An evaluation of farmers’ willingness to pay for efficient irrigation for sustainable usage of resources: the GAP-Harran Plain case, Turkey

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ABSTRACT
We evaluated farmers’ willingness to pay (WTP) for efficient irrigation and improved water productivity with the economic benefits of sustainable use of resources in the long-run, while reducing irrigation-related problems in the GAP-Harran Plain, Turkey. The data come from a sample of 21,094 farmers; 461 of them were chosen via simple random sampling method and interviewed face to face. The Tobit regression model was used for analysis. The results indicate that the average WTP value is $133.7 per hectares comprising 8.87% of net income of farmers, whilst the total amount derived from the WTP was around 20.05 million for Harran Plain. Explanatory factors such as primary school graduates, users of modern irrigation technologies, a crop pattern involving large areas of cotton and wheat increase the WTP by 4.4, 4.3 and 3.8%, respectively. On the other hand, married farmers, property owners, gravity irrigation users and one of the index variables (indexb, measuring farmers’ perceptions about natural resources) lower the WTP by 9.3, 3.3, 13.7 and 0.9%, respectively. These results have valuable and important implications for decision makers to draw better sustainable natural resources policies in future for the good in question.

1. Introduction
The natural resources are limited and under pressure due to rapidly increasing demands by human beings. The policies are needed for optimum use, preservation and protection of natural resources for today and the future. Sustainability of natural resources for which continuity of systems and processes remain diverse and fertile indefinitely has a great impact on production economics. Water resources are under more pressure now than before in terms of quantity and quality due to increasing demands and mismanagement among the other natural resources. These exposures mainly result from population growth and increased irrigation areas along with improper irrigation networks and practices. Mismanagement is mainly related to education and training, that is, inexperienced staff, insufficient laws, poor planning, lack of or improper allocation and usage of funds for water resources and networks, and insufficient attention given to operation, maintenance and repair. Agricultural
production, along with ecosystem services, is necessary to human existence and quality of life. The global population is expected to grow rapidly to more than 9 billion by 2050, resulting in increased demand for agricultural products. A doubling in global food demand poses huge challenges for agricultural sustainability in terms of food production, and the terrestrial, and aquatic services the industry provides to society. These will require additional agricultural output per person (Anonymous 2015a).

Irrigation agriculture is the main user consuming 70% of water supply globally (Johansson et al. 2002; Grafton & Hussey 2011). The share of agricultural irrigation in Turkey is 72.27% among water usage sectors (Aydogdu et al. 2015). It is not possible to obtain significant yields from agricultural activities without irrigation in arid and semi-arid regions and there is risk of salinization, pollution of groundwater and degradation of soil if the proper irrigation method is not taken into account. Irrigation is done either by surface or pressurized methods. For years 2000, 2015 and 2016, surface irrigation accounts for 94, 92 and 91% respectively, while the pressurized irrigation systems remain 6, 8 and 9% for the aforementioned years, respectively (DSI 2000; Anonymous 2015b; TUBITAK-MAM 2016). These figures show an upward trend for the pressurized irrigation systems in recent years in Turkey. Pressurized irrigation systems such as the drip and sprinkler systems are also known as efficient irrigation due to their high level of efficiency. Efficient irrigation may also be defined as giving timely water according to the crop and soil needs to save water and protect the soil. According to 2006 data, in Turkey overall irrigation efficiency in furrow irrigation was 41, while the figure was 94% for sprinkler irrigation in the pressurized system and 60% in surface irrigation of the half-pressurized system (TUBITAK-MAM 2016). Efficient irrigation systems need knowledge, investment and technology with high initial investment costs, whilst its contribution to production technology and employment is of importance. The agricultural sector has a significant role in the Turkish economy, contributing 8.4% to the GDP in 2010, while its GDP contribution will substantially decrease over time (e.g. 7.8% for 2013) (MKA 2013) as the country develops in terms of industry and services. The economic value created by irrigated agriculture will continue to grow as the world needs to double its agricultural output between now and 2050 (UN 2009).

