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Authors: Samir Belaidi & Amine M. Benmehaia

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The Selection of Modern Irrigation Technologies Within a Rural Community in Algeria: Stated Preferences Approach

Samir Belaidi
Research Center in Applied Economics for Development (CREAD)
Algiers, Algeria
s.belaidi@cread.dz

Amine M. Benmehaia
Department of Agricultural Sciences, University of Biskra
Biskra, Algeria
ma.benmehaia@univ-biskra.dz

Abstract

This study aims to provide insights into the adoption process of new irrigation technologies within a rural community situated in the Mitidja Plain, Algeria. The study employs the stated (direct) preferences approach to explain the various obstacles and motivations faced by irrigators when considering the adoption of water-saving irrigation techniques. A representative sample of 136 farms (29%) was selected through a random sampling procedure, and a structured questionnaire was specifically designed for data collection. The findings highlight the significance of the direct preferences approach in validating critical factors that influence the non-adoption of water-saving technologies. Credit constraints, limited access to subsidies, high investment and information costs, and complexities related to land tenure emerged as the primary reasons hindering the adoption process. Besides, the study reinforces econometric conclusions by demonstrating that resource costs play a pivotal role in motivating farmers to embrace resource-conserving technologies. This study provides essential insights to support irrigated perimeter managers in successfully implementing projects for the adoption of new irrigation technologies among farmers.

Keywords: Adoption choice, water-saving irrigation technologies, stated preferences, Algeria

La sélection des technologies d’irrigation modernes au sein d’une communauté rurale en Algérie : Approche des préférences déclarées

Résumé

Cette étude vise à fournir un aperçu du processus d'adoption de nouvelles technologies d'irrigation au sein d'une communauté rurale située dans la plaine de la Mitidja, en Algérie. L’étude utilise l’approche des préférences déclarées (directes) pour expliquer les divers obstacles et motivations rencontrés par les irrigants lorsqu’ils envisagent l’adoption de techniques d’irrigation économes en eau. Un échantillon représentatif de 136 exploitations (29 %) a été sélectionné par une procédure d'échantillonnage aléatoire et un questionnaire structuré a été spécialement conçu pour la collecte de données. Les résultats soulignent l'importance de l'approche des préférences directes dans la validation des facteurs critiques qui influencent la non-adoption de technologies économes en eau. Les contraintes de crédit, l'accès limité aux subventions, les coûts élevés d'investissement et d'information et les complexités liées au régime foncier sont apparus comme les principales raisons entravant le processus d'adoption. En outre, l'étude renforce les conclusions économétriques en démontrant que les coûts des ressources jouent un rôle central dans la motivation des agriculteurs à adopter des technologies économes en ressources. Cette étude fournit des informations essentielles pour aider les gestionnaires de périmètres irrigués à mettre en œuvre avec succès des projets d'adoption de nouvelles technologies d'irrigation parmi les agriculteurs.

Mots-clés : Choix d'adoption, technologies d'irrigation économes en eau, préférences déclarées, Algérie

1.0 Introduction

The preservation and rational use of water resources are crucial aspects of achieving sustainable agricultural development on a global scale. However, in many regions worldwide, the water demand exceeds its supply, leading to intensified competition among various economic sectors for this scarce resource. Water plays a vital and limited role for all users, including farmers, residential customers, and industrial producers.

