The adoption of water saving irrigation practices in the Region of West Macedonia

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Abstract

The use of irrigation water for agricultural production requires innovative and sustainable research and an appropriate transfer of water saving technologies. The main aim of this paper is to explore the irrigating behaviour of farmers examining factors affecting their decision to adopt novel water saving practices. In order to achieve the above aim both summary statistics and multivariate methodologies are employed. In particular, a two-step cluster analysis was used to explore the different adoption levels of water saving practices and a categorical regression model was estimated to explain this variation. Data were collected through a survey addressing 400 irrigators, carried out in 2008 in a typical Greek rural area. Results show that although respondents have already adopted several water saving practices the current irrigated agriculture cannot be sustained in a sustainable manner.

Keywords: adoption-diffusion, extension, irrigation, water saving, water policy

1. Introduction

Globally, over the last 30 years, irrigated areas have increased rapidly while the irrigation water demand is still increasing because the area being irrigated continues to expand. In particular, 70% of water diverted for human purposes goes to agricultural sector in order to increase the agricultural output and feed a growing population (Cai et al., 2003). By all odds, irrigation spends the largest part of available water in almost all countries, developed or developing. Moreover, in some developed countries the recent expansion of urban-industrial water needs drives to an unexpected transferring out of agriculture putting additional stress on the performance of the irrigation sector (Rosegrant and Ringler, 2000). On the other hand, the construction of new water storages or dams, to meet such demands, is no longer feasible. Actually, recent environmental concerns effectively prohibit new constructions thus pointing to the reallocation of water from current users as the best alternative available (Michailidis et al., 2003). Thus, water efficiency and water policy issues emerge as important research topics especially in the study area where farming uses more than 45,000 hectares of irrigated land (NSSG, 2009) while irrigation is by far the largest consumer of water.

In light of sustainability, the Hellenic Ministry of Environment, Physical Planning and Public Works has recently implemented an integrated water management approach recognizing that water saving practices will receive substantial attention in the next few years as such water is an administrative, managerial and shared responsibility. Actually, the Greek government embarked on a public review process to develop a long-term regional water management strategy designing the National Project of Water Resources Protection and Management, released in March 2008 (HMEPW, 2008). The above mentioned project confirms that water resources in the study area are fully or over committed while demand for water is likely to continue increasing. The strategy identifies improved water use efficiency and productivity as the primary methods of satisfying such an increased demand. One of the strategy's main objectives is a 20% increase in efficiency and productivity by 2016 over 2008 levels. Thus, it is vital to determine new water saving irrigation and management practices in order to achieve the above objective improving the water use efficiency.

Modern irrigation water management should concurrently achieve two general objectives: (a) sustaining irrigated agriculture for food security and (b) preserving the associated natural environment (Cai et al., 2003). Unambiguously, both current and future strategies indicate that a well-balanced relationship should be maintained between these two objectives, while potential conflicts should be mitigated through appropriate water saving irrigation practices. This paper focuses on achieving a sustainable balance between irrigation management and environmental preservation, through a case study of the irrigation management in the Western Macedonian Region, which have recently experienced serious water deficiency caused by excessive irrigation (Michailidis et al., 2003).

The main aim of this paper is to explore the irrigating behaviour of farmers examining factors affecting their decision to adopt water saving practices. In order to achieve the above aim a survey was carried out, addressing 400 irrigators, in the four irrigation districts, i.e. the four Prefectures (Florina, Grevena, Kastoria and Kozani), comprising the study area. The survey instrument was designed utilising the existing literature, as identified by Bjornlund et al. (2009), tested in collaboration with local experts (Directorates of Agriculture) of the four regions and finalised to accommodate the specificities of the research area.

The next section provides with a background of the water saving practices following by a short description of the case study area, the outlines of the methodology as well as survey data and model's details. Finally the conclusions and future research are argued in the last section and policy implications are deduced. Although the specific study results may be limited in scope to the study region, we expect that the study procedure would be applicable to similar resource-limited farming systems that are abundant elsewhere in the planet.

