socio-economic factors.

THE CITY OF RIYADH

Riyadh is located almost in the center of the Kingdom of Saudi Arabia on the Najd Plateau. It is about 600 meters above mean sea level. The climate is hot and dry with average temperature ranging from 6.6°C in winter to 42.9°C in summer. The relative humidity ranges from 19.5% in June to 52.5% in January with an annual average of about 34.4%. The average annual precipitation is about 81.2 mm [6]. The estimated population of Riyadh in 1980 according to various consultants varies between 900,000 to 942,000, and the projected population for the year 2000 is expected to be around 2.5 million [2, 3, 4, 5, 7]. Principally there are only two main sources from which Riyadh gets its present water supply: (*i*) The traditional underground water supply and (*ii*) The desalinated sea water supply from the Arabian Gulf. The traditional source consists of numerous wells dug to extract water from shallow and deep aquifers in the area. The underground water supply is estimated to be around 240,000 m^3/day from shallow wells of Wadi Hanifa and Wadi Nisah [8] and around 410,000 m^3/day from deep aquifers of Minjur and Wasia [8, 9]. The plan to supply desalinated water from the Arabian Gulf city of Jubail to Riyadh through 466 km length of twin pipeline was commissioned in 1983. The pipeline has a designed capacity of 830,000 m^3/day, but at commissioning, around 400–500 thousand m^3/day was being pumped [4]. The actual municipal water consumption of Riyadh increased from 76,730 m^3/day in 1973 to 460,230 m^3/day in 1984, an increase of about 600% in only 11 years [10]. In the absence of actual population figures and water supply figures from other sources, the actual per capita water consumption could not be precisely determined from the available data. Therefore various consultants' estimate of per capita water consumption for the year 1985 varied from 240 to 350 lpcd and for the year 2000 varied from 390 to 450 lpcd [2, 3, 4, 5]. This difference means between a 46% and 18% excess or deficit in water supply quantity and system elements (water treatment, distribution networks, wastewater collection and treatment facilities) for the year 1985 and 2000, respectively, depending on the estimate used.

METHODS AND PROCEDURES

The analysis was performed by carrying out a field survey of individual households covering about 0.5% of the population in three different locations of the City. Measurements at these locations were obtained for a 12-month period in the year 1983-84. The field work essentially consisted of two parts. The first part was a questionnaire survey and the second part was the measurement of the actual water consumption in each individual household.

Sampling Criteria

It is impractical to study the whole population of the city. Samples, of course, should represent the population from which it is drawn. In view of time, cost, and other practical considerations it was decided to limit the size of the samples to cover about 0.5% of the population in three homogeneous social groups. The groups were selected according to (*i*) general housing conditions and house locations, (*ii*) economic activities or income level and (*iii*) social and cultural factors. The samples for each group were chosen randomly.

The Study Area

The Riyadh municipal area, covering most of the Riyadh city, was the study area for this project. The

Group A areas were in Ulaya, Sulaimania, Old Airport, and Malaz Quarters. The samples were mostly of large (average plot area 855 m^2) new villas with ample green landscapes. The income level of 70 percent of the households was more than Saudi Riyal 10,000 per month (equivalent to 2667 US$). One to three children per household were present, and most of the households had domestic servants, car drivers, full time housemaids, and baby sitters. Many houses in this Group had their own swimming pools. The Group B areas were located in Badey'ah, Al-Sahfa, Al-Sewedi, and Al-Fakherryah Quarters. These houses were mostly of medium to small size (average plot area 647 m^2) two story villas and a few apartment buildings, with small gardens. Most of the villas of this group did not have swimming pools and very few households employed any domestic servants or car drivers. The income level of 64 percent of the samples in this group was in the medium range. Group C areas were located in down-town Manfouha, Bat'ha, Khazzan, Shumessy, Asir Street, Naseryah, and Muraba'a. The housing types were mostly multi-storied apartment buildings with neither gardens nor swimming pools. The income level of most of the samples in this group (89 percent) was in the medium range (between 5–10 thousand Saudi Riyals monthly per household). Most of the houses did not employ any domestic help. Plate No. 1 shows the location of each group in the city of Riyadh.

Surveys

After a preliminary survey, 88, 53, and 54 samples (households) were selected randomly for groups A, B, and C respectively. Table 1 shows the distribution of samples among the different groups and various categories.

All samples were surveyed twice by questionnaires: first, after choosing the samples, and second, when the last water meter reading was taken. The survey included information pertinent to the objectives of the project, such as number of residents (male, female, and children), monthly income, plot area, type of house, the existence of swimming pool, religion, nationality, and other pertinent information. An extensive amount of literature has been published concerning the methodology and the selection of variables that could affect per capita water consumption. Interested readers are referred to the cited references [11 to 17].

Water meter readings were taken for each household. Two readings were taken weekly for each household, one on Saturday and another on Wednesday, to differentiate between the week days and week-end days consumption throughout the period of survey from May 1983 to June 1984. Saudi Arabia follows a five-days working week starting from Saturday, with Thursday and Friday being the week-end. All data were transferred to a computer tape for storage and further analysis.

Table 1. Distribution of Samples Among Different Groups and Various Categories.