In Algeria, agriculture is the main user of water, and water scarcity, which differs from one region to another, remains the most impeding problem for the development of Algerian agriculture. Due to Algeria belonging to the Middle East and North Africa (MENA) region, and with nearly 87% of its territory classified as desert, its average annual rainfall varies from 1600 mm in the extreme northeast to 12 mm in the extreme southwest (Mouhouche, 2012; Food and Agriculture Organization of the United Nations [FAO], 2015). However, the average rainfall across all zones of the territory is only about 89 mm (FAO, 2015). The analysis of rainfall data reveals significant disparities in precipitation across different geographical regions. Coastal areas exhibit substantial precipitation levels, with values reaching 400 mm in the west, 700 mm in the center, and 900 mm in the east. The mountainous regions of the Atlas Tellien display even higher precipitation, ranging from 600 mm in the west to a range of 700-1000 mm in the center and 800-1000 mm in the east. In contrast, the High Plains show more moderate levels, with stable values of 250 mm in the west and center but reaching 400 mm in the east. The Saharan Atlas regions feature variable precipitation, with 150 mm in the west, 200 mm in the center, and a range of 300-400 mm in the east. Finally, the Sahara records the lowest precipitation, ranging from 20 to 150 mm in all directions. These records highlight the diversity of precipitation patterns and provide crucial insights for understanding regional climate variations. (Ministry of Territorial Planning and the Environment [MATE], 2010). Indeed, according to data from the Ministry of Agriculture and Rural Development (MADR) (2019), there has been a significant increase in the allocation of water resources to agriculture. In 2018, approximately 70% of the available mobilized water, totaling 8 billion m^3, was directed towards agricultural purposes, a stark contrast to the less than 40% observed in 2000, which amounted to 1.8 billion m^3.

Despite the strategic importance of the agricultural sector, given its contribution to the national economy and the active population in this sector, which remain considerable, according to Bessaoud et al. (2019), agriculture accounts for about 12.2% of GDP and employs 25% of the country's labor force. Given the available resources, Algerian agriculture is still far from its real potential. The country's water potential is estimated at twenty billion m^3 per year, of which only 75% are renewable (60% for surface water and 15% for groundwater), the current mobilization capacity is only nine billion m^3/year, corresponding to the 81 existing dams (Ouamane et al., 2022). Additionally, Mozas and Ghosen (2013) report a water potential estimate of 18 billion m^3 per year, with 10 billion m^3 in surface runoff in the northern regions and 0.5 billion m^3 in surface runoff in the Saharan regions. Similarly, Bouchedja (2012) suggests that the water potential of Algeria averages around 17.20 billion m^3 per year, with 10 billion m^3 in surface runoff in the North and 0.2 billion m^3 in surface runoff in the Sahara.

However, despite the water scarcity in the country, the poor distribution of this resource in space and time leads to shortages and conflicts of use over a large part of the national territory. The rapid population growth and expanding irrigation practices added further tension to water resource use and confronted the coastal aquifers with the problem of saline intrusions. On the other hand, resource management has so far mainly focused on the mobilization of new resources. The Algerian government policy on water management, initiated ten years ago, has focused more on the mobilization of new resources than on the search for better use of available water (Benblidia, 2011). Faced with the rise in demand for water, the priority was to develop the supply, as evidenced by the preponderant share granted to the investment budgets for large hydraulics (dams, exploitation of deep aquifers, desalination, large water transfers) (Mozas & Ghosen, 2013). The water mobilization infrastructure, such as the number of dams, has experienced significant growth over the past 50 years. From 13 operational dams in 1962, the number increased to 78 dams in 2018 and is projected to reach 124 dams by 2030 (Kherbache, 2020). Similarly, the number of wastewater treatment plants (WWTP) increased from 12 active stations in 1999 to 177 in 2016 (Kherbache, 2020). At the end of 2021, fourteen (14) desalination stations were operational, currently contributing 17% to the water supply, with a daily production volume exceeding 2.1 million cubic meters of potable water. The total investment for these desalination plants and two associated power stations is estimated at over USD 3.3 billion (Programme des Nations Unies pour le développement [PNUD], 2023). The equipped area for water management reached 225,304 hectares (ha) in 2017, compared to 156,000 ha in 1999 (Kherbache, 2020).

