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INFLUENCE OF PRICE AND NON-PRICE FACTORS ON THE RATIONALIZATION OF DOMESTIC WATER CONSUMPTION IN SAUDI ARABIA

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ABSTRACT

This study aimed to analyze the most important factors in rationalizing the consumption of domestic water, and then identify the most appropriate water policies to be applied to maintain supply and consumption of domestic water. The study was mainly relying on primary data in the form of a questionnaire designed to achieve the objectives of the study. Descriptive statistical measures have been applied to assess the impact of some factors on the rationalization of water consumption, as well as the use the multinomial logit model to estimate the proportion of households water consumption, which is located in the various segments of the block price, and finally multi-regression model has been applied to estimate the average household consumption in different segments. The results revealed that 11% of the water consumers are affected by water conservation campaigns organized by the Ministry of water and electricity, while 58% (a high percentage) are not affected by the rationalization campaigns, which indicates that the voluntary policy is not feasible in the short term and that the ministry should search for complementary policy of water demand management to be more influential on the rationalization of water consumption.

Key words: Water policies, Multinomial logit model, Complementary policy, Water demand management.

INTRODUCTION

The Saudi Arabia is one of the arid areas that lack water resources; in addition, it has a desert like dry climate featured by the shortage and irregularity of rainfall besides the rare tributaries or renewable water resources such as lakes and rivers. This makes water in the Saudi Arabia precious basic commodity with an extremely important economic and political position. The Saudi Arabia suffers from a sever lack of the available water amounts specially from non-renewable underground water resources due to the constructing, industry and agriculture uprising and the increase in the population growth rate- notably in Riyadh city, which is considered with one of the highest population growth rate in the world- and the increase in the individual consuming rate that exceeds the international rates, in addition to the non-rightly guided consuming. These factors together lead to a significant increase in demand of water, hence a great disturbance in the supply and demand balance of water. This made the decision makers seek to increase the water sources from untraditional ways such as desalination of seawater or treated water to achieve the balance between the available and demanded water supply and to satisfy the residents' requirements and the other economic activities by this commodity.

Keeping in view the economic importance of water, there is an urgent need to look for the best economic and social ways and means thought establishing policies and programs that achieve the rationalization of water consumption. It includes to manage the demand of the domestic, industrial and agricultural with the universal concept, i.e. the complementation of the pricing and non-pricing policies or what is sometimes being called the alternative policies that include the pricing, aesthetic and voluntary policies such as the awareness campaigns, general information and mandatory policies in reducing and rationalizing the domestic water consumption and others. The main objective of this study was to determine the appropriate water policies that should be applied to maintain the domestic water through analyzing the most important factors influencing the rationalization of domestic water consumption.

MATERIALS AND METHODS

Data Resources: The study rely mainly on the primary data gathered from the questionnaire designed to achieve the study objective. The data of Riyadh city have been analyzed only as a study case. The size of the sample was 700 consumer including the different category and units of water consumer in different places of the city (north, east, west, south).

Methodology: The economic theory of driving the traditional demand function of the commodities consumer assumes that it be linear and could be differentiated and contains a continuous distribution to explain and estimate the consumer behavior (Abu-Zeid, 2006 and Cassey, 2005). However, when the commodities prices that face the demand function include different price segments, the demand function of commodities is usually non-linear

and the function cannot be differentiated and often contains a separate distribution (Celine and Ricaed, 2000). Due to this, the usage of recognized demand curve cannot indicate and explain the consumer behavior when he faces non-linear input to the budget (the income). The prices of the domestic water within the kingdom of Saudi Arabia are prices of ascending segments; therefore driving the demand function of the domestic water of the individual assumes non-linearity of the demand curve. So the non- linear input of income (the budget), which assumes to take some of the fragmented linear demand curves (m) that were given as follows (Hanemann and Celine, 2005):

$$\begin{aligned} I + d_1 &= P_1 W + y \quad \text{if } W \le W_1 \\ I + d_2 &= P_2 W + y \quad \text{if } W_1 < X < W_2 \\ I + d_m &= P_m W + y \quad \text{if } W_{m-1} < W < W_m \end{aligned} \quad (1)$$

Where:

I = the income (Riyals) per month,

d_i = the difference for every variable i ,

W = the water consumption (cubic meters),

W_i = the level of the water consumption when the price changes,

y = the vector of commodities,

P_i = different price segments of the cubic meter.

