The Contingent Valuation Method for the economic assessment of Groundwater: A Lebanese case study

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Abstract

Lebanon is directly concerned with the economic evaluation of water resources given their importance in a region where such resources are scarce. Moreover, on the Lebanese coast, this resource is strongly interested by seawater intrusion and quality deterioration. The study is carried out in Byblos district (Jbeil Caza), 35 km north of Beirut. In the absence of any modern irrigation systems for water distribution in the region, our objective is to estimate the economic value of that water for agricultural use. In the economic evaluation, we adopted the contingent valuation method to estimate the farmers' willingness to pay in order to contribute to the improvement of the groundwater quality. To know the WTP, two alternative scenarios were proposed and compared with the current situation. Farmers would pay 102 US\$ yr^{-1} for the first proposal and 166.67 US\$ yr^{-1} for the second.

Keywords: Lebanon, seawater intrusion, economic evaluation, contingent valuation method.

Résumé

Le Liban est directement intéressé à l'évaluation économique de ses ressources en eau vue leur importance dans une région où ces ressources sont rare. De plus, la côte libanaise est fortement exposée à l'intrusion d'eau de mer et à la détérioration de sa qualité. L'étude est menée au district de Byblos (Jbeil Caza), 35 km au nord de Beyrouth. En l'absence de systèmes modernisés pour la distribution de l'eau d'irrigation, notre objectif est d'estimer la valeur économique de l'eau pour son utilisation en agriculture. Dans l'évaluation économique nous avons adopté la méthode de l'estimation contingente pour estimer la propension à payer de la part des agriculteurs afin de contribuer à l'amélioration de la qualité de l'eau souterraine. Pour connaître la propension à payer, deux scénarios alternatifs ont été proposés et comparés avec la situation actuelle. Les agriculteurs devraient contribuer avec 102 US\$ an^{-1} dans le premier scénario et 166.67 US\$ an^{-1} dans le second.

Mots-clés: *Liban, intrusion de l'eau de mer, évaluation économique, méthode de l'estimation contingente.*

1. Introduction

In recent years, valuing non-market goods has become a major area of concern due to an increased recognition of the social importance of such goods and the losses associated with inadequately accounting for them. The absence of markets for such goods results in a need for public intervention that in turn requires that, in turn, requires accurate valuation in order to design socially optimal policies (FAO, 2000). The economic valuation is now an influential instrument in environmental decision making (Ampomah, 2004).

Lebanon is directly concerned with water valuation in domestic, agricultural, industrial and hydro-electric sectors as it is an increasingly important instrument and vehicle of integrated and concrete management of polyvalent water demand.

As already mentioned (Geadah, 2002), the present Lebanese institutional situation on the water sector has many shortcomings and deficiencies among which the outdated accounting systems and the inadequate valuation of water resources.

The phenomenon of seawater intrusion is particularly severe along the southern Lebanese coast (El Moujabber *et al.,* 2004; El Moujabber *et al.,* 2003; El Moujabber and Bou Samra, 2002) and - as previous studies demonstrated – it is caused by the over pumping of groundwater from the aquifer for agricultural purposes.

This will have a detrimental effect on water and soil quality, which will become inadequate for the cultivation of many crops, thus threatening their growth and production and reducing the agro-diversity in the region (El Moujabber *et al.*, 2006).

In this perspective, the present work aims to make an economic evaluation of the groundwater in order to provide policy makers with essential information to choose the most appropriate options to manage water resources.

Research carried out was specifically addressed to evaluate the willingness of local farmers to contribute to the preservation of their groundwater resource from deterioration.

2. Materials and methods

2.1. Description of the study area

The area of the economic study stretches from the sea level to 500 m above the sea level in the Byblos district for a total of about 101.74 km², of which nearly 22.05 km² are under cultivation. The district, known as «Caza Jbeil», is located in the northern part of the governorate of Mount Lebanon (Fig. 1), with a total surface of 423.3 km² (4.04% of the total Lebanese area), it is rectangular in shape and with a length between 30 and 35 km east-west and 12 to 16 km north-south (Antoun, 2004). It contains 93 cities and villages, located at different altitudes.