In addition, there is little funding devoted to the preservation and maintenance of existing installations or improving the performance of irrigation distribution systems. The decrease in the quantities of surface water collected, the lowering groundwater levels, the increase in demand for water, and the imperative to increase the productivity of the irrigated agricultural sector are all reasons that plead in favor of a rationalization of the use of water for irrigation. This rationalization inevitably involves improving the efficiency of the techniques used and/or introducing more water-efficient techniques. The reorientation towards management of demand and not only of supply is, therefore, a major concern that fits well into the new policy of irrigation water today. The margins for water savings in terms of irrigation water demand appear significant, as excessive consumption often surpasses crop requirements.

An incentive policy for the adoption of new water-saving technologies (WST) has been initiated, allowing farmers to benefit from subsidies for investment in irrigation equipment. Since 2014, efforts to promote irrigation development and water conservation have prioritized activities, including drilling or well construction, installing pumping equipment, establishing storage basins, and implementing water-saving irrigation systems. This support, outlined in the Ministerial Decision No. 943 of 2014 (MADR, 2014), varies from 50% to 60% depending on the usage type (individual or collective) and the geographic regions within the country (North or Grand South).

The adoption of WST in agriculture is an important process for both economic and environmental reasons, such as increasing agricultural productivity and saving water resources. However, recent literature shows that even when water is saved at the plot level, water demand tends to increase at other scales, such as at the farm or regional level (Ward & Pulido-Velazquez, 2008; Batchelor et al., 2014; Grafton et al., 2018). Efficient water supply systems, such as drip irrigation, can help increase crop yield potential and improve water and fertilizer use efficiency (Badr et al., 2010).

This study aims to gain a deeper understanding of the adoption process of new irrigation technologies within a rural community, specifically focusing on the Mitidja Plain. By uncovering the motivations and obstacles faced by stakeholders in adopting new irrigation technologies, this research aims to provide valuable reflections for irrigated scheme managers to enhance the success of projects and promote the adoption of WST in Algeria. It turns out that the empirical literature on the adoption of irrigation technologies is dominated by the revealed preference approach, where the actors' motives are considered unobserved. Unlike previous studies on this region that attempted to reveal the determinants of WST adoption (Salhi et al., 2012; Belaidi, 2013; Belaidi et al., 2019, 2022), this study uses a more realistic approach, that of declared preferences, to highlight the real motivations and obstacles of the actors vis-à-vis a new irrigation technology. The irrigated schemes of the Mitidja plain[1], large in terms of the extent of its fertile and productive land and important in terms of its water resources, still today experiences the predominance of traditional gravity irrigation techniques. [2] The shortage of water resources and their fluctuation according to climatic conditions have imposed a new perception of irrigation on the perimeter. Major irrigation modernization efforts have been made to improve irrigation efficiency. They have allowed the introduction of certain techniques that are more efficient than traditional gravity irrigation. However, in practice, these techniques have not been able to be introduced in a significant way by farmers, and the conversion of traditional irrigation comes up against technical and socio-economic constraints. A very significant evolution of water-saving irrigation technologies between 2000 and 2018 has been recorded, probably due to these support programs. The area irrigated with drip irrigation increased from 5,000 ha in 2000 to 312,788 ha in 2018, while sprinkler irrigation increased from

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[1] Irrigation in the Mitidja Plain is divided into two main areas. Firstly, the Mitidja East perimeter, also known as the Hamiz perimeter, was built during the colonial period and commissioned in 1937. It covers an equipped area of approximately 17,500 irrigable hectares from the Hamiz dam and the Réghaia Marsh. On the other hand, the Mitidja West perimeter is located at the extreme west of the Mitidja Plain. It is organized into three distinct irrigation zones: (1) the Sahel Algiers perimeter, located in the Tipaza Wilaya, began operation in 2005 with an area of 2,888 hectares; (2) the Mitidja West irrigation perimeter slice I, located in the Blida Wilaya, started operation in 1989 with an area of 8,600 hectares; and (3) the Mitidja West perimeter slice II started operating in 2004 and covers an area of 15,600 hectares, shared between the Tipaza Wilaya (14,400 hectares) and the Blida Wilaya (1,200 hectares).