When putting a fixed value it is within the difference variable, and then d_i represents the difference variable for every segment, which equals:

$$d_i = f_c - \sum_{j=1} (P_j - P_{j+1}) W_j \quad (2)$$

The consumer would like to maximize the semi concave benefit function with the power U(W,y) according to the budget input of the eq. (1). Since the budget input is not differentiated, then the optimism requires two stages, where the stages of optimism comply with choosing the continuous and separate distributions that face the consumer.

The first stage of maximization: The optimum level of every fragment of the non-straight budget input is chosen (each curve of the linear demand curves), this stage is a result of the conditioned demand function (Kolokytha et al., 2002).

The second stage of maximization: The choice of the consumer for the fragment of the conditioned demand that maximizes its total benefit (Inman, and Jeffrey, 2003).

In order to simplify, it is supposed that the conditioned demand curves are straight and by using this assumptions, the unconditioned demand function of water in the equation takes the simplified following form:

$$q_t = \beta_0 + \beta_1 \left\{ \sum_{i=1} s_{it} (I + d_{it}) \right\} + \delta Z_t + \varepsilon_t \quad (3)$$

Where:

q_t = the average of the water consumption (m^3) of every house within the time period (t)

s_{it} = the percent of the consumers that lie within the price segment i

Z_t = the matrix representing the non-pricing variables like climate, economic, social and rationalizing factors to maintain the water consumption within the time period (t)

β = the parameter of the unknown factors

δ = the parameter of the unknown factors that needed to be estimated

ε = random variable

It is not suitable to estimate the equation (3) using the observation possibilities that lie on a definite part of the price segment (s_i); this is because it forms the preference functions and is determined by the problem of the separate choice of the consumer. Therefore, it is related to the random error limit (ε). To be able to deal with this problem, equation (3) is estimated by stages, which are parallel to the separate and connected distribution stages of the problem of the consumer choice of optimum. By using the multinomial Logit model, the percent of the consuming houses of water that lie within the different estimated price segments (s_i) is estimated first, and the general formula of the multinomial Logit model is (Fezzi et al., 2008):

$$Prob(choice) = e^{\beta_i W_t} / \sum_i e^{\beta_i W_t} \qquad i = 0, 1, \ldots, M \quad (4)$$

In equation (4) the dependent variable is the consumers' percent in every price segment (s_i), while the independent variables are of the matrix W, which is featured by definite time such as temperature, rainfall, income and the size of the house. In the presence of these given features, the percent of the consuming houses of the water within every price segment in the time t and within a definite place is estimated. By using the expected percent of the water consumers, the unconditional demand function of water consumption can be estimated. In case of using the collective procedure, which assumes so many assumptions on the contrast matrix of the random error, it may suffer from a problem

of contradiction difference and self-connection. However, if the random error was large, then the average consumption of the houses of water will be large. It is supposed that a big percent of the consumers lie within the high price segment. Therefore, the observation possibilities (S_i) is of positive relation with the random error (Jasper et al., 2001).

RESULTS

Analyzing the influencing factors on the rationalizing the domestic consumption of water:

First: Analyzing the most important descriptive results shown in Tables (1-12):

It is shown from the results that 41% and 26% of the domestic water consumers of the study sample are within the second and third segment, respectively (1-50 cubic meter to the second segment and 51-100 cubic meter for the third segment). This is an important indicator indicating the increase in the domestic water consumption –Saudis and non-Saudis- according to its low price. Then this indicator should be taken into account when developing the water price and non-price policies.

When studying the relation between the educational level and its effect on water consumption, it was indicated that there are high levels in water consumption of the sample of university graduate members and that the least percent of water consumption was of the illiterate members. These percents agree with the economic theory that refers to a direct proportional between consumption and the educational level. Only 11% of water consumers are affected by the rationalization of water consumption campagins organized by the ministry of water and electricity, while 58% do not affect by the rationalization campagins, which is a high percent. It indicates that the optional policy is not feasible for the short term and that the ministry should search for a complementing policy to mamnge the water demand that is more influcning on the rationalization of water consumption. 57% of consumers use air conditioning devises –which are water consuming-that is an indicator for non- rationalization of water. 19% of consumers has no idea about the consumption segments, while 23% do not have the intereset in knowing the consumption segments, which means that the socity is unaware of the importance and rare of this commodotiy.

It was shown that most of the sample members have negative trends towards rationalization of water consumption, about 54% do not use the rationalization tools and do not care about the rationalization of water consumption.