2. Water saving practices

"Water saving practices" are several techniques of irrigation water management that cause significant improvement of water use ability, efficiency and productivity and thereby provide a sustainable balance between irrigation management and environmental preservation. Therefore we expect that the irrigators of the study area would be open-ended to novel irrigation practices in order to meet all these ongoing water demands or take advantage of the low cost practices and more sustainable ones. Two leading general categories of water saving practices have been identified by Bjornlund et al. (2009) affecting or expected to affect irrigation systems over the coming decades (Fig. 1): (a) more efficient water technologies and (b) improved management practices, among others.

The suite of general water saving practices includes a mix of others, more detailed ones. Some of them increase the efficiency of already existent water technologies, while others are rather new or unused. In particular, the more efficient water technologies include five water saving practices: (a) convert form surface to wheel move sprinklers, (b) convert from wheel move sprinklers to pivot, (c) convert from surface to pivot, (d) convert from high pressure to low pressure and (e) purchase a computer panel for pivot. On the other hand, the improved management practices include six water saving ones: (a) visual monitoring, (b) hand auger and feel methods, (c) monitoring instruments, (d) computer-phones, (e) web-based programs and (f) private consultants. We hypothesize that the use of the above mentioned water saving practices will drive to the satisfaction of the strategy's main objective as well as to the achievement of the two general ones: (a) preserving the associated natural environment and (b) sustaining irrigated agriculture for food security.

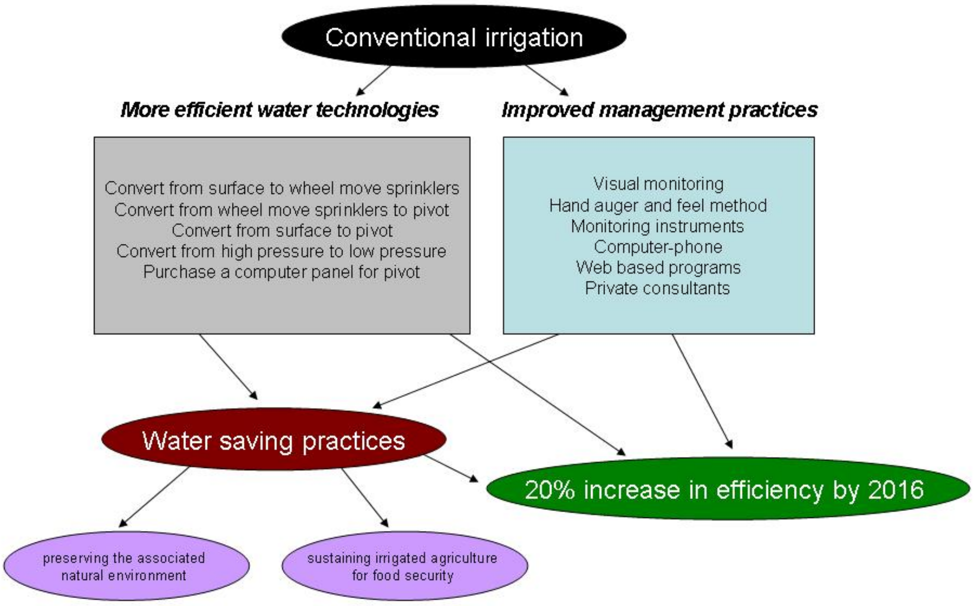

Figure 1. Key drivers of change in irrigation practices

3. Materials and methods

3.1. Study area

The Western Macedonian Region (WMR) is located in the northwest part of Greece and it is characterized by semi-arid climate and considerable agricultural activity (Michailidis et al. 2003). The WMR is a typical Mediterranean rural region which comprises of four prefectures: Florina, Grevena, Kastoria and Kozani (Fig. 2). WMR is a natural gate of Greece to the northwest borders, especially to Albania and to the Former Yugoslavian Republic of Macedonia, holding a central position in the Western Balkans. In light of landscape, the region mainly consists of highlands (69.2%), forest areas (26.0%), rangelands (43.0%) and cultivations or fallow lands (24.0%). In particular, it is considered a major agricultural production center, mainly of wheat, corn, apples and peaches. According to the National Statistical Service of Greece, the whole land of the WMR consists of 9,451.6 Km^2 or 7.2% of the total country land (NSSG, 2009).