[2] For a comprehensive literature on agriculture in the Mitidja plain, see Imache et al. (2011).

70,000 ha to 444,706 ha during the same period. Gravity irrigation, on the other hand, increased by 108.43%, from 275,000 ha in 2000 to 573,175 ha in 2018 (MADR, 2019). However, there is a strong disparity in these rates and a compensatory effect between regions. For example, the Blida region is one of the main agricultural regions of Algeria, with the majority of its area located in the famous Mitidja Plain. According to MADR (2019) report, it had 24,700 ha under gravity irrigation, only 4,017 hectares under drip irrigation, and 3,563 hectares under sprinkler irrigation, accounting for 76.50%, 12%, and 11%, respectively, relative to a total irrigated area of (32,280 ha).

2.0 The Choice of Adoption of an Irrigation Technology: A Conceptual Framework

This study addresses two aspects that are of paramount importance: water-saving irrigation technologies (WST) and their adoption, which form the crux of ongoing water-saving debates, and the theory of stated preferences, which serves as a central component of our methodology. Stated preference (SP) surveys are commonly utilized by transportation planners to analyze the effects of transport policies on travel demand (such as Louviere & Timmermans, 1990; Hensher, 1994; Hensher et al., 1988; Fujii & Gärling, 2003).

2.1 Adoption of Water-Saving Irrigation Systems

The development of modern irrigation techniques must aim to optimize water usage, along with other essential inputs, and similarly to enhance the sustainability of agricultural production. Selecting the appropriate irrigation technology involves complex considerations, often with conflicting factors, contingent upon physical and socio-economic conditions. In regions where water scarcity is acute, the foremost priority lies in enhancing water use efficiency. Conversely, in areas with limited capital, the focus may shift toward identifying irrigation techniques with minimal capital requirements.

The review of the main empirical evidence from previous research was made from the analysis of farmers' statements and statistical observations. From the perspective of farmers, however, things can be quite different. In Algeria, for instance, farmers' reasons for adopting new irrigation technologies were linked to reduced working hours, labor savings, and the ability to practice fertigation (Salhi et al., 2012). In Tunisia, these reasons were related to the reduction of water consumption, an increase in yields, the reduction of working time, and the use of inputs (Foltz, 2003). In the United States, they relate to water costs, groundwater use, stone fruit production, differences in geographical locations, water prices, extension service, land slope, soil permeability, size of farm, source of water supply, and type of crop (Caswell & Zilberman, 1985; Moreno & Sunding, 2003). In Greece, these reasons are related to production risk, land quality, age, level of education, farm aridity index, debts, access to irrigation advice, profit from income outside agriculture, the nature of the farm (family or not), access to information (formal and informal channels), water costs, crop prices, land quality (Koundouri et al., 2006; Genius et al., 2014).

In India, they are linked to less demand for labor, subsidies provided, similar production, water scarcity, higher productivity, good water use efficiency and the possibility to irrigate steep slopes, education, social status, availability of cash, access to groundwater, production of high value-added crops (Namara et al., 2007; Chandran & Surendran, 2015, 2016). Other reasons cited in Spain, Morocco, and Zambia relate to ease of use, reduced labor costs or the ability to irrigate sloping land (van der Kooij, 2009; Benouniche et al., 2011; Tuabu, 2012; Sese-Minguez, 2012; van der Kooij et al., 2013).