Description	Group			All Samples	
	A	B	C	No.	%
Number of samples					
Villas	84	45	13	142	72.8
Buildings	4	8	41	53	27.2
Total	88	53	54	195	100
Number of samples (households) having a monthly income level of:					
Less than SR[a] 5,000	3	7	3	13	6.7
SR 5,000 to 10,000	24	34	48	106	54.3
More than SR 10,000	61	12	3	76	39.0
Number of samples (household) occupied by:					
Saudis	77	50	16	143	73.3
Non-Saudis	11	3	38	52	26.7

[a] 1 US$ = 3.75 SR

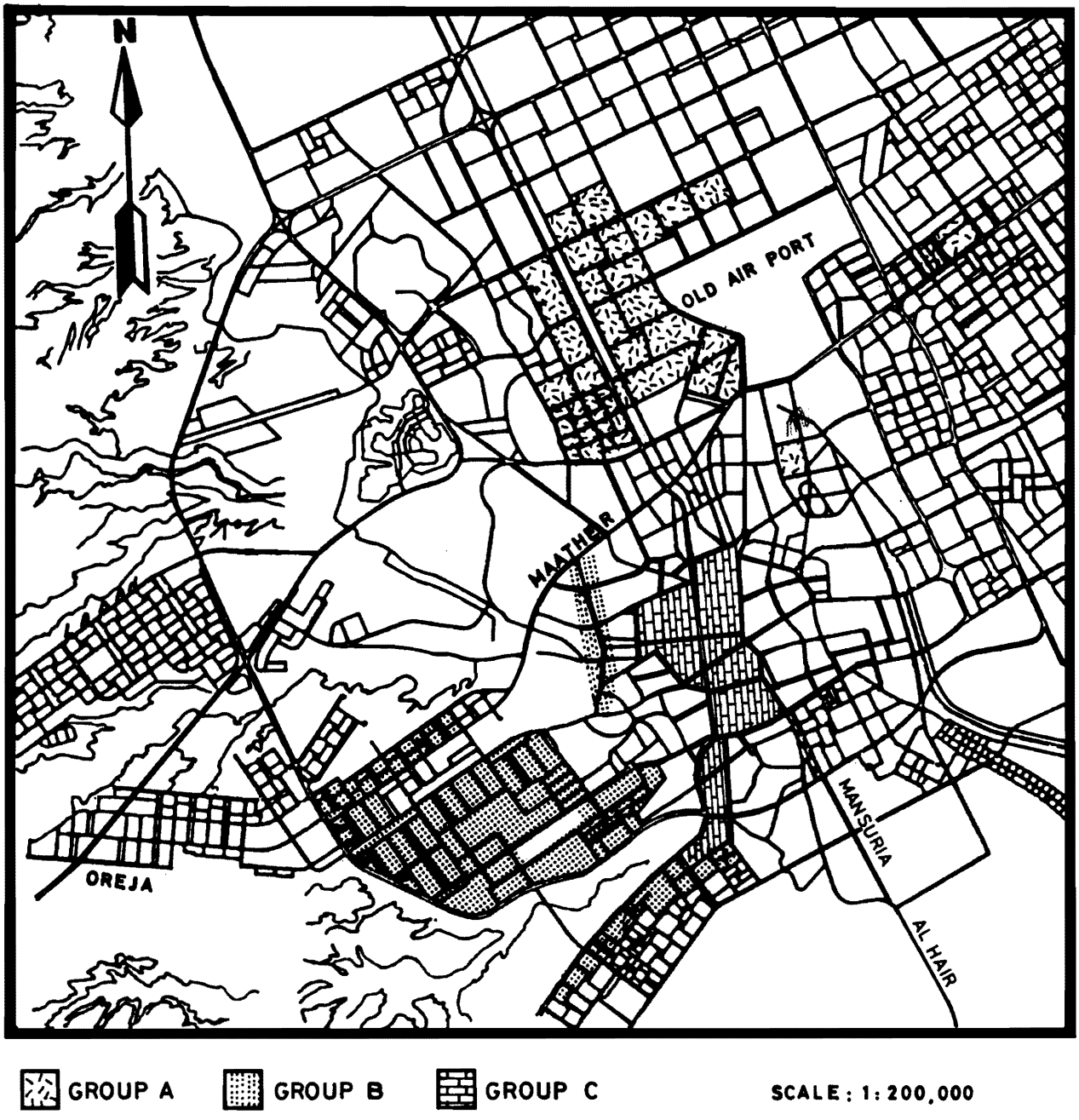

Plate 1. The Location of Samples in the City of Riyadh.

DATA ANALYSIS

Data from the various studied samples were recorded over a span of twelve months. These data were analyzed on a personal computer utilizing a program called "Data Analysis". The program took a series of records as input. Each record consisted of periodic water meter readings along with their respective dates and days. Each set of readings represented a particular type of accommodation (villa or building) known as a sample. Each set of readings was also preceded by a header that identified the characteristics of the sample (income level, number of residents, Saudi or Non-Saudi occupants, *etc.*). The output from the program consisted of tabulated results listing the averages for water consumption in liters per capita per day (lpcd) for the various conditions of flows and types of samples.