Figure 2. Western Macedonian Region

3.2. Data collection

Data were collected through a survey questionnaire addressing 400 randomly selected farmers in the WMR, during October and November 2008. Each one of the four prefectures, of the study area, participates in the research dataset with the same number of respondents (100 farmers each). The main target of the survey was to determine the irrigating behaviour of farmers relating to the adoption of water saving practices. In particular, the questionnaire included sections on: (a) farmers' practices in the distant (prior to 2000) and more recent past (2000-2008) as well as on their future intentions (2008-2016) concerning the improvement of water use efficiency on their farms; (b) their view of drivers and impediments in undertaking such improvements; (c) influences on their decisions regarding the adoption of improved technologies and management practices; and (d) socio-demographic factors such as age, education, dependence on off-farm work, family history and prospects of farm succession. The main survey questions were based on a previous instrument developed by Bjornlund *et al.* (2007) but they were retested and survey instruments were redeveloped in order to address the specificities of the research area.

3.3. Methodological framework

Both summary statistics and multivariate analysis methodologies were employed in order to achieve the aims of the paper. In particular, two-step clustering was first employed in order to segment the dataset into several clusters of respondents with similar irrigation behaviour (Kayri, 2007; SPSS, 2008). Reliability analysis (Bohmstedt, 1970) was then employed to determine the extent to which several independent variables are related to each other and to identify ones to be excluded from the designed scales of the subsequently multivariate techniques. Finally, a categorical regression model was used in order to find out possible relations between irrigation behaviour and a set of selected independent variables (Kooij and Meulman, 1997). In Figure 3 the general methodological framework of data collection, statistical analysis and obtained results is illustrated.