Many different irrigation technologies are used by farmers according to their farming land, knowledge and financial situations. Efficient irrigation is mainly based on water productivity and is critical to long-term sustainability of land and water resources. It requires technologies, products and services that are an effective means of either increasing agricultural productivity (e.g. the amount of agricultural output per unit of applied water) or minimizing the water losses or both together. The studies showed that water saving and yield increases obtained by using the pressurized irrigation system as compared to furrow irrigation for corn in Harran Plain-Turkey were 15 and 11.6%, respectively (Şimşek et al. 2003), while these figures for Coleambally-Australia were 17.6 and 13.9%, respectively (Humphreys et al. 2006). A kilogram (kg) of seed cotton production needs 2500 L of water in surface irrigation, while 1167 L are required in drip irrigation, resulting in 46.7% of water saving that can be achieved in Harran Plain. A kilogram of corn production needs about 1100 L of water for surface irrigation. However, this figure falls to 500 L for drip irrigation, indicating that 15 to 23% in yield increase could be achieved in the Harran Plain (Anonymous 2015b). On the other hand, efficient irrigation practices require knowledge, awareness, willingness, demonstration, encouragement, training, income and financial support.

Many countries use pricing as the main tool for regulating irrigated water to increase water efficiency. The development of pricing mechanisms receives high priority among the
various tools of efficient water management (Bjornlund & McKay 1998) and indirectly for soil management. There is no consensus among countries, even among the different regions of a country, on how to do effective pricing. The contending factors in effective pricing include not exceeding the ability of users to pay, being effective on water savings, since lower prices tend to lead to waste of water, and providing maximum contribution to the financing of the system. The pricing is affected by many factors that may reflect different considerations, such as reducing the amount of water used, soil and water savings, better management, that is, the amount of collection fee will be increased due to efficient pricing for operation and maintenance of the systems, the financing of irrigation institutions, enforcement of use of efficient irrigation technologies, cost recovery and repaying those who have invested in irrigation. Public policy can either be applied by the establishment of efficient irrigation technologies, while it reimburses from farmers or sets different water charge tariffs for different irrigation systems, or investment costs may be added to water charge. However, pricing with the objective of full cost recovery may not be feasible or even desirable in the transitional phase (Majumdar & Gupta 2009). Unless the price will not exceed farmers’ ability to pay, as the price of water increases, the benefits associated with efficient irrigation technologies receive a boost. This will without doubt impact on the use of efficient irrigations. Fostering the adoption of efficient irrigation technologies and practices are an effective tool for improving overall soil and water usage efficiency, quality and crop productivity, while they hold sustainability of these resources for future generations. Public policy can and does accelerate the adoption of products and services through incentives, including cost sharing, regulatory relief, tax credits, rebates and technical assistances (Anonymous 2015a). Every efficient irrigation technology has its own cost together with benefit and is quite different from the others based on crop type. The initial costs are high in efficient irrigation technology, while it requires fewer production inputs and maintenance costs. A study based on total input and output production costs of corn, without the water and soil saving aspects, indicated that the pressurized system yields 22% more profit per hectare (ha) in Turkey (Kaltu & Gunes 2010). The question that can be posed here is that it is very crucial to know the farmers’ abilities and willingness-to-pay (WTP) for the efficient use of irrigation products and services for effective policy-making by decision makers. Therefore, the purpose of this study is to determine the WTP value for an efficient irrigation system for farmers and explore the potential factors that contribute to it. The current water fees are low and insufficient to meet the operation and maintenance of the systems properly which results in waste of water and salinization of soil. The WTP amount derived from this study can shed some light on how effective water pricing in the region can be if the local or regional policy makers intend to enforce such a system on farmers.