RESULTS AND DISCUSSIONS

A summary of the main results is shown in Table 2. The results indicate that the average daily water consumption for all samples during the twelve months of study was 310 lpcd. The maximum and minimum daily consumptions were also recorded for each group of samples. The averages for these were 1323 lpcd and 41 lpcd respectively. Discussion and comments on the obtained results are included in the following sub-sections.

Variation in Average Water Consumption Rates

The average daily water consumption showed considerable variation among the different areas. The averages were 415, 214, and 232 lpcd for groups A, B, and C respectively (see Table 2). The consumption rate was highest for group A at 34% more than the overall average, whereas the lowest consumption was found to be within group B at 31% less than the overall average and 51.6% less than group A.

The average consumption for group A was highest due to the high income level of the occupants (70% of the households were in the highest income bracket). Most of the houses in this group had large gardens and swimming pools requiring a large water demand. In contrast, the houses in group B had much smaller gardens, no swimming pools, and consisted of occupants with medium income level (64% of the households fell in the medium income bracket). Although most of group C was comprised of residents with lower income level than those of group B, yet its average water consumption was higher. This can be attributed to the fact that 89% of the residents in group B were owners of their villas, whereas most of the residents in group C rented apartments in multistoried buildings. Thus, group B households were liable for actual amount of water they used, while those in group C paid on a lump sum basis (a fixed amount set by the owner of the building) irrespective of consumption volume.

The overall average domestic water consumption determined in this study (310 lpcd), indicates that

Table 2. Summary and Comparison of Results.

Description	Average consumption, lpcd				Ratio of particular consumption to the average daily consumption of that group of all samples			
	Group A	Group B	Group C	All samples	Group A	Group B	Group C	All samples
Daily consumption for all samples:								
Average day	415	214	232	310	1.00	1.00	1.00	1.00
Maximum day	1437	1434	1025	1323	3.46	6.70	4.42	4.27
Minimum day	58	22	34	41	0.14	0.10	0.15	0.13
Week-end day	383	260	250	301	0.92	1.22	1.08	0.97
Average daily consumption for households having a monthly income level of:								
Less than SR 5,000	552	218	410	339	1.33	1.02	1.77	1.09
SR 5,000 to 10,000	264	179	224	219	0.64	0.84	0.97	0.71
More than SR 10,000	468	312	176	432	1.13	1.46	0.76	1.39
Average daily consumption:								
For villa occupants	415	351	343	343	1.00	1.64	1.48	1.11
For building occupants	412	213	221	221	0.99	0.99	0.95	0.71
Average daily consumption:								
For Saudis	333	208	237	279	0.80	0.97	1.02	0.90
For non-Saudis	986	319	229	395	2.38	1.49	0.99	1.27

the 1980 estimated values [3] of 162, 204, and 255 lpcd for the years 1985, 1990, and 2000 respectively, have been greatly underestimated. This can be attributed to the supply of adequate quantities of desalinated water to the city in 1983 upon the commissioning of the water transmission line from the Arabian Gulf. The continuity of water supply in adequate quantity and good quality, coupled with the abandoning of the previous practice of supplying water to various districts on alternate days, have eliminated the constraints which previously had a limiting effect on water consumption.

Water Comsumption During Week-end Days

There was no overall significant difference in water consumption between week-end days and working days. The ratio of water consumption during weekends to the yearly average was 0.97 (see Table 2). However, when each group is considered separately, group A shows the lowest consumption during weekends (0.92 of the average consumption). The corresponding ratios for groups B and C were 1.22 and 1.08 respectively. The lower consumption for group A may be due to the trends among people of higher income, such as dining out during week-ends or visiting friends residing out of town. On the other hand, residents of the other two groups, especially group B, tend to spend their week-end mostly at home attending to chores such as weekly cleaning and washing.

Seasonal Variations: Minimum and Maximum Consumptions

The average minimum household water consumption rates for the three groups A, B, and C were equal to 58, 22, and 34 lpcd respectively. The ratios of these minimum daily flows to the corresponding average consumption rates were equal to 0.14, 0.10, and 0.15 respectively (see Table 2). Comparison of these values with the average minimum consumption of all samples (41 lpcd), shows that there was 40% more consumption in group A while in the case of groups B and C, the consumption is 47% and 19% less than the overall minimum rates respectively. This is the same trend that was illustrated by the three groups for average water consumption rates, as has been explained previously.

The average maximum household water consumption rates were equal to 1437, 1434, and 1025 lpcd for groups A, B, and C respectively. The corresponding ratios of daily maximum to average consumption (*i.e.* daily peaking factors) were equal to 3.46, 6.70, and 4.42 respectively. The overall daily peaking factor for all samples was 4.27. The actual daily peaking factors for the whole city of Riyadh as reported in 1983 and 1984 were 1.16 and 1.20 respectively [10], while the design value for the distribution system is 1.3 [3]. The higher peaking values determined in this study are to be expected, considering that they are values for residential consumptions of individual households excluding commercial and public consumption as well as losses in the distribution system. It must be noted that peak daily flows rather than peak hourly flows were determined, since all households had storage tanks which tend to average out the hourly variations.

The monthly and seasonal variation in water consumption rates are shown in Figure 1. The monthly peaking factor (*i.e.* the ratio of the average of maximum daily consumption for each month and of the average daily consumption for the whole year) is maximum, 2.34, for the month of June and minimum, 1.48, for January. Overall, it is clear that the highest water consumption occurred in the summer season (May, June, and July), while the lowest consumption occurred in the winter season (November, December, and January). There is no restriction of use of water during the summer season.