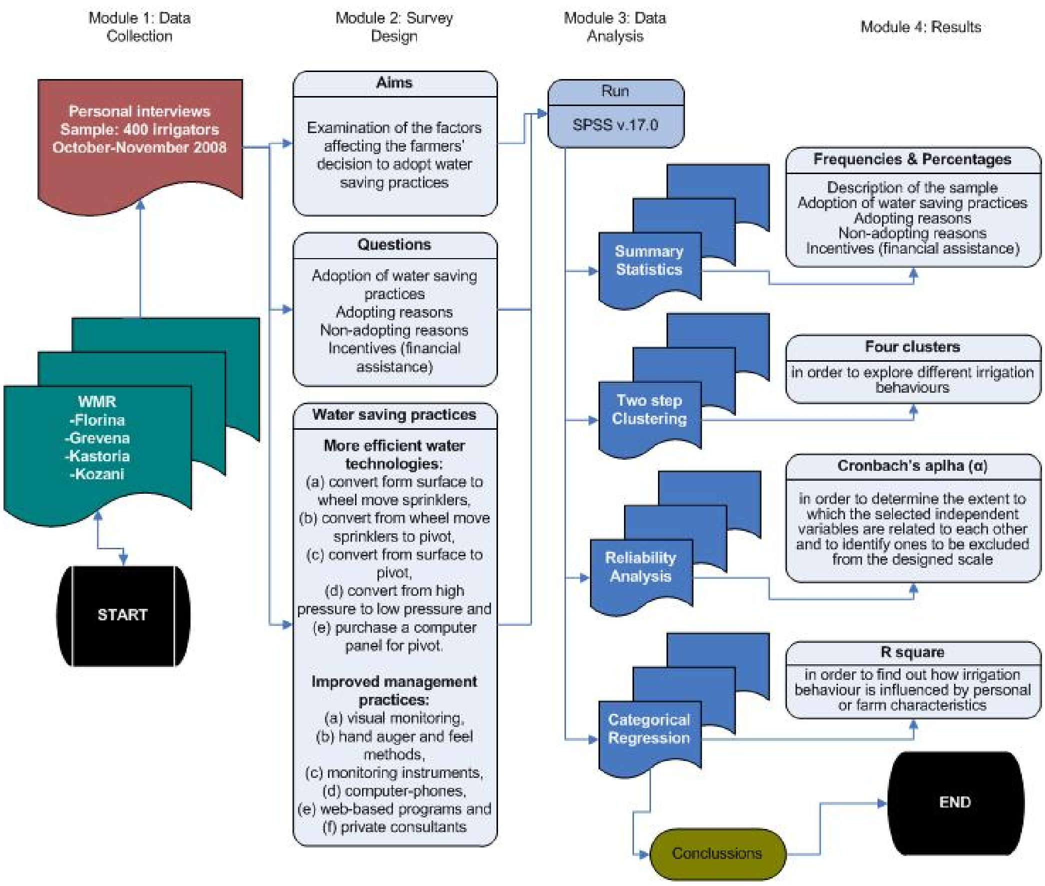

Figure 3. General methodological framework

4. Results

Table 1 presents the farmers' preferences for water saving irrigation practices in the distant (prior to 2000) and more recent past (2000-2008) as well as on their future intentions (2008-2016) concerning the improvement of water use efficiency on their farms. According to the summary statistics analysis of the dataset, in order to improve the efficiency of irrigation water use participants have already adopted or plan to adopt within the next few years two cases of equipment modification: (a) the conversion from wheel move sprinklers to pivot and (b) the conversion from high pressure to low pressure. Besides, many farmers in the region (53.8%) use the services of private consultants while 43.5% of them monitor soil moisture using visual crop conditions. Farmers' future intentions show that although quite a few of them plan to invest in new, or modify their existing irrigation equipment, it seems that the potential for technological improvements within existing financial and physical constraints is largely exhausted.

Table 1. Adoption of water saving irrigation practices

Irrigation practices	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Never	231 (57.8)	141 (35.3%)	298 (74.5%)	32 (8.0%)	229 (57.3%)
Before 2000	116 (29.0%)	149 (37.3%)	70 (17.5%)	135 (33.8%)	26 (6.5%)
2000-2008	27 (6.8%)	75 (18.8%)	23 (5.8%)	170 (42.5%)	85 (21.3%)
2008-2016	26 (6.5%)	35 (8.8%)	9 (2.3%)	63 (15.8%)	60 (15.0%)
Irrigation practices	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Never	156 (39.0%)	141 (35.3%)	271 (67.8%)	341 (85.3%)	287 (71.8%)
Before 2000	93 (23.3%)	123 (30.8%)	67 (16.8%)	12 (3.0%)	14 (3.5%)
2000-2008	81 (20.3%)	92 (23.0%)	43 (10.8%)	21 (5.3%)	14 (3.5%)
2008-2016	70 (17.5%)	44 (11.0%)	19 (4.8%)	26 (6.5%)	85 (21.3%)

(1) Convert from surface to wheel move sprinklers, (2) Convert from wheel move sprinklers to pivot, (3) Convert from surface to pivot, (4) Convert from high pressure to low pressure, (5) Purchase a computer panel for pivot, (6) Visual monitoring, (7) Private consultants, (8) Hand auger and feel method, (9) Monitoring instruments, (10) Other water saving practices

Figure 4 illustrates the most important reasons for adopting water saving irrigation according to farmers' responses. The majority of them indicated the improvement of crop yield or the improvement of crop quality (55.8%). In addition, almost 20% of the respondents pointed out the reduction of energy cost or the reduction of water use while quite a few suggested other adoption reasons.