The paper is organized as follows: The materials and method are provided in Section 2. Results and discussions are outlined in Section 3. Finally, the last section provides a brief summary and policy implications.

2. Materials and methods

2.1. Survey area

The Southeastern Anatolian Project (GAP, is its Turkish acronym), is a multi-sectorial, integrated regional development project that seeks to use soil and water resources to increase
farmers income levels in particular and quality of life for the region’s population in general, while it intends to eliminate inter-regional developing inequality and contribute to the economic development and social stability targets on the national level. Within the project’s scope, there are 22 dams, 19 hydroelectric power plants and 1822 million ha of irrigated agricultural land. The total investment cost is $32 billion (GAP 2012). Harran Plain is the study field that is located at 375 meters of altitude and is among the lowest altitude locations in the GAP at the southeast part of Turkey. The average precipitation is around 350 mms and annual evaporation is 1848 mms (DMI 2011). From 1975 to 2009 at Harran region based on 35 years data, the number of drought years, near normal to exceptionally dry, were 26 (Yapar & Ağraz 2012). Agricultural irrigation in the plain within the scope of GAP began in 1994 and today around 150,000 ha are under irrigation (DSI 2013), and maintenance, operation, management and repair of the networks are the responsibility of the water user associations (WUAs) in the plain under the supervision of the State Hydraulic Works (DSI, is its Turkish acronym), which is the main supplier of water and irrigation systems in Turkey.

2.2. Materials

The primary material of this study comes from a sample of 21,094 farmers in the Harran Plain who were chosen via a simple random sampling method. There are 22 WUAs and 363 settlements in the plain. The farmers residing in 173 of these settlements were interviewed in person and were given questionnaires. Sampling was conducted in 48% of the settlements during the irrigation season of 2011 and validity of data was observed until 2015. The sample size was determined using the formula (1) (Yamane 2001).

\[
n = \frac{Nt^2pq}{d^2(N - 1) + t^2pq}
\]

where; \(n\): sample size, \(N\): farmers in the main population, which is 21,094, \(t\): the sample size is larger than 30, \(Z\) table value with 5% error margin is 1.96 in normal distribution table, \(p\): the probability of farmers who might accept the given proposal is 50% so 0.50, \(q\): the probability of farmers who might say ‘no’ to our offer, \(1 - p = 0.50\), \(d\): it was taken as 0.05 with 95% confidence interval. These values indicated that conducting 377 questionnaires would be appropriate, but to be on the safe side, 461 questionnaires were conducted. Within this scope, all the WUAs were visited in the Harran Plain. To maximize the reliability of the results, villages that represent every WUA were purposefully selected, and local interviewers were used.

2.3. Methods

The economic theory of non-renewable resources was first pioneered by Meadows (1972). Several evaluation criteria are used to determine the economic value of natural resources (Thampapillai 2002). The Tobit model, which is pioneered by Tobin (1958), describes the relationship between a non-negative dependent variable and a set of independent variables. Knowledge of the dependent variable may only be related to some observations that are known as censored sampling. Therefore, the Tobit model is also referred to as censored or truncated regression model (Amemiya 1973, 1984; McDonald & Moffit 1980; Gujarati 2006).
If the range of changes in the dependent variable is limiting in the regression model and observations are being lost completely outside of a given range, it is called a truncated model. If at least the independent variables can be observed that is called a censored model. Thus, the censored variable $Y_i$ is 0 if the unobserved latent variable $y^*_i$ is smaller than or equal to zero and $Y_i = y^*_i$ is positive. This can be expressed as follows:

$$
Y_i = X_i \beta + u_i \quad \text{if } y^*_i = X_i \beta + u_i > 0 \\
Y_i = 0 \quad \text{if } y^*_i = X_i \beta + u_i \leq 0,
$$