Effect of Household Income Level on Water Consumption

The average water consumption rates for occupants of various income levels in groups A, B, and C as well as all samples are given in Table 2. A calculation of chi-square (χ^2) based on a 3×3 contingency table gave $\chi^2 = 105.28$ showing a significant dependence of water consumption on income level. However, since in group A, only 3 samples out of 88 (*i.e.* 3.4%) were within the lowest income level and in group C only 3 samples out of 54 (*i.e.* 5.5%) were within each of the highest and lowest income levels (see Table 1), it is concluded that these numbers of samples are too low to give significant and realistic figures of water consumption if the analysis is based on each individual group.

Figure 2 shows the variation of the average per capita water consumption with income level for all groups. As expected, the occupants of households in the high income bracket (greater than SR 10,000 per month) had the highest per capita water consumption (432 lpcd, *i.e.*, 39% higher than the overall average consumption). On the other hand, medium

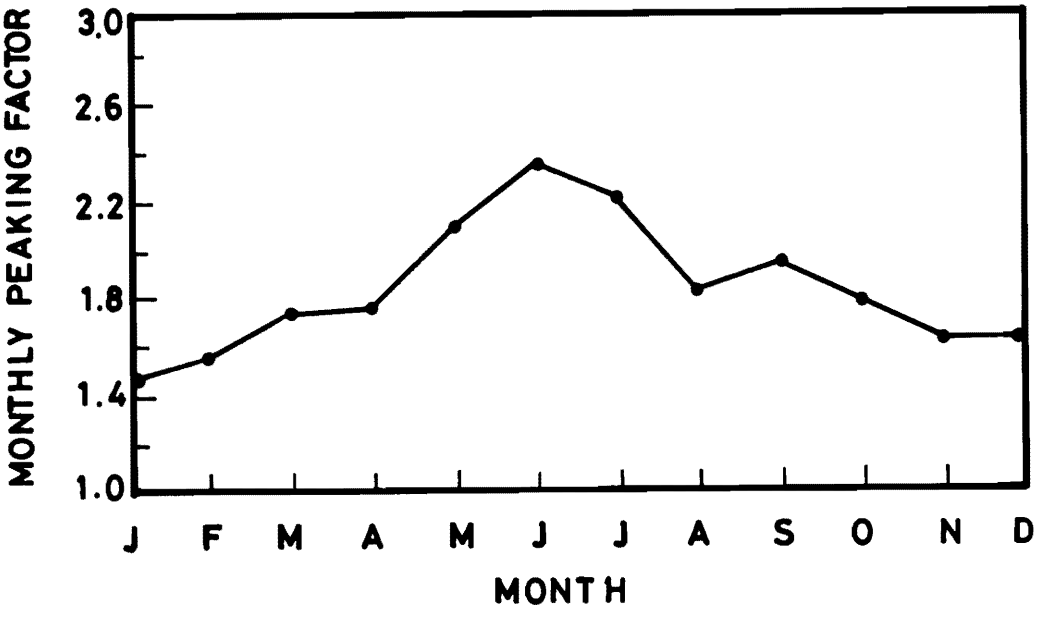

Figure 1. Variation of Monthly Water Consumption.

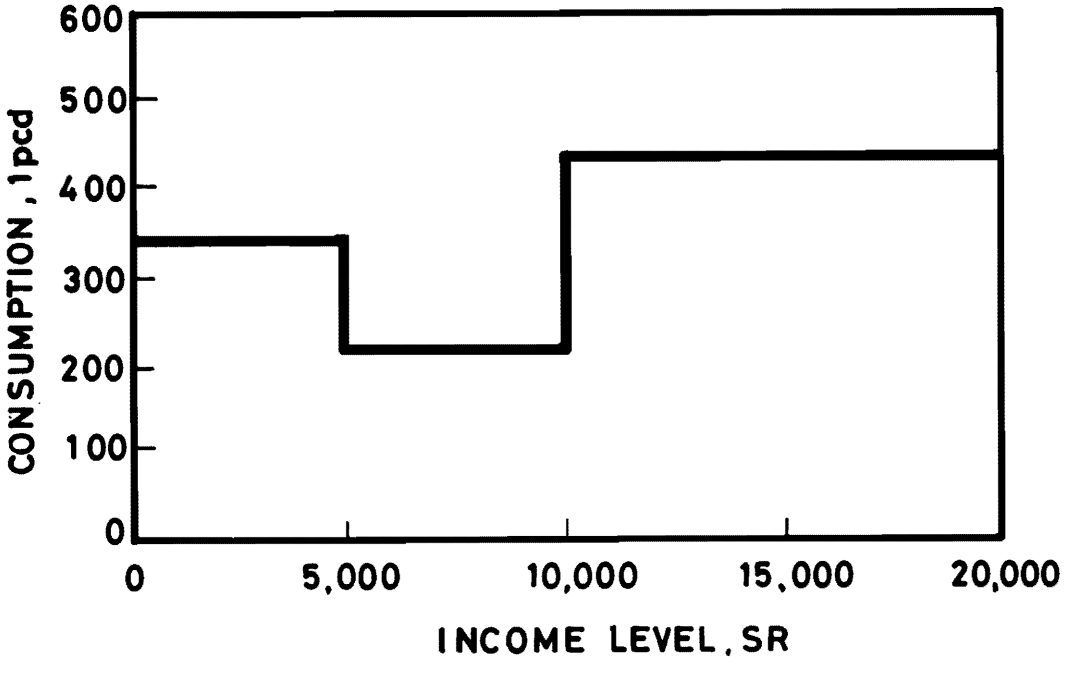

Figure 2. Relationship Between Average Consumption and Income Level for All Groups.