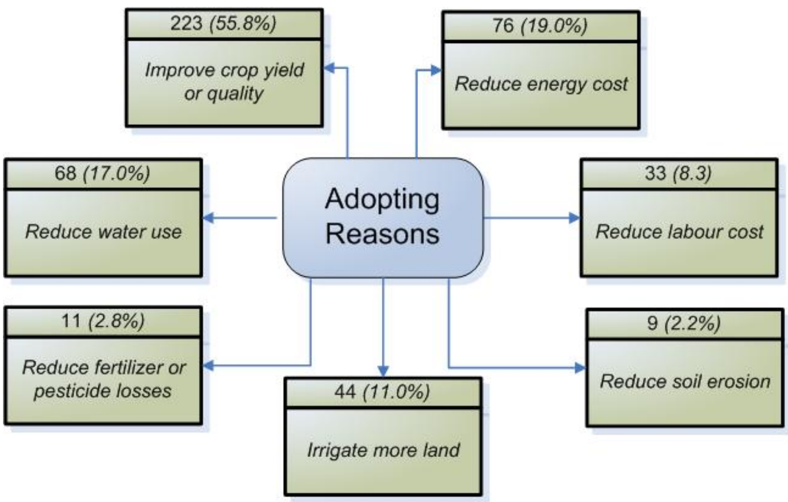

Figure 4. Adopting reasons of water saving irrigation practices

On the other hand, non-adoption reasons of water saving practices related mainly to the farmers' beliefs that they are already using all the water saving practices that are feasible (40.3%)

followed by financial constraints (37.0%), low commodity prices (17.8%) and several other secondary reasons (Figure 5).

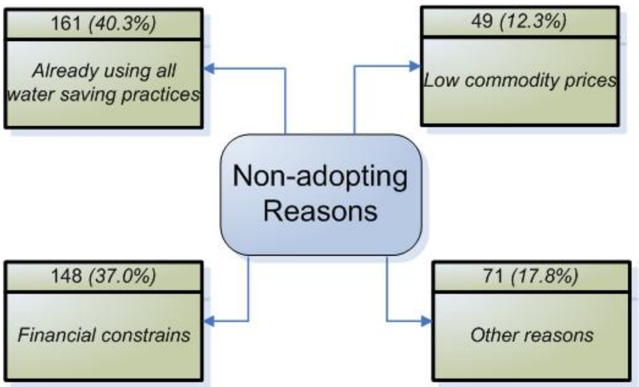

Figure 5. Non-adopting reasons of water saving irrigation practices

Various types of financial assistance deemed necessary by farmers to encourage them to invest in water saving practices are presented in the Figure 6. A subvention was ranked as the first choice by the majority of the irrigators (85.3%) while fewer ones indicated the interest subsidisation (8.8%), the express depreciation (4.5%) and other types (1.5%).

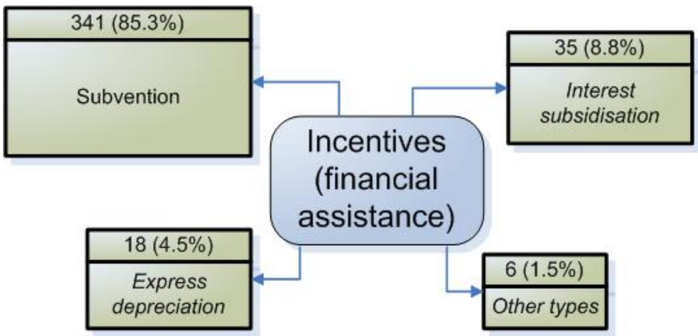

Figure 6. Incentives (financial assistance)