(2)

where $Y_i$ is the amount of money that could be dedicated in the presence of the efficient irrigation system per ha presented to the farmer $i$. The bid amounts are determined based on several discussions with the WUAs. The bid amounts are appropriately ranged and then randomly selected for a farmer and then replaced for the next raffle. $u_i \approx N(0, \sigma^2)$, $X$ is a vector of explanatory variables representing farmers and farm-related factors such as education levels, years in experiences and etc., $\beta$ shows unknown parameters to be estimated (Maddala 1989). $y^*_i$ is an unobservable latent variable and when $y^*_i \leq 0$, some observations cluster at zero in the Tobit model. When data is limited to below or above a certain limit, distribution applied to the sample data would be a mix of truncated and continuous distributions. The estimation of the model is entirely based on economic reasons. It means that the hurdle is entirely based on a farmer’s economic condition. This could be, for example, the income of a farmer is so low that the farmer cannot irrigate his land, or the current price of water is so high that a farmer cannot afford it. In case of not being able to buy goods or services, if their price, which is subjected to research is very high or respondent has low income level, then zeros may be reported. Usually, the Maximum Likelihood (ML) method is used to estimate the unknown parameter estimates. The likelihood function (L) for the Tobit model can be written as (Maddala 1989).

$$
L = \prod_{Y_i > 0} \frac{1}{\sigma} \phi \left( \frac{Y_i - X_i \beta}{\sigma} \right) \prod_{Y_i \leq 0} \Phi \left( -\frac{X_i \beta}{\sigma} \right),
$$

(3)

where $\phi$ represents the normal distribution density function, $\Phi$ represents cumulative normal distribution function and $\sigma$ denotes the standard deviation of the model. If likelihood function is maximized according to $\beta$ and $\sigma$ maximum likelihood estimates are obtained as follows:

$$
\log L = \sum_{Y_i = 0} \log \left( \Phi \left( -\frac{X_i \beta}{\sigma} \right) \right) + \sum_{Y_i > 0} \log \left( \frac{1}{(2\pi\sigma^2)^{1/2}} \exp \left( -\frac{1}{2\sigma^2} (Y_i - X_i \beta)^2 \right) \right),
$$

(4)

where $Y$ is the question that was asked how much they want to pay more per ha regarding efficient irrigation for economical and sustainable income considering soil and water resources aspects. The payment amount (e.g. $Y_i$) is thus determined by farmers’ socio-demographic and economic factors. The power of the variation in exogenous variables to the variation in the dependent variable is tested by using a conventional statistical test procedure like the Lagrange Multiplier test (LM) (Greene 2003; Bilgic and Eren 2008).
3. Results and discussion

3.1. Descriptive statistics

The descriptive statistics of the model is given in Table 1. The survey is conducted with male farmers. The total amount of cultivated land is 7660 ha, average land size is 14.84 ha in the surveyed area and 59% of the farms are 10 ha or smaller. Almost 41% of the farmers have their farmland in addition to other rented lands and/or partnerships. There are 88.5% of the farmers located in the gravity area and 11.5% located in the pumping irrigation area. Cotton is the main crop in the plain being 58%, and then wheat is 26% and corn is 14%, followed by other crops. The average farm income was calculated as 37,326 Turkish lira (Tl)/year and 2517.7 Tl/ha. The index variables were created to measure the farmers' perceptions and attitudes by using the Likert scale. The indexa, five-point scale has strongly agree, agree, fair, disagree and strongly disagree, from which the respondent makes a selection by indicating the corresponding number from 1 to 5. It covers ten questions that measure the farmers' overview to WuAs, values range from 10, the most positive viewpoint, to 50, the most negative perspective. The indexb variable consists of three questions regarding farmers' knowledge and perceptions towards natural resources, values range from 4, the most positive viewpoints to natural resources, to 5, the most negative perspective, and 9 indicates unawareness of the issues. The indexc is the multiple-question index, which measures the farmers' overview of the economic value of water; values range from 11, the most positive, and 7 is the most negative.