income households had the lowest per capita consumption (219 lpcd, *i.e.*, 29% less than the overall average consumption), while the low income households (less than SR 5,000 per month) consumed 339 lpcd which is the nearest to the overall average of 310 lpcd.

Most of the households in the high income level had large gardens and swimming pools which explain the high water consumption level for these occupants. However, although the consumption of low income households is 22% lower than for high income households, it is 55% higher than the consumption of medium income occupants (339 lpcd compared to 219 lpcd). This finding can most probably be attributed to the lower education and awareness of the low income population to water conservation measures and the proper use and maintenance of household water fixtures. This is, of course, in addition to the fact that in apartment buildings one water meter is used to service each group of flats.

Effect of Household Type on Water Consumption

The average water consumption rates for villa occupants were equal to 415, 351, and 343 lpcd for groups A, B, and C respectively (see Table 2). The ratios between the average water consumption for villas' occupants in each group and the average water consumption of the respective group were 1.00, 1.64, and 1.48 for groups A, B, and C respectively.

The average water consumption rates for building occupants were equal to 412, 213, and 221 lpcd in groups A, B, and C respectively. The ratios between the average water consumption for buildings occupants in each group and the average water consumption of the respective group were 0.99, 0.99, and 0.95 for Groups A, B, and C respectively (see Table 2).

The χ^2 value based on 2×3 contingency table was 25.12 which shows that water consumption was also dependent on type of accommodation (that is, villa or building).

As expected, the average water consumption for people who lived in a villa was higher than for people who lived in a building. The average water consumption for a villa occupant was 343 lpcd compared to 221 lpcd for a building resident *i.e.* an increase of 55%. Villa people needed more water for gardening, swimming pools, and car washing.

Effect of Plot Area on Water Consumption

Figures 3 and 4 show the relationships between average per capita water consumption and plot area

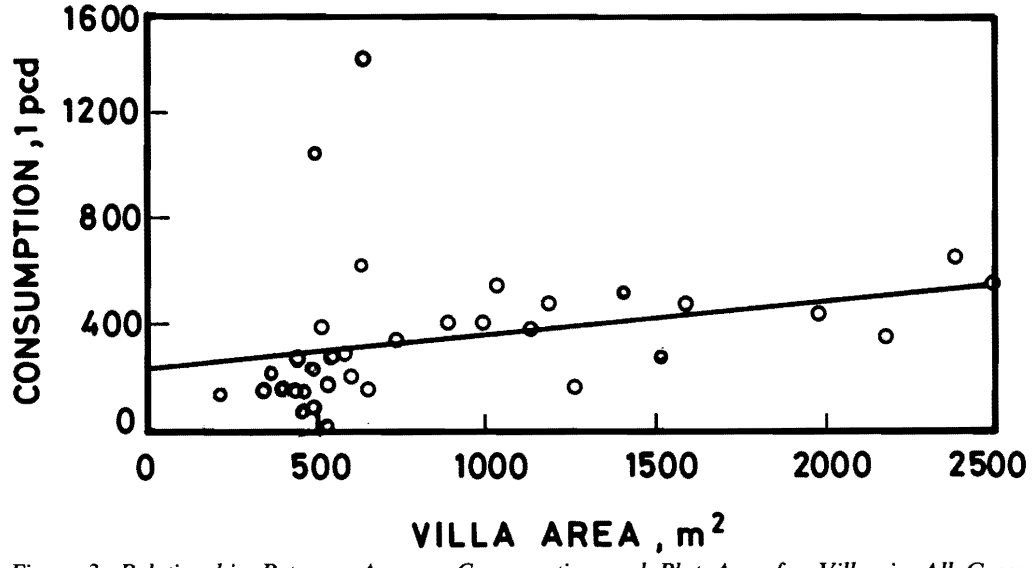

Figure 3. Relationship Between Average Consumption and Plot Area for Villas in All Groups.