Then, multivariate statistical methodologies were employed in order to assign and explain different adoption levels of water saving irrigation practices. First of all two-step cluster analysis, based upon the seven adoption reasons (Figure 4) and the four non-adoption ones (Figure 5), was used in order to segment the whole dataset (400 observations) in several clusters of respondents. The above mentioned items were figured in a five level *likert* scale (where: 5=strongly agree, 4=agree, 3=neither agree nor disagree, 2=disagree and 1=strongly disagree). The two-step clustering model, via the SPSS V.17 for Windows, extracted automatically the optimal solution of four clusters. As shown in Figure 7, the first cluster mainly includes non-adopters of water saving irrigation practices who claim that their decision owes to financial constraints, poor commodity prices or several other secondary reasons. The second cluster comprises by farmers who are probably willing to adopt water saving irrigation practices mainly because they expect to improve crop yield and crop quality or allow for the irrigation of more land. The third cluster comprises potential adopters of water saving irrigation practices that mainly present price or cost orientation (farmers who are willing to adopt water saving irrigation practices in order to reduce water use, to reduce energy cost, to reduce labour cost or to reduce fertilizer or pesticide losses. Finally, the fourth cluster is quite different since it comprises of more environmentally sensitive farmers who already use all the water saving practices or are worried about soil erosion. The majority of the observations included within the clusters of the "guarded non-adopters" or the "productivity orientated adopters" (122 respondents or 30.5% in each cluster) while only 94 of the respondents (23.5%) fall into the cluster of "environmental interactive adopters" and the rest ones (15.5%) into the cluster of "cost-price orientated adopters".