The MLE parameters are presented in Table 2. Before discussing parameter estimates and their unitary impact on the WTP value, the exogenous variables used in the model present overall to the variation of the dependent variable. That is the variation in the dependent
Table 2. Maximum likelihood estimates of the censored Tobit model.

| Variables     | Coefficient | Std. error | t-value | p-value | 95% Confidence level |
|---------------|-------------|------------|---------|---------|-----------------------|
| Constant      | 41.512c     | 10.430     | 3.98    | 0.000   | 21.069 61.955         |
| Primary       | 4.870a      | 2.887      | 1.69    | 0.092   | -0.789 10.528         |
| Secondary     | 0.093       | 3.430      | 0.03    | 0.979   | -6.630 6.815          |
| Highschool    | 3.287       | 3.522      | 0.93    | 0.351   | -3.617 10.190         |
| University    | 2.123       | 4.286      | 0.50    | 0.620   | -6.277 10.523         |
| Married       | -10.324c    | 3.873      | -2.67   | 0.008   | -17.914 -2.734        |
| Ownership     | -3.658b     | 1.819      | -2.01   | 0.044   | -7.223 -0.092         |
| Livestock     | 2.011       | 1.846      | 1.09    | 0.276   | -1.607 5.628          |
| Harran        | -0.014      | 2.070      | -0.01   | 0.995   | -4.070 4.043          |
| Akcakale      | 2.640       | 2.425      | 1.09    | 0.276   | -2.112 7.392          |
| Mdmirr        | 4.780b      | 2.259      | 2.12    | 0.034   | 0.353 9.207           |
| Crop1         | 4.214b      | 1.993      | 2.11    | 0.035   | 0.308 8.120           |
| Crop2         | -0.826      | 2.317      | -0.36   | 0.722   | -5.367 3.715          |
| Gravity       | -15.241c    | 3.037      | -5.02   | 0.000   | -21.194 -9.288        |
| Canalirr      | 0.778       | 1.853      | 0.42    | 0.675   | -2.854 4.409          |
| Wellirr       | 3.167       | 3.387      | 0.94    | 0.350   | -3.471 9.806          |
| Age           | -0.007      | 0.092      | -0.08   | 0.939   | -0.186 0.172          |
| Household     | -0.119      | 0.320      | -0.37   | 0.711   | -0.747 0.509          |
| Lnland        | 0.602       | 1.171      | 0.51    | 0.607   | -1.693 2.896          |
| Indexa        | 0.043       | 0.117      | 0.36    | 0.715   | -0.186 0.271          |
| Indexb        | -0.962a     | 0.544      | -1.77   | 0.077   | -2.028 0.104          |
| Std variation | 17.476c     | 0.578      | 30.23   | 0.000   | 16.342 18.609         |

The logarithmic likelihood function is -1963.339.

Table 3. Measuring marginal impact of factors affecting the probability of WTP for acres.