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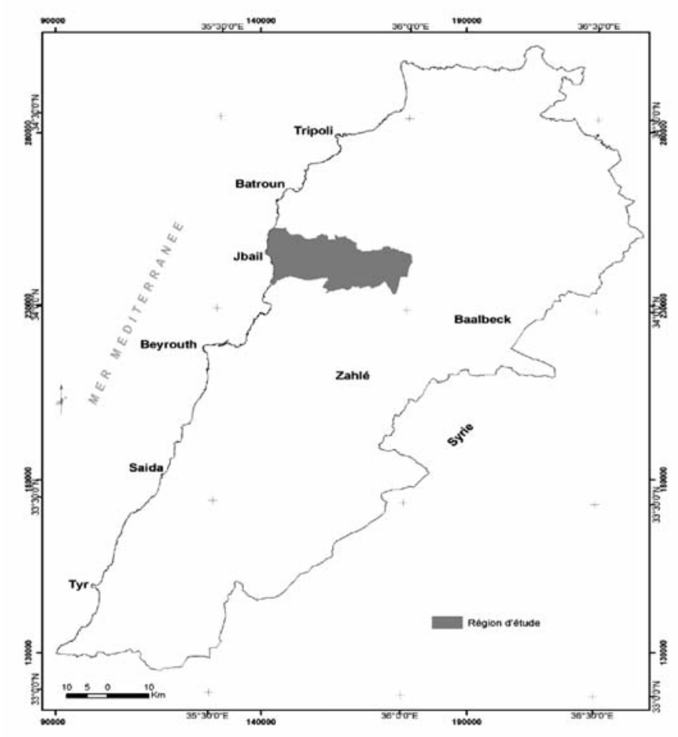
About 42% of the cultivated land is irrigated (9.26 km^2) and the total number of farms, distributed in the different cities and villages of the region, is about 3,099. The active labor force in the agricultural sector is about 7.5% of the population (about 30% of related activities generated from agriculture). The participation of paid labours on farm is of 2.1 labors per farm as average, and the participation of the family members is of 1.2 as average. About 13% of farmers are less than 35 years old and the level of education is as follows: illiterates 6.2%, those who know to write and read 18%, primary school 25.7%, complementary school 19.9%, secondary school 14,2%, and finally university 14.5%.

About 2 to 3 km^2 (at 150 m altitude) are irrigated with an open channel taking water from the Nahr Ibrahim river, but this project is facing different problems of quality and quantity that lead the farmer to buy extra water. The rest is mainly irrigated from the aquifer.

Figure 1 – *Location of the study area on the Lebanese map.*



(Source: CNRS, 2006).

2.2. Economic evaluation

When the outcome of a policy measure falls outside existing economic market systems, as it is often the case with environmental policy measures, it can be valued through the concept of individuals' willingness to pay (for an improvement) or their willingness to accept compensation (for a deterioration).

In order to value such a concept, different methods are available, categorized as revealed preference approaches or indirect methods (i.e. hedonic pricing, travel cost method), and stated preference approaches or direct methods (i.e. contingent valuation).

In order to estimate the value of the non-market good, revealed preference methods use the actual choices made by consumers in related or surrogate markets of the non-market good under evaluation. In the stated preference methods, which have been developed to solve the problem of valuing non-market goods that have no related or surrogate markets, consumer preferences are elicited directly on the bases of hypothetical, rather than actual, scenarios. The characteristics of each method are listed in the table below (Table 1).

Table 1 – *Difference between revealed and stated preference approaches.*

Revealed preference data	Stated preference data
Based on actual market behaviour	Based on hypothetical scenarios
Attribute measurement error	Attribute farming error
Limited attribute range	Extended attribute range
Attributes correlated	Attributes uncorrelated by design
Hard to measure intangibles	Intangibles can be incorporated
Cannot directly predict response to new alternative	Can elicit preferences for new alternative
Preference indicator is choice	Preference indicators can be rank, rating, or choice intention
Cognitively congruent with market demand behaviour	May be cognitively non-congruent

(Source: Birol et al., 2006).

Among the direct valuation techniques of elicitation of the economic values of water resources, we used the contingent valuation method (CVM), which is one of the most used and appreciated. Individuals' willingness to pay is elicited by asking them how much they would be prepared to pay if a specific policy measure was implemented. This is done through questionnaire survey.

By using hypothetical markets, the CVM unites two advantages and a disadvantage. On the one hand, it enables both the *ex ante* valuation of future changes of the environment and the measurement of non-use values, i.e. existence values, bequest values and option values. On the other hand, since respondents do not actually have to pay the amount of money they state in the survey, the hypothetical nature of the stated willingness to pay (WTP) is still at the centre of the debate on whether the CVM elicits reliable and valid estimates of the value that individuals attribute to environmental goods and services (Boyle and Bergstrom, 1999; Carson and Hanemann, 2005).