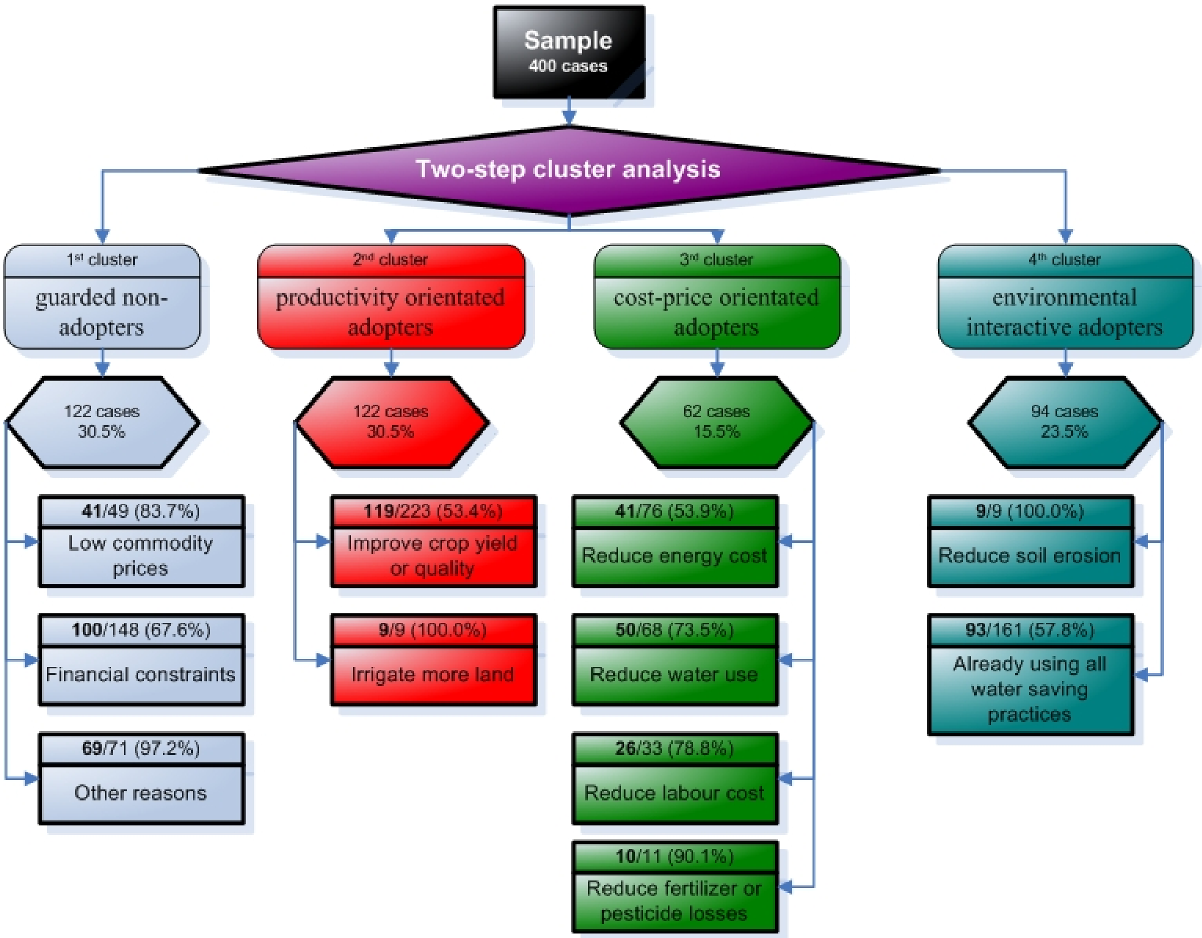

Figure 7. Two-step clustering model

Next, a general categorical regression model was employed in order to find out how the adoption decision of water saving irrigation practices is influenced by personal or farm characteristics (Table 2). Before that, reliability analysis (Bohmstedt, 1970; SPSS, 2008) was used for the determination of the extent to which the thirteen selected independent variables (some of them categorical) of the categorical regression model are related to each other and for the identification of the ones to be excluded from the designed scale. The value of *Cronbach's alpha* (α) reliability coefficient was found equal to 0.77 indicating that the designed scale of "behaviour of water saving irrigation practices" is reliable (SPSS, 2008). In addition, Friedman two-way analysis of variance, with x^2=2,004.4 (α=0.00) and Hotelling's T^2=1,366.0 (F=32.18 and α=0.00), indicated the significance in differences of item means while no items were dropped from the initial list of thirteen ones. Having accepted the consistency of the items, the average value (1=no plans to adopt, 2= have already adopted and 3=plans to adopt within the few next years) of all the water saving practices for each respondent was used as the numerical value of the dependent variable "behaviour of water saving irrigation practices".

Table 2. Selected independent variables

Independent variables	*Categories*
Age	1=under 25, 2=25-45, 3=45-60, 4=over 60
Area	1= Florina, 2= Grevena, 3= Kastoria, 4= Kozani
Children	Number of children
Farm experience	Number of years
Farm size	Number of cultivated hectares
Gender	1=male, 2=female
General education	1=six or less years, 2=from seven to nine, 3=ten or more
Higher education	1=university degree, 2=other
Income	Annual household income (€)
Irrigation water	1=sufficient, 2=somewhat sufficient, 3=insufficient
Main cultivation	1=cereals, 2= arboriculture, 3=other
Marital Status	1=married, 2=not married
Type of farming	1=full time farmer, 2=other

The categorical regression model yielded R^2 value equal to 0.760 indicating moderate relation between adoption decision of water saving practices and the group of selected predictors (Michailidis, 2007; SPSS, 2008). More specifically, since R^2=0.760, it is indicated that 76% of the variance in the dependent variable rankings is explained by the regression of the optimally transformed selected variables. From the standardized correlation coefficients (Table 3) of the independent variables the highest value corresponds to the “area” variable followed by the “income” and “irrigation water” variables, all of them with positive sign. Among the zero order coefficients, highest are the coefficients that correspond to “general education” (r=0.273), “farm type” (r=0.222) and “income”(r=0.213), indicating the bilateral relationship (positive in all cases) which relates each of the independent variables with the dependent, if all the other dependent variables are excluded. The partial correlation coefficients after removing the linear relationship of the remaining variables from the particular independent as well as the dependent variable, present the highest value for the “area” variable followed by the variables accounting for “income” and “irrigation water”. More specifically, the value 0.247 of the partial correlation coefficient explains 6.10% (0.247^2) of the variation of the tactical values of the dependent variable when the effects of all the other independent variables are removed.

As regards the coefficients of part correlation the highest value corresponds to the correlation between the dependent variable and the “farm size” variable. The square of this coefficient expresses the proportion of variance of the dependent variable that can be explained by the “farm size”, relative to the total, once the effects of all the other variables on the specific independent variable are removed. In particular, after removing the effect of all other variables on the “farm size”, the resulting percentage explains 8.70% of the variance of the dependent variable.