Second: Analyzing the quantitative results as illustrated in Table No (13):

It was indicated from the results that the average of water consumption of the study sample amounted about 72 cubic meters every month. This amount is very high, which neccessitates reconsidering the optional and mandatory water policies. It was shown from the results the existence of statistical difference in water consumption of the Saudi and non-Saudi families. The results also indicated the high consumption of the citizens that lived in villas than the average by 52.2, a reverse relation between the price and water consumption, which shows the influence of the price on the rationalization of water consumption, hence the segments prices within the governerat should be reconsidered. There was also a direct relation between the income and number of the family members, which agrees with the logic, that is, the more increase in the income and the number of family members the more amount of water consumption.

Table 1: **The relation between nationality and the consumption segments**

nationality	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
Saudi	57	150	93	39	25	364
Percent	10.73	28.25	17.51	7.34	4.71	68.55
Non-Saudi	43	69	43	7	5	167
Percent	8.10	12.99	8.10	1.32	0.94	31.45
Non-Saudi	43	69	43	7	5	167

Source: calculated and gathered from the questionnaire.

Table 2: The relation between the educational level and water consumption

description	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
Illiterate	2	2	2	0	0	6
Percent	0.38	0.38	0.38	0	0	1.13
Read and write	4	6	4	1	2	17
Percent	0.75	1.13	0.75	0.19	0.38	3.20
Primary	5	12	4	2	1	24
Percent	0.94	2.26	0.75	0.38	0.19	4.52
Prep.	18	24	14	5	8	69
Percent	3.39	4.52	2.64	0.94	1.51	12.99
High school	39	74	44	14	5	176
Percent	7.34	13.94	8.29	2.64	0.94	33.15
University	26	85	55	20	14	200
Percent	4.90	16.10	1.36	3.77	2.64	37.66
Post university	6	16	13	4	0	39
Percent	1.13	3.01	2.45	0.75	0	7.34

Source: calculated and gathered from the questionnaire.

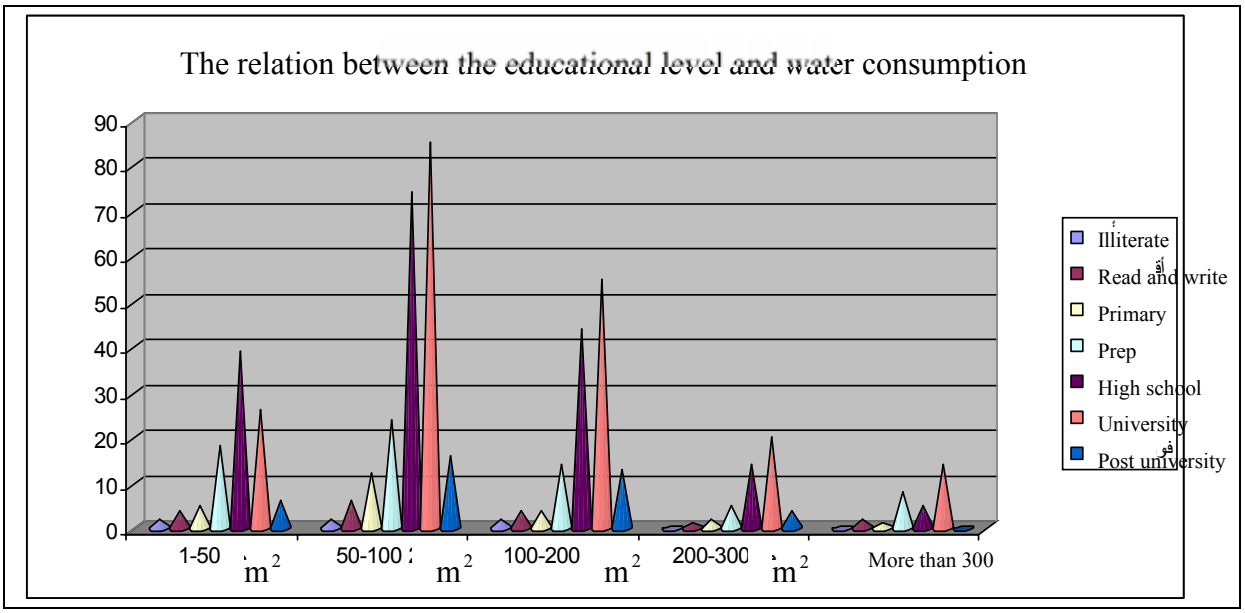

Table 3: The influence of income on the consumption segments

income	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
Less than 2000	18	34	13	1	1	67
2000 – 5000	45	63	45	7	7	167
5000 – 8000	20	50	26	13	6	115
8000 – 10000	9	25	16	12	6	68
10000 – 13000	5	24	12	5	2	48
13000 – 17000	3	12	14	4	0	33
17000 – 20000	0	7	1	0	1	9
More than 20000	0	4	9	4	7	24

Source: calculated and gathered from the questionnaire.