The main reasons for the adoption of water-saving irrigation technologies explained by farmers, therefore, refer mainly to the easier organization of work, then to the reduced labor requirements, lower water consumption, the ability to irrigate sloping plots, and achieving higher yields. The efficient organization of working time and labor considerations play pivotal roles in farmer'' decision-making processes. Surprisingly, these factors are not the primary motivations for authorities supporting localized drip technology. Furthermore, some researchers are also interested in the causes of the non-adoption of more efficient irrigation technologies by farmers in regions where these technologies are strongly encouraged. For example, in China, these reasons relate to the lack of social stability, a prioritization favoring other livelihood strategies, a lack of technical knowledge, market risks, and problems related to land tenure (Burnham et al., 2015). In India, installation costs, clogging of drippers, difficulty in obtaining subsidies, and fear of change or loss of yield are noted by Chandran & Surendran (2016). The reasons noted in Algeria and Tunisia relate to budgetary constraints, difficulty in accessing credit, and lack of time (Foltz, 2003; Salhi et al., 2012). Mention to the lack of relevance of the technology with regard to the objectives pursued is only noted in Tunisia, where 6% of the farmers questioned mention this argument (Foltz, 2003).

Based on the existing empirical literature, the non-adoption of more efficient irrigation technologies, as perceived by farmers, is predominantly influenced by practical constraints. In contrast, from the perspective of authorities advocating these technologies, the primary reasons for their support are largely attributed to their potential for water savings, increased yields, and enhanced economic productivity. However, it is important to note that the reality perceived by farmers presents a less straightforward picture. Farmers' explanations for adopting these technologies revolve around the facilitation of work organization, reduced labor requirements, lower water consumption, the feasibility of irrigating sloping plots and achieving higher yields.

This brief overview of the empirical literature highlights that the measurement of technical efficiency is a continuously evolving research domain, enriched by numerous advancements. Building upon the analysis of previous studies, we have embraced a more pragmatic methodological approach—the stated preference approach—to investigate the factors that may either motivate or impede the adoption of water-saving irrigation technologies (WSTs) such as drip and sprinkler systems on farms within the Mitidja Plain (Algeria).

2.2 The Theory of Stated (Direct) Preference

The Rational Choice Theory allows us to assess the probabilities of new technology adoption by representative individual farmers or farms. This theory operates under the assumption that rational economic reasoning, driven by the maximization of an objective function under constraints, guides individual decision-making. The likelihood of technology adoption is explained by correlating the realizations of the discrete variable to be explained with those of several explanatory variables, which can be qualitative or quantitative in nature. This relationship is established using either the distribution function of the normal law (probit model) or the distribution function of the logistic law (logit model).

The importance of preferences in the analysis of decision-making mechanisms is presented by Tversky et al. (1988) as follows: The relationship of preferences with the choice of actions and options constitutes the essential element of decision theory and provides the basis for the measurement of utility. Hence, observable behaviors reveal the preferences of their actors. The latter are considered rational, consistently seeking to optimize their satisfaction and individual well-being.

Rational choice theory is formulated by relating the level of individual utility to the general well-being of an individual. The utility level is, in turn, predetermined by the satisfaction of preferences. The bases of this theory are briefly presented in the following: classical theory has linked the internal consistency of preferences to the verification of three main axioms (Varian, 1992). The first is the axiom of complete preferences means that individuals always know what they want. The second is the axiom of reflexivity, which indicates that each choice is always as desirable as itself or that preferences are stable. Finally, the third, called the axiom of transitivity, provides information on the ability of individuals to compare the benefits of their choices in a way that is always logical.

Varian (1992) defined revealed preferences in terms of observable choices. Only apparent choices in the form of measurable behaviors are thus considered. Stated preference methods are distinguished by the fact that they can contribute to revealing choices that other methods cannot reveal. Preferences can be classified into two categories depending on whether the analysis of preferences is done before (stated preferences) or after adoption (revealed preferences) (Alriksson & Öberg, 2008). The stated preference approach allows an a priori assessment of adoption and is better suited to assess the adoption potential of innovation as well as to weigh the determinants influencing the choice of adoption (Roussy et al., 2015). In revealed preference models, the preference parameters are assumed to be an unobserved random variable with mean zero and constant standard deviation. We then used observations of their behavior and information on their characteristics to obtain their technological preference. Using observations of farmers' behavior and information on their characteristics, a set of preferences and motivations for their actions were interpreted. This dictates an interpretation of farmer motivation from correlations of farmers' behavior and characteristics that may overestimate motivation to characteristics rather than individuals' stated preferences. Only if these characteristics (e.g., wealth, level of education) fully determine or strongly correlated with preferences, do we not have this problem of misidentifying types of individuals who could adopt.