Table 3. Categorical regression model (R^2=0.760)

Independent variables	Standardized coefficients		F	Correlations			Tolerance	
	b	St. error		Zero order	Partial	Part	Before	After
Marital Status	0.088	0.031	0.013	0.039	0.012	0.092	0.019	0.023
Children	-0.114	0.071	1.288	-0.096	-0.128	-0.106	0.884	0.832
Area	**0.248**	0.082	8.036	0.119	**0.247**	**0.212**	0.748	0.873
Gender	-0.173	0.080	1.848	-0.103	-0.171	-0.133	0.746	0.786
Age	0.198	0.076	1.340	0.189	0.126	0.109	0.827	0.984
General education	0.202	0.017	5.733	**0.273**	0.225	0.101	0.865	0.105
Higher education	-0.174	0.057	0.048	-0.126	-0.193	-0.167	0.863	0.877
Income	**0.216**	0.073	7.520	**0.213**	**0.234**	0.191	0.859	0.861
Farm experience	0.012	0.024	0.028	0.084	0.067	0.088	0.027	0.033
Type of farming	0.019	0.008	0.031	0.102	0.093	0.076	0.062	0.046
Farm size	0.192	0.007	2.056	**0.222**	0.130	**0.295**	0.822	0.964
Irrigation water	**0.221**	0.011	7.110	0.126	**0.231**	**0.206**	0.874	0.107
Main cultivation	-0.093	0.019	0.011	-0.048	-0.033	-0.029	0.862	0.962

Nevertheless, the most interesting model outputs are the relative importance measures of the independent variables (Pratt, 1987) which show that the most influential factors predicting the decision to adopt (or not) water saving irrigation practices correspond to “high income” (accounting for 27.1%), followed by “more than 10ha farm size” (21.7%), “more than 45 years old” (15.9%), “nine or more years old” (14.1%) and “Prefecture of Kozani” (12.8%). The total percentage of the dependent variable which is explained by the above mentioned estimated five independent variables is calculated in the last column of Table 4. In particular, the additive importance of the estimated model variables accounts for 91.6% of the total explanation of the “adoption of water saving irrigation practices”. The lack of multicollinearity becomes apparent from the very high values of the tolerance of the independent, values that express the participation of the variance of each independent variable that cannot be explained by the remaining independent variables (Table 3).

Table 4. Relative importance measures

Relative Importance					*Total Explanation*
Area (Kozani) (0.128)	High Income (>30,000€) (0.271)	Nine or more years of education (0.141)	More than 45 years old (0.159)	Big farm size (>10ha) (0.217)	(91.6%)

5. Conclusions

The way to achieve sustainability in irrigation water management is to balance the benefits between current and future generations resolving the conflicts arising from the interactions between water use and the environment. Globally, to achieve sustainability, it becomes more urgent than ever before while the adoption rates of water saving practices are not quite satisfactory.

The current status of irrigation water management in the study area demonstrates the Western Macedonian Region as a prime example for unsustainable irrigation development. In particular, it becomes clear that although irrigators have adopted several more efficient water technologies and several improved management practices lessons from the study area show that the current irrigated agriculture cannot be sustained in a sustainable manner. Improvements in the current infrastructure, including several water saving practices are recommended to sustain both agricultural production and the environment in the region. On the other hand, to encourage adoption, significant incentives in the form of (cash or interest) subsidisation are required.

The employment of two-step clustering model clearly demonstrates the importance of sample stratification into four discrete groups of farmers as the drivers for the adoption of water saving irrigation practices are entirely different among these groups. Thus, the input of new policy measures, in order to encourage any desirable use of water saving practices, should be specifically targeted towards these segments of the farmers, taking into account the specificities of each group.

On the other hand, the current findings suggest that the objective of a 20% increase in the water efficiency required in study area is rather unlikely to be achieved in the short term. Thus, in order to achieve the above mentioned objective, more emphasis should be placed upon promoting the adoption of more efficient water saving practices. This will probably require extension campaigns as well as more research on the adoption of such irrigation practices among farmers.

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