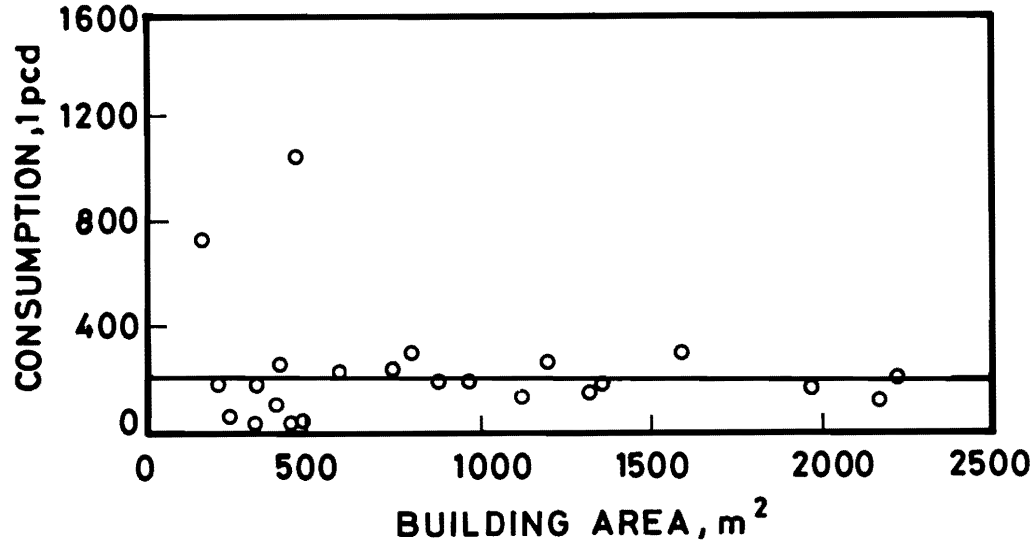

Figure 4. Relationship Between Average Consumption and Plot Area for Buildings in All Groups.

for the two types of accommodations studied. It can be seen that water consumption increased with increasing plot area for villas, but that it slightly decreased (remaining almost constant) with increasing plot areas for buildings. This is self-explanatory since villas with larger plot areas require more water for gardening, swimming pools, and general cleaning than villas with smaller plot areas. However, buildings with larger plot areas (thus with more number of stories and larger number of flats) result in slightly lower per capita consumption due to the shared use of water, when compared to buildings with smaller plot areas. Linear regression analysis of the data was carried out. Consumption was taken as the dependent variable and plot area as the independent variable. Correlation coefficients of 0.163 and 0.02 were obtained for villas and buildings respectively. The hypothesis that the results are linearly related was thus rejected in both cases.

Effect of Number of Residents on Water Consumption

Figures 5 to 8 show the relationships between per capita water consumption and number of males, females, children and total residents respectively. In all cases, as the number of occupants (whether males, females, children or total residents) increased in each household the water consumption per capita per day decreased. The only difference was in the rate of decrease which was higher for males than for females as depicted by the greater slope of the line in Figure 5 (for males) when compared with the line in Figure 6 (for females).

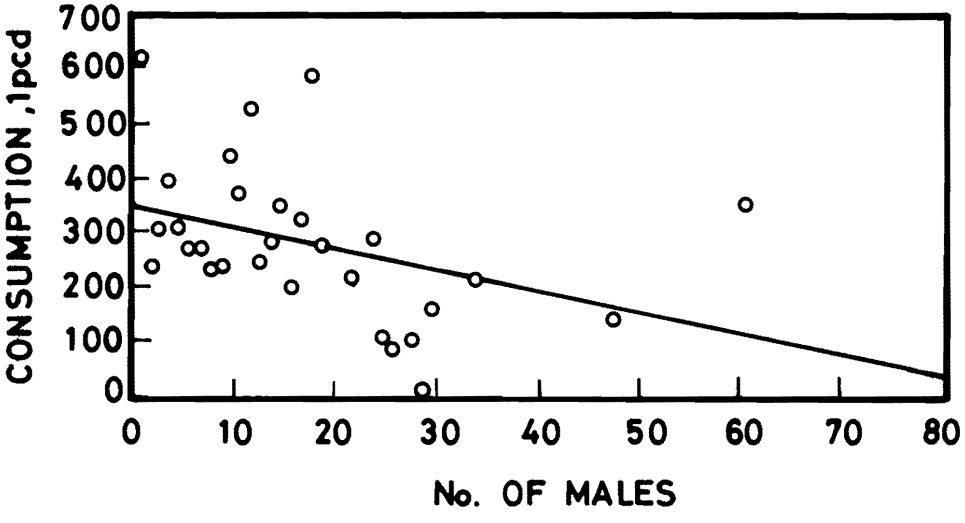

Figure 5. Relationship Between Average Consumption and Number of Males in All Groups.

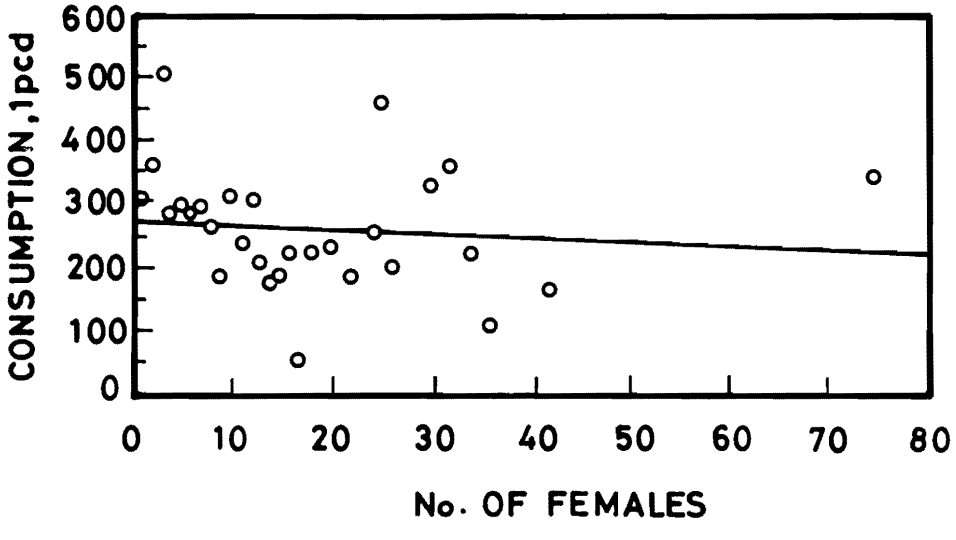

Figure 6. Relationship Between Average Consumption and Number of Females in All Groups.