| Variables     | Partial effect | Std. error | t-value (z) | p-value | 95% Confidence level |
|---------------|----------------|------------|-------------|---------|-----------------------|
| Primary       | 4.376a         | 2.595      | 1.69        | 0.092   | -0.710 9.462          |
| Secondary     | 0.083          | 3.082      | 0.03        | 0.979   | -5.958 6.124          |
| Highschool    | 2.954          | 3.166      | 0.93        | 0.351   | -3.251 9.158          |
| University    | 1.908          | 3.852      | 0.50        | 0.620   | -5.641 9.457          |
| Married       | -9.278c        | 3.482      | -2.66       | 0.008   | -16.103 -2.453        |
| Ownership     | -3.287a        | 1.635      | -2.01       | 0.044   | -6.492 -0.082         |
| Livestock     | 1.807          | 1.659      | 1.09        | 0.276   | -1.444 5.058          |
| Harran        | -0.012         | 1.860      | -0.01       | 0.995   | -3.658 3.633          |
| Akcakale      | 2.373          | 2.179      | 1.09        | 0.276   | -1.898 6.644          |
| Mdmirr        | 4.296b         | 2.031      | 2.12        | 0.034   | 0.316 8.276           |
| Crop1         | 3.787b         | 1.792      | 2.11        | 0.035   | 0.275 7.299           |
| Crop2         | -0.742         | 2.082      | -0.36       | 0.722   | -4.833 3.339          |
| Gravity       | -13.697c       | 2.735      | -5.01       | 0.000   | -19.057 -8.337        |
| Canalirr      | 0.699          | 1.665      | 0.42        | 0.675   | -2.565 3.963          |
| Wellirr       | 2.847          | 3.044      | 0.94        | 0.350   | -3.120 8.813          |
| Age           | -0.006         | 0.082      | -0.08       | 0.939   | -0.167 0.155          |
| Household     | -0.107         | 0.288      | -0.37       | 0.711   | -0.671 0.458          |
| Lnland        | 0.541          | 1.052      | 0.51        | 0.607   | -1.521 2.603          |
| Indexa        | 0.038          | 0.105      | 0.36        | 0.715   | -0.167 0.244          |
| Indexb        | -0.865a        | 0.489      | -1.77       | 0.077   | -1.822 0.093          |
| Indexc        | -0.070         | 0.416      | -0.17       | 0.866   | -0.885 0.745          |

Table 4. The comparison of actual WTP value to the estimated value derived from the Tobit model (In TL/ha).

| Model       | Real value | Estimated value |
|-------------|------------|-----------------|
| Tobit       | 223.3      | 257.1           |
| t value     | 252.0      | 218.9           |
variable seems likely to occur from variations in each exogenous variable. The contributions of exogenous variables are tested using the Lagrange Multiplier (LM) test (LM = 105.71, df = 22).¹

There is a positive and statistically significant relation between primary school graduation and the WTP amount. These farmers are generally older and had seen differences between irrigated and dry farming. There is a positive perception towards having sustainable water, soil and farming, resulting in higher income and so enabling them to pay more for efficient irrigation. There is a negative and statistically significant relationship between WTP and the married farmer. Family expenses are more due to marriage issues with 7 being the average household number. The family members are also considered as a labor force for farming. Pressurized irrigation has the advantage of lower maintenance requirement by 8.4% (Kaltu & Güneş 2010), meaning the need for less workmanship, while on the other hand farmers have enough workmanship for furrow irrigation. As such, more payment is perceived as a welfare loss.

Being a property owner negatively and significantly affects the WTP amount. Property owners are less likely to meet the WTP as compared to their peers. This is an unexpected result because the owners are more than land tenancy and shareholders and thus they more likely derive income from farming and need more sustainability. On the other hand, another study showed the existence of a positive and statistically significant relationship between them for sustainable water usage in Harran Plain (Aydogdu & Yenigun 2016). The farmers who have small land holdings of about less than 5 ha are mostly not in a position to afford the expensive irrigation systems such as sprinkler and drip irrigation in Punjab (Bakhsh et al. 2015). The property owners are the biggest group among the others and have 47.4% satisfaction from services provided by WUAs. Status of ownership, land amount, age, farming experiences, income and service quality given by WUAs are the factors that explain significant attitudes of farmers (Aydogdu et al. 2015). Therefore, there is an insufficient trust and satisfaction from WUAs. Their payment amount is already much more than that of the others, leading them to pay less.