2.3. The survey

The survey used to estimate the WTP is composed of 6 major parts, each one including several questions. It begins with a general introduction describing the area and the actual situation of the groundwater. The second part includes some filter information, on the basis of which farmers to be questioned are selected. Questions about general information follow: they include issues about socio-demographic characteristics of farmers and some general questions about the farm. The forth section relates to the water status on farm: it emphasizes, together with the fifth part, the degree of «awareness of the problem» and the perception of the effects of the increasing deterioration of the main source of water in the area. The final part concerns the payment questions directly devoted to estimate the willingness to pay for the two proposed plans to contribute to the improvement of the groundwater quality. We adopted close-ended questions.

The proposed plan includes two different hypotheses that follow the strategy of the government to solve the problem of water deterioration trough a reduction of the withdrawals from groundwater:

Renewing the open channel project already installed in order to deliver enough good quality water to farmers;

Installing a new pressurized irrigation system.

Based on some previous estimations of water value for agriculture (Geadah, 2002), we decided to propose a WTP ranging between 20 and 200 US\$ yr^{-1} for both the above-mentioned hypotheses. Collected data were elaborated using excel and SPSS for statistical work.

3. Results and discussion

A preliminary comparison between the socio-economic characteristics of all farmers in the district and those of the interviewed farmers was made in order to check the representativeness of the sample (Table 2).

Table 2 – *Comparison between the socio-economic data of the district and of the sample.*

Factor	District*	Sample
	Farm size	
< 1ha	83.4%	65.0%
> 1ha	11.5%	22.0%
> 2ha	4.0%	5.0%
> 4ha	1.1%	8.0%
	Residence	
Farm	73.3%	65.0%
City	16.0%	12.0%
Other village	8.4%	23.0%
Abroad	1.7%	–
	Level of education	
Illiterate	6.2%	15.0%
Know to write and read	18.0%	–
Primary school education	25.7%	40.0%
Complementary school	19.9%	–
Secondary school	14.2%	20.0%
University	14.5%	25.0%

(*Source: Census, 1999).

3.1. Willingness to pay of farmers

The willingness to pay assigned by respondents for both anticipated hypotheses (WTP1 and WTP2) was distributed as absolute and relative frequencies in the following tables (Table 3 and 4).

It must be emphasized that in our study the group of zero values or «protest response» given by individuals who, although able to pay, refuse to declare their own WTP, is not excluded from the samples.

Table 3 – *Distribution of absolute and relative frequencies of WTP1.*

WTP1 (US\$ yr^{-1})	Absolute frequency (n)	Relative frequency (%)
0	10	16.67
20	0	0.00
40	0	0.00
60	11	18.33
80	20	3.33
100	9	15.00
120	5	8.33
140	6	10.00
160	11	18.33
180	0	0.00
200	6	10.00

Table 4 – *Distribution of absolute and relative frequencies of WTP2.*

WTP2 (US\$ yr^{-1})	Absolute frequency (n)	Relative frequency (%)
0	1	1.67
20	0	0.00
40	0	0.00
60	0	0.00
80	2	3.33
100	9	15.00
120	0	0.00
140	4	6.67
160	9	15.00
180	3	5.00
200	32	53.33

The statistical parameters calculated for each single hypothesis (WTP1 and WTP2) are shown in a descriptive table (Table 5).

The WTP2 mean is higher than the WTP1 mean with a lower standard deviation and a lower confidence level (95%), which means that the range of variability in WTP2 is narrower than in WTP1.

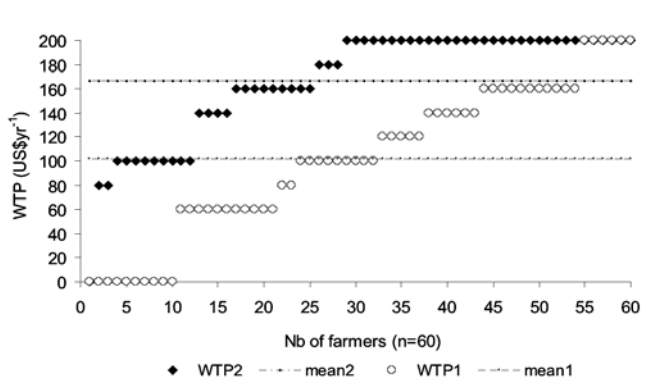
Table 5 – *Statistical parameters of WTP1 and WTP2.*

Parameter	WTP1	WTP2
Mean	102.00	166.67
Standard error	8.05	5.87
Median	100.00	200.00
Mode	60.00	200.00
Standard deviation	62.35	45.50
Variance	3887.46	2070.06
Kurtosis	– 0.91	1.67
Skewness	– 0.24	– 1.39
Interval	200.00	200.00
Minimum	0.00	0.00
Maximum	200.00	200.00
Sum	6120	10000
Number of respondents	60.00	60.00
Confidence level (95%)	16.11	11.75

The answers for the second hypothesis and the mean of each WTP were drawn (Fig. 2): 102 for WTP1 and 166.67 for WTP2 with a difference of 63%.