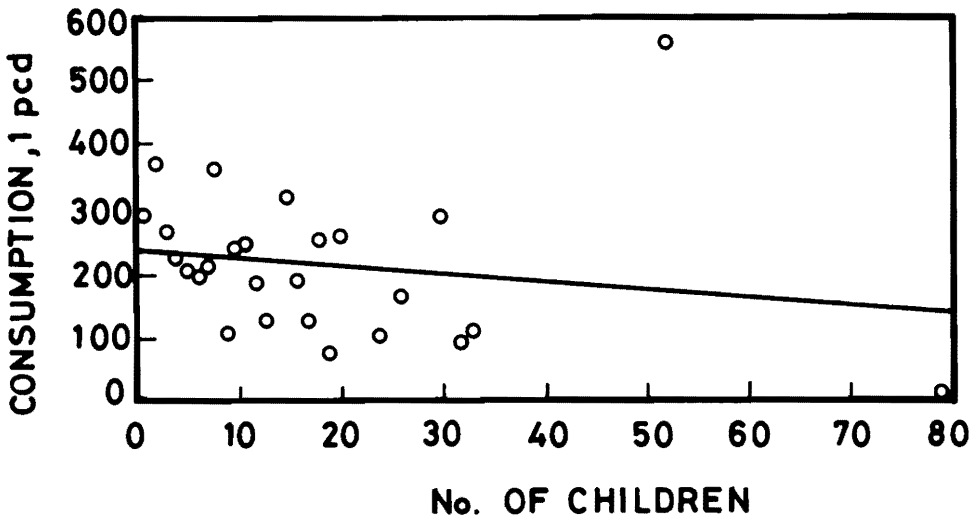

Figure 7. Relationship Between Average Consumption and Number of Children in All Groups.

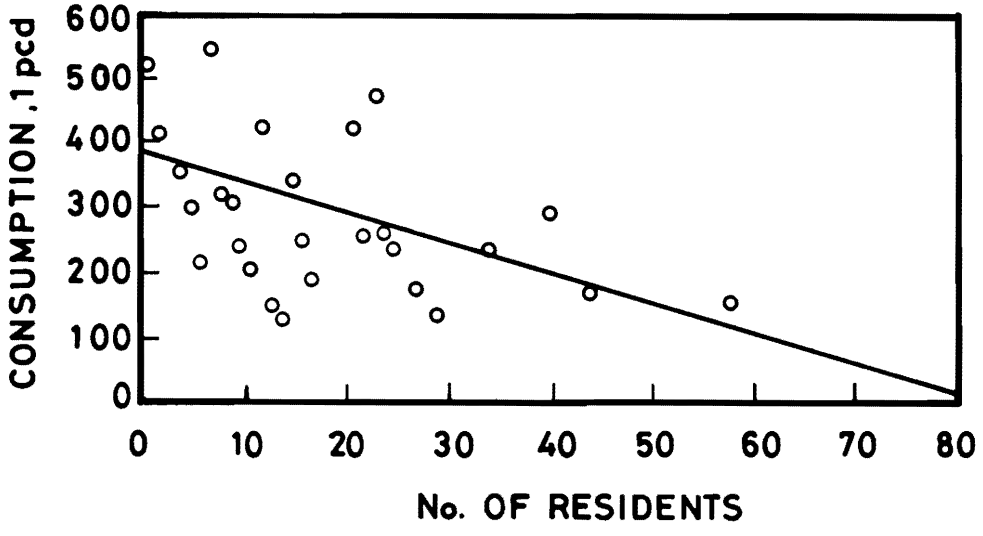

Figure 8. Relationship Between Average Consumption and Number of Residents in All Groups.

This trend of having lower per capita water consumption for larger number of household occupants is expected because of sharing in water consumption such as: water required for swimming pools, gardens, car wash, and clothes washing.

The results of the linear regression analysis of the data of Figures 5 to 8 gave correlation coefficients 0.460, 0.443, 0.311, and 0.364 respectively. A t-test of the hypothesis that the results are linearly related, shows that it can be accepted at the 5% significance level for male, female, and total residents, and rejected for children.

Effect of Expatriates on Water Consumption

The average water consumption rates for Saudis were equal to 333, 208, and 237 lpcd in groups A, B, and C respectively. The ratios between the average water consumption for Saudis in each group and the average water consumption of the group were equal to 0.80, 0.97, and 1.02 for groups A, B, and C respectively (see Table 2). Comparison of these figures with the overall average water consumption for Saudis (279 lpcd) showed 20% more consumption in group A, 25% less consumption in group B, and 15% less consumption in group C.