In many cases, observation of behavior can lead to misidentification of the cause by attributing it to characteristics rather than stated preferences. As Lewin (1996, p. 1293) notes:

> In many circumstances, observations of behavior are quite poor (or even misleading) data for determining which preferences an individual possesses; Non-behavioral information, such as verbal communication, may be much more revealing of individual motivation, especially when moral considerations dominate choice.

For example, estimates of statistically insignificant coefficients of labor resources have been interpreted as indicating that this is not a major motivation for farmers to adopt a WST. However, it cannot be deduced from this information that farmers are not concerned about the labor scarcity on their farms. The impediment from a political point of view is to direct policies towards characteristics rather than preferences. Instead of assuming that preferences are unobservable for the econometrician, although known to individuals, we could instead ask individuals for their real preferences. We therefore turn to a direct explanation of the determinants of technology adoption decisions by farmers: asking farmers why they have adopted a technology or not. Obtaining direct statements on preferences, although common in sociological and psychological studies, remains rare in economics.

Economists generally prefer revealed preference methods because they are supposed to be consistent and more independent of measurement problems. Measurement problems in revealing preferences arise from the inability of respondents to adequately describe their choice process, the dependence of the response on the question formulation, and the subjective nature of the preferences itself as data.

3. Research Methodology

The study was carried out within the irrigated scheme of West Mitidja, located in the province of Blida, Algeria. The total irrigated area in this province spans 32,280 hectares, with the distribution of irrigation systems as follows: 76.52% for gravity systems, 11.04% for sprinkler systems, and 12.44% for drip irrigation.[3] The West Mitidja perimeter, specifically Tranche 1, benefits from irrigation water supplied by the Bouroumi dam, making it an agricultural area of paramount importance. While most of the agricultural land in this perimeter belongs to the State, it is cultivated by farmers who hold use rights in the form of collective and individual farms. The region boasts a diverse array of agricultural activities, from which farmers derive their income. Key crops grown in the area encompass cereals, citrus fruits, orchards (peach, apricot, apple, and pear), vegetables, and greenhouse crops.

To investigate farmers' attitudes towards the adoption of water-saving technologies (WST) in this region, a structured questionnaire[4] was employed to interview representatives from various types of farms, including EAC (State collective farms), EAI (Individual State farms), and private farms.[5] Using a stratified random sampling method, the ONID database, comprising 473 farms in the region, was divided into three distinct strata based on land ownership type. A random selection of farms was then performed within each stratum, ensuring adequate representation of each group of landowners. As a result, 136 farms were selected within the irrigated perimeter of West Mitidja. This chosen sample is considered to be highly representative of the entire rural population in the study region.

In this study, the stated preferences approach is used in order to analyze farmers' choices in terms of adopting WSTs. This approach was developed by Lewin (1996), Alriksson & Öberg (2008), Asrat et al. (2010), Espinosa-Goded et al. (2010), Blazy et al. (2011), Beharry-Borg et al. (2013), Kuhfuss et al. (2014), in response to criticisms of the revealed preference approach in neoclassical economic theory.