The WTP2 is higher than the WTP1 and this result can be explained by the fact that the users of the existing channel (about 44% as shown above), especially those who are using it on demand without any control, will not have any intention to pay for renewing the channel but, on the other side, they will pay for a modernized pressurized system.

Figure 2 – *The willingness to pay of farmers.*



4. Statistical study

By analyzing the results, we tried to find out which factor or factors are mostly affecting the WTP of interviewed farmers.

We assumed that the most prominent factors that could influence the willingness to pay of farmers are:

- The ownership of the land (the farmer is owner or tenant). It is a very natural human reaction to have tendency to preserve and protect the own properties.
- The level of education of farmers could be important because it helps the person having wider views on any situation, better understanding the problem and, finally, reacting differently.
- The observed variations in quantity as well as in quality of the production attributed to the deterioration of the groundwater they currently use. The observed or perceived variations can influence the willingness to pay both in a direct and indirect way. The WTP can increase (decrease) when farmers remarked higher (lower) negative variations in the quantity and quality of their production. On the other side, the WTP can also be affected by the variation in the revenue of farmers caused by modification in the quality and quantity of the agricultural production.
- The source of the irrigation water can influence the WTP because it is related to the risk of pollution. While the water from open channels has no salinity pollution, the water drawn from wells could be contaminated by seawater intrusion.

Correlations between each single factor and the WTP were individually studied, and then the statistical relation between all the characteristics together and the willingness to pay of farmers was estimated.

A GLM (General Linear Model) was used to estimate the relationship between all factors and the WTP. The GLM provides linear regression analysis and analysis of variance for multiple independent variables when the dependent variable is quantitative.

Through the regression analysis, it is possible to identify the relationship between two or more quantitative variables: a dependent variable, whose value is to be predicted, and an independent or explanatory variable. The regression analysis allows specifying hypotheses concerning the nature of effects, the explanatory factors and, when successfully executed, it can produce a quantitative estimate of net effects. On the other side, it requires a huge number of quantitative data that can be time-consuming and expensive and it is likely to reach the conclusion that there is a strong link between two variables whereas the influence of other, more important, variables may not have been estimated (the so called «data snooping» error).

When, as in our study, factors are categorical or string values, they have to be preliminarily converted into dichotomy or dummy variables in order to be introduced into the model.

If the variable assumes modalities, dummy variables will be introduced.

In the case of our survey, the 5 studied factors are: the ownership, the quality of production, the quantity of production, the source of water and the level of education. The appropriate dummy variables are the following:

$$Ownership = \left| Z_1 \begin{cases} Z_1 = 0 \rightarrow Tenant \\ Z_1 = 1 \rightarrow Owner \end{cases} \right.$$

$$Quality\ difference = \left| Z_2 \begin{cases} Z_2 = 0 \rightarrow No\ Difference \\ Z_2 = 1 \rightarrow Diffrence\ in\ quality \end{cases} \right.$$

$$Quantity\ difference = \left| Z_3 \begin{cases} Z_3 = 0 \rightarrow No\ Difference \\ Z_3 = 1 \rightarrow Diffrence\ in\ quantity \end{cases} \right.$$

$$Source\ of\ Water = \left| \begin{array}{l} Z_4 \begin{cases} Z_4 = 0 \rightarrow Other \\ Z_4 = 1 \rightarrow Channel \end{cases} \\ Z_5 \begin{cases} Z_5 = 0 \rightarrow Other \\ Z_5 = 1 \rightarrow Collective \end{cases} \end{array} \right.$$

$$Level\ of\ Education = \left| \begin{array}{l} Z_6 \begin{cases} Z_6 = 0 \rightarrow Other \\ Z_6 = 1 \rightarrow Illiterate \end{cases} \\ Z_7 \begin{cases} Z_7 = 0 \rightarrow Other \\ Z_7 = 1 \rightarrow \mathrm{Pr}imary \end{cases} \\ Z_8 \begin{cases} Z_8 = 0 \rightarrow Other \\ Z_8 = 1 \rightarrow Secondary \end{cases} \end{array} \right.$$

The willingness to pay of farmers can be now expressed by the model in terms of a linear equation:

$$WTP = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \beta_8 Z_8 + \varepsilon \quad \textbf{(1)}$$

Where:

β_0 = Intercept when $Z = 0$ for any i.
$\beta_1 \rightarrow \beta_8$ = *Coefficient of regression*, indicates the impact of each independent variable.
ε= *Total error*.