Table 4: the relation between the house kind and the consumption segment

The house kind	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
Flat	11.49	16.76	7.91	1.51	0.94	38.61
Story	1.69	7.72	4.71	1.13	0.38	15.63
Villa	2.26	9.98	9.60	4.90	3.20	29.94
Building	1.32	3.39	1.51	0.75	0.94	7.91
Traditional house	2.07	3.39	1.88	0.38	0.19	7.91

Source: calculated and gathered from the questionnaire.

Table 5: the segments according to the domestic water resource

Resource	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
Net	84	170	110	35	21	**420**
Bottled	9	25	10	6	8	**58**
White	7	23	16	5	1	**52**

Source: calculated and gathered from the questionnaire.

Table 6: the residents' knowledge of the consumption segments

Knowledge	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
I don't know	63	127	67	30	15	302
I don't care	11	35	37	5	6	94
I know	25	56	32	11	9	133

Source: calculated and gathered from the questionnaire.

Table 7: the distribution of hose gardens over the consumption segments

Status	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
No	77	175	84	23	12	371
Yes	23	44	52	23	18	160

Source: calculated and gathered from the questionnaire.

Table 8: the influence of air conditioning devices on the consumption segments

Status	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
No	57	132	72	31	13	305
Yes	42	86	62	15	17	222

Source: calculated and gathered from the questionnaire.

Table 9: the percent of influenced individuals by the rationalization campaigns distributed over the consumption segments

Influence	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
None	2.26	4.90	2.45	1.13	0.19	10.92
Little	4.90	14.12	6.97	1.88	1.13	29.00
Often	6.59	13.18	10.73	3.39	2.07	35.97
Very much	4.71	8.10	5.27	2.26	2.26	22.60

Source: calculated and gathered from the questionnaire.

Table 10: usage of rationalization devices distributed over the consumption segments

Usage	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
No	54	116	74	24	16	284
I don't know	8	23	12	5	3	51
Yes	37	76	50	17	11	191

Source: calculated and gathered from the questionnaire.

Table 11: the percent of influence of a servant on the consumption segments

Servant	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
None	14.50	26.37	13.75	3.20	1.69	59.51
One	3.01	9.04	7.72	3.58	1.88	25.24
Two	0.94	3.77	3.01	1.32	0.75	9.79
More than 2	0.38	1.32	1.32	0.56	1.32	4.71

Source: calculated and gathered from the questionnaire.

Table 12: the range of concern about the rationalization of water by the study sample distributed over the consumption segments

Concern	1-50 m^2	50-100 m^2	100-200 m^2	200-300 m^2	More than 300 m^2	Total
Never	6	27	10	4	1	48
Sort of	43	86	65	21	12	227
Much	10	42	31	13	9	105
Always	41	60	30	8	8	147

Source: calculated and gathered from the questionnaire.

Table 13: the results of multi-regression model of water consumption

Section	Variable	Statistical value of T
Inceptor	217	14
Nationality	2.3	0.3
Residence near to south Riyadh	3.5	0.4
Residence near to west Riyadh	-31.8	-2.3
Residence near to east Riyadh	-0.2	-0.3
Residence near to north Riyadh	21	1.2
Residence in an apartment	-27.9	-1.97
Residence in a story	-4.3	-0.4
Residence in a villa	52.5	2.3
The percent of consumer within the sample	-136	-3.3
Income	3.2	1.8
The number of the family members	16.5	2.6

Source: calculated and gathered from the questionnaire.

Recommendations: The policy of using a modern devices and tools will enable the rationalization of domestic water consumption. This policy can be applied through developing some description for the imported devices that achieve the the rationalization of water consumption. Taking care of continous and regular maintainance of water piped networks inside and outside the house. Developing restricive monitoring procedures to eliminate the misuse of water, in addition to reconsidreing the current water pricing policy that helps in maintaining the water consumption and in the same time concening the poor class of consumers. Making continous and regular awareness campagins, throughwhich basic information and facsts about the rare water resources in Saudi Arabia are being delivered.

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