The average water consumption rates for non-Saudis were equal to 986, 319, and 229 lpcd in groups A, B, and C respectively. The ratios between the average water consumption for non-Saudis in each group and the average water consumption of the groups were equal to 2.38, 1.49, and 0.99 for groups A, B, and C respectively (see Table 2). Comparison of these figures with the overall average water consumption for non-Saudis (395 lpcd) showed 150% more consumption for non-Saudis in group A and 19% and 42% less consumption in groups B and C respectively. The χ^2 value based on 2×3 contingency table was 111.5 which shows that water consumption was highly dependent on nationality of the residents.

The overall comparison of water consumption by Saudis and non-Saudis showed an apparent trend of higher consumption by the latter. The non-Saudis consumed water at an average rate of 395 lpcd compared to 279 lpcd for Saudis, an increase of 42%. However, it must be noted that this trend was only apparent in groups A & B, while group C the average consumption of Saudis and non-Saudis was almost the same. Considering the fact that the samples sizes of non-Saudis in both groups A & B (11 out of 88 and 3 out of 53 respectively) are small, one should be careful not to make a definite conclusion concerning the difference between water consumption of Saudis and non-Saudis.

The Forecasting Model

Both linear and non-linear regression analyses were performed separately for villa occupants, building occupants, Saudis and non-Saudis. In each case, per capita water consumption was taken as the dependent variable, and number of residents, plot areas, and income level as the independent variables. Non-linear regression analysis gave better correlations than the linear regression analysis. Therefore the forecasting model was assumed to be of the form

$$C = a\,(R)^b\,(A)^c\,(I)^d$$

where

C = water consumption in lpcd
R = total number of residents
A = Area of plot in m^2
I = Income level (Average income was considered for each level, that is average monthly income for high, medium, and low income groups were taken as Saudi Riyals 15,000, 7,500, and 2,500 respectively (1 US$ = 3.75 SR)
a, b, c, d = regression coefficients.

The results of the regression analysis are shown in Table 3.

Applicability of Results to Present Water Consumption

Within the last five year period (1984–1989), the population of Riyadh has grown to 1.5 million inhabitants and the overall water consumption has gone up to an average of 850,000 m^3/day [18]. Thus the present overall per capita water consumption is 567 liters per day.

According to the Design Report by Sogreah–Seureca [3], the estimated various water demands for Riyadh up to the year 1990 are expected to be distributed as follows:

Domestic	53.7%
Commercial & Institutional	8.7%
Manufacturing	5.6%
Landscaping	14.5%
Losses in distribution	17.5%
Overall water consumption	100%

Consequently, the estimated present domestic consumption is 53.7% of 567 *i.e.* 305 lpcd, which compares very favorably with the findings in this study (1983-84) of 310 lpcd.

Table 3. Results of Non-linear Regression Analysis.

Residential Type	Nationality	a	b	c	d	Correlation coefficient
Villas	Non-Saudis	4.385×10^{-24}	−0.858	8.053	0.322	0.670
	Saudis	1.1776	−0.387	0.686	0.186	0.477
Buildings	Non-Saudis	9.77×10^{-3}	−1.298	1.157	0.761	0.557
	Saudis	2.23×10^{-2}	−1.051	1.749	0.066	0.693

CONCLUSIONS

1. The results of the study, it is hoped, will be helpful to consultants, planners, and designers of water and sewage works, particularly for the city of Riyadh and generally for the Kingdom of Saudi Arabia and the Gulf Region. An up-to-date evaluation of local, physical, and socio-economic conditions should be carefully considered when any extrapolation of results are done.
2. The daily average, maximum, and minimum water consumption rates were 310, 1323, and 41 liters per capita per day (lpcd) respectively. The maximum and minimum consumptions were 427% and 13% respectively in comparison to the average water consumption.
3. On the week-end days average consumption (301 lpcd) was not significantly different from the average daily. Percentage-wise it was only 3% less than the average daily consumption.
4. The average residential water consumption rates were 396 and 249 lpcd for the summer (May, June, and July) and winter (November, December, and January) seasons respectively. The highest consumption was during the summer season, being 59% higher than the winter consumption.
5. Out of the total 195 samples studied 7% were in the low income group (income less than SR 5,000 = US$ 1333 monthly per household), 54% were in the medium income group (income between SR 5,000 = US$ 1333 and 10,000 = US$ 2667 monthly per household) and 39% were of high income group (income more than SR 10,000 = US$ 2667 monthly per household). The average water consumption for these three groups were 339, 219, and 432 lpcd respectively. The medium income group was found to consume substantially less water than the other two groups.
6. The average consumption rate for a villa occupant was 343 lpcd as compared to 221 lpcd for a building resident. That is to say, a villa occupant used on the average 55% more water than a building resident.
7. The study showed an increase in the daily per capita rate of water consumption for the villa residents with an increase of plot area, whereas consumption remained almost constant for the building residents with an increase in building plot area.
8. In all cases, as the number of males, females, children or total residents increased in each household, the daily per capita water consumption decreased.
9. Non-linear regression analysis gave a better correlation than the linear regression analysis.
10. The average domestic water consumption in Riyadh for the last year of available records (1988) is 305 lpcd, which compares quite favorably with the findings of this study (1983-84) which indicates an average consumption of 310 lpcd.

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