The WTPs calculated through the Square Means method are given in the following equations:

WTP_1=123.318+42.341Z_1–15.907Z_2+5.670Z_4+18.941Z_5–45.228Z_6–54.462Z_7–36.318Z_8 **(2)**

WTP_2=172.096+13.756Z_1–5.119Z_2+2.818Z_4–43.327Z_5–50.786Z_6+20.607Z_7–2.558Z_8 **(3)**

More details are given in Tables 6 and 7**,** where the coefficient of the regression, β, the standard error and the Student's t are specified.

Given that the number of samples studied is not so high, we consider that the tolerable error probability can reach about 20%.

Table 6 – *Regression analysis of WTP1.*

Parameter	β	Std. Error	t	Sig.
Intercept	123.318	25.728	4.793	0.000
[owner=no]	42.341	16.057	2.637	0.011
[owner=yes]	0.000	.	.	.
[education=illiterate]	-45.228	26.334	-1.717	0.092
[education=other]	-54.462	22.960	-2.372	0.021
[education=primary]	-36.318	20.950	-1.734	0.089
[education=secondary]	0.000	.	.	.
[source=channel]	5.670	22.142	0.256	0.799
[source=collective]	-18.941	26.333	-0.719	0.475
[source=private]	0.000	.	.	.
[quality=no]	-15.907	22.031	-0.722	0.473
[quality=yes]	0.000	.	.	.
[quantity=no]	0.000	.	.	.
[quantity=yes]	0.000	.	.	.

For WTP1, the ownership of the land is significant with an error probability of about 1%, but in an opposite direction with respect to what we were assuming. This means that the tenants have a positive coefficient of about 42.

Concerning the education level for WTP1, the «illiterate» has a negative coefficient of about 45 with a probability of error of about 9%, the coefficient of the «other» level is positive and about 54 with 2% probability error. For «primary» the negative coefficient is about 36 with about 8% probability of error.

The coefficient of the source of water is positive for the channel but negative for the collective, but it has no statistical significance. The same can be said for the coefficient of the quality that is negative but has not statistical significance.

Table 7 – *Regression analysis of WTP2.*

Parameter	β	Std. Error	t	Sig.
Intercept	172.096	17.515	9.826	0.000
[owner=no]	13.756	10.931	1.258	0.214
[owner=yes]	0.000	.	.	.
[education=illiterate]	-50.786	17.927	-2.833	0.007
[education=other]	20.607	15.630	1.318	0.193
[education=primary]	-2.558	14.262	-0.179	0.858
[education=secondary]	0.000	.	.	.
[source=channel]	2.818	15.073	0.187	0.852
[source=collective]	-43.327	17.927	-2.417	0.019
[source=private]	0.000	.	.	.
[quality=no]	-5.116	14.998	-0.341	0.734
[quality=yes]	0.000	.	.	.
[quantity=no]	0.000	.	.	.
[quantity=yes]	0.000	.	.	.

For the WTP2, the relevant factors are mainly the level of education and the source of irrigation water. Regarding the level of education, the most significant is «illiterate»; it has a probability of error of about 0.7% and a negative coefficient of about 50. It is followed by «other» that has a positive coefficient of nearly 20 and about 19% of probability of error. For the source of irrigation, the only significant value is the «collective» level with 1.9% of probability of error and about 43 of negative coefficient.

5. Conclusions

Notwithstanding seawater contamination is still at the emerging phase and its effects may not be noticed by farmers, either in terms of quantity or in terms of quality of production, the economic evaluation of the groundwater in the study region confirmed the existence of a positive farmers' willingness to pay in order to take improvement measures to save their local groundwater resources from deterioration and to ameliorate their quality.

The WTP for installing a new pressurized irrigation system is higher than the WTP to renew the existing open channel: the dissatisfaction of farmers for the management of the actual channel and their good aptitude towards innovation and more environmentally-friendly agricultural practices could explain this result.

This predisposition of farmers can be an incentive for the public administration to take actions in the field of environmental education through extension campaigns aiming at highlighting the environmental aspect of the problem since it seems to be completely ignored by farmers.

Furthermore, the development of this study has also revealed some limits that should be taken into account in future research lines: it would be better to reduce the area of the economic study to the to two zones of the region where intensive agriculture is concentrated and deterioration of water quality is more severe; «protest response» should be taken into consideration, and the number of interviewed farmers should increase.

Despite these limitations, the results of the present work could represent a starting point for the future assessment of development priorities in the field of water resources policies.

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