The WTP amount increases significantly with irrigation technology users. Modern irrigation, pressurized system, users were using less water as compared to those located in gravity irrigation area. Their agricultural yields are greater and payment amounts are less than their counterparts. A study indicated that irrigation type (gravity or pumping) significantly explained WTP in the Harran Plain (Aydogdu 2016). These technologies were mainly used by more educated farmers and who have water-based problems, such as shortages and drainages, or salinity in the soil. They are located either downstream where there is a water shortage at peak irrigation season or in the middle of the plain where the slope is very low and the water table level is high due to furrow irrigations. The drip irrigation method brought a 40% water saving for wheat as compared with the conventional irrigation method, and the perforated pipe irrigation technique also saved water up to 20% in Punjab, Pakistan. The internal rate of return for drip and perforated pipe irrigations over conventional irrigation practices were 40 and 36%, respectively (Bakhsh et al. 2015). Pricing and effective irrigation methods are the most basic tools to ensure the sustainability of systems and may have positive effects on the drainage problems. The rate of water fee affects the ability to pay and WTP (Yenigun & Aydogdu 2010). There is a salinity problem due to high evaporation rates in some parts of the Harran Plain.
There is a positive and statistically significant relationship between crop pattern (Crop1) and WTP. The dominant crop is cotton followed by wheat. The total ratio of cotton to wheat was 83.7%. Cotton is a highly profitable product also supported by the government. It is also very well known in terms of production methods by farmers in the plain. Cotton is the most water-consuming plant. The peak irrigation period of cotton is summer when temperatures are quite high. Water shortages and salinity problems have frequently been seen in the cotton planting areas due to excessive irrigations and the high evaporation rate. It is essential to use efficient irrigation technologies, such as pressurized systems for water and soil savings, in these areas. The Imambakir WUA is located at the lowest altitude of the plain in a 7464 ha of land. The groundwater level is high and intensive salinity is observed due to excessive irrigation in this area, leading to significant yield losses (Aydogdu et al. 2014a).

Salt stress undesirably affects plant growth and productivity during all developmental stages (Abari et al. 2011). Salinity has led to a 1841 tonne yield loss of cotton, resulting in income loss of $935,711 in 2009 in the Akcakale district (Aydogdu et al. 2014b). The degradation of soil and groundwater quality is a consequence of brackish water use in irrigation. The impact of this practice is more pronounced in the arid and semi-arid regions where irrigation is an important factor of agricultural intensification. In these regions, dry climate creates a high evaporative demand, resulting in the need for large quantities of water for crop irrigation. The soil water balance generates an extra supply of water associated with considerable amounts of salts (Kanzari et al. 2012). Soil, as a basic means of agricultural production and a carrier and regulator of processes in various spheres of the environment, requires our attention, but namely our protection. The loss of high-quality agricultural land is perceived worldwide as an extensive problem touching not only the developing countries (Podhrázská et al. 2015) but also developed ones.

The WTP amount lowers with gravity irrigation. The land amount of gravity irrigation area is much more than that of pumping area. In addition, they are close to a major canal and so get enough water at peak irrigation time, leading to consumption of more water. Efficient irrigation investments and their being reflected in pricing will be more. They do not want to pay more, whilst more payment is considered as a welfare loss. Efficient irrigation is only considered in terms of water availability; the sustainability of the land and water resources are ignored. It should create awareness on these issues among the farmers.

An increase in the indexb variable decreases the WTP. This was a most unexpected result. Indexb consists of multiple questions regarding farmers’ knowledge and views towards natural resources (mainly water and soil) and their future availability. This result does not coincide with overall expectations. On the other hand, the responses of the farmers to individual questions of indexb had a lot of inconsistencies. It was found there was a difference in the perception of natural resources. For example, the question of whether there are enough natural resources for everyone got 44% yes and 31% no (Aydogdu 2012; Aydogdu, Karlı et al. 2014). It is believed that natural resources are sufficient for future needs. This result came from a lack of awareness about natural resources, mainly from false beliefs and lower education levels, but also from perceptions of the future as time-based. Farmers often perceive the next year or a few years from today, as the time called the future. In addition, perceptions about the source of irrigation water are another factor for this result. Ataturk Dam, which is the main source of the Harran Plain irrigations, is the 6th biggest dam in the world in terms of embankment volume, with 817 km² of lake area, 487 billion m³ of water storage capacity and an average yearly flow rate of 267 billion m³ (DSI 2013). It is believed
that Atatürk Dam will meet the future needs. Impacts of natural, social and health science education for environmental knowledge and behaviors have not been investigated yet. A study in Turkey showed that there is a statistically significant negative relation between environmental behavior and knowledge for all students, especially for health and natural science students ($p < 0.01$; $p < 0.05$), contrary to expectations (Yıldırım et al. 2015).

The marginal impact of an exogenous variable on the unconditional mean of the dependent variable is:

$$
\frac{\partial E[Y_i|X_i]}{\partial x_{k,i}} = \frac{\partial (\Phi(X_i\beta)X_i\beta + \sigma \phi(X_i\beta))}{\partial x_{k,i}}
$$

Where the unconditional mean of the model is $E[Y_i|X_i] = \Phi(X_i\beta)X_i\beta + \sigma \phi(X_i\beta)$ and $\Phi$ and $\phi$ are the cumulative and normal density function, respectively, while the $\sigma$ represents the standard deviation of the model. The delta method is used to construct the variance-covariance of the marginal effects (Greene 2003).

The unitary effects of statistically significant variables are given in Table 3. Results show a change in the WTP variable due to a unitary change in the independent variable. One unit change of efficient irrigation has a partial impact effect on primary school graduates with 4.4% in education levels in a positive way. This partial impact has a positive effect on farmers who use modern irrigation technologies at the rates of 4.3 and 3.8% on crop pattern who produce cotton and wheat, respectively. Crop value has an effect on WTP that is directly related to the income of farmers. Leyva and Sayadi (2005) carried out a survey on tropical fruit growers’ WTP in Granada, Spain, where the problem of water scarcity existed in summer. Farmers expressed WTP for the water, and their attitude towards the use of alternative sources, such as residual water, was examined. The average WTP was found to be €0.27 m$^3$ and the majority was between €0.21 and €0.36 m$^3$. The WTP is rather higher than that of other crop type producers. On the other hand, this partial impact has an effect on married farmers at the rate of 9.3%, property owners at the rate of 3.3%, farmers who use gravity irrigation at the rate of 13.7% and Index at the rate of 0.9% in a negative way.

A comparison of the WTP values resulting from the model and the actual values are given in Table 4. The difference between the predicted values and the actual values is quite low. The model estimated an actual value with a margin of error of 15%. The model is successful at result estimation.

### 4. Conclusion

The research results indicated that farmers have WTP for efficient irrigation technologies, but the expressed value of $133.7 per ha, which is 8.87% of yearly income, is not enough for investment of such systems. The investment cost of efficient irrigation systems changes depending on the specifications and technologies used, status and topography of land and availability of water resources. It is estimated that the investment cost of irrigation is roughly $1500 per ha (Anonymous 2015b). The constant cost for sprinkler and drip irrigation was calculated as $620.8 and $842.3 per ha, respectively, for corn (Kaltu and Gunes 2010). The state is promoting the use of modern irrigation systems among farmers in Turkey by 50% grants and 5 years interest-free loans; despite all these modern irrigation has not expanded at the desired level in Turkey. There is a need for additional regulations. Pricing based on
volumetric payment can be used or more grants and soft loans can be provided. The total WTP was calculated as $20.05 million for the Harran Plain according to the currency exchange rate at the time of survey. In fact, farmers have abilities to pay more than their expressed WTP. Farmers should be encouraged in this regard and must be supported more by the state. It is a necessity to use efficient irrigation technologies for sustainable land and water resources. Thus, trust to WUAs, extension services, training, support programs and public awareness should be increased by policy makers. This study, to our knowledge, is first of its kind in the GAP-Harran Plain and contains useful information for countries that have similar technical and socio-economic conditions in terms of policy and investment.

Note

1. The validation of the model based on $R^2$ is not preferred in the limited dependent variable model because the model is non-linear with a lower value of the $R^2$.

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