In recent years, the revealed preference approach has been extensively utilized in the irrigation sector to understand the complex decision-making process behind farmers' choices of irrigation technologies. This approach assumes that farmers adopt new irrigation technologies through a thoughtful cost-benefit

[3] According to the MADR (2019).
[4] Many preliminary surveys were used in order to minimize hypothetical bias or social desirability bias.
[5] Collective farms (EAC) have at least three members, with a strong dynamic of informal individualization; and individual farms (EAI) are farmland in the public domain with 40-year concession rights (Official Journal of the Republic Algeria, No. 46 of 18/08/2010, No. 10-03 of 15/08/2010). Private farms are owned by their owners (Decree 90-25 of 18/11/1990).

analysis, particularly in situations of uncertainty (Richefort, 2008). In contrast, economic studies have rarely explored the use of the stated preferences approach, which involves obtaining direct statements from individuals about their preferences. Surprisingly, this approach has seldom been applied to the specific problem of farmers' selection of irrigation technologies, despite its potential advantages. It was initially developed to analyze the diffusion and adoption of environmentally beneficial technologies by producers. Rather than assuming that preferences are unobservable to the observer, despite being known to individuals, we propose a simpler and more direct method: asking farmers directly about the reasons behind their decisions to adopt or not adopt a particular technology.

Economists widely favor revealed preference methods due to their internal consistency and perceived independence from measurement issues. However, when obtaining direct preferences from respondents, measurement problems can arise. Nevertheless, with a diligent and well-structured sampling procedure, these measurement challenges can be effectively addressed, offering valuable insights into farmers' motivations and decision-making processes.

4.0 Results and Discussion

This section starts with the exploration of the survey results in the first subsection. Subsequently, in the following subsection, we present the analysis and compare it with the revealed preference approach adopted by previous studies in the same study region (Salhi & Bedrani, 2007; Salhi et al., 2012; Belaidi, 2013; Azzi et al., 2018; Belaidi et al.,2019, 2022).

4.1 Analysis by Stated Preferences

The choices facing farmers are multiple. Farmers can decide to keep their current technique or adopt a technique that improves land or water productivity. To apply the stated preferences method, each technology adopter was asked about the main reasons for choosing drip irrigation. The findings of this inquiry are presented in Table 1. However, farmers acknowledged the impact of adopting technical innovations on the economic profitability and yield of their agricultural productions. The results indicated that adopters of water-saving technologies (WST) experienced benefits comparable to those observed at experimental stations. Their primary motivation for adopting drip irrigation lies in its water-conserving attributes, with a majority stating this as one of the two main reasons for adoption.

Table 1. *Results of Stated Preferences on the Reasons for Adopting a WST*

Reasons for adopting a WST	**Water saving**	**Improving yield**	**Savings on labor**	**Savings on inputs**	**Others***
	(1)	(2)	(3)	(4)	(5)
N = 64 adoptors	30%	55%	44%	16%	5%

* Other reasons why farmers have adopted a WST are to reduce the risk of certain diseases. A farmer may have one or more reasons, the total may exceed 100%.

The results indicate that the adoption of WST primarily hinges on the potential productivity gains enabled through its implementation. Notably, a substantial proportion of farmers (30%) experienced significant potential yield increases from adopting drip irrigation. However, these yield gains were overshadowed by the conservation benefits associated with reduced usage of inputs such as water, labor, and chemicals. This evidence supports the notion that resource constraints play a predominant role in farmers' decisions to adopt the new technology. It suggests that those who have adopted the technology are driven, at least partially, by the desire to conserve their resources. However, the question remains: why are non-adopters refraining from investing in this new technology if its benefits in terms of resource conservation and potential yield gains are evident among adopters?

Table 2 presents the results of questions posed to WST non-adopters regarding their reasons for not adopting drip or sprinkler irrigation. The most frequently cited reasons are as follows: (1) Capital constraints: Many farmers indicated that financial limitations are a significant barrier to adopting new irrigation technologies; (2) Land tenure insecurity: The establishment of a 40-year concession on agricultural holdings (EAI and EAC) in the private domain of the State since 2010 is perceived as a setback by the farmers surveyed, compared to the previously enjoyed right to perpetual enjoyment of their land (3) Lack of subsidies for equipment: The absence of financial assistance for acquiring irrigation equipment is seen as a hindrance to technology adoption; and (4) Limited access to irrigation advice: The non-availability of proper guidance and support in adopting the new technology was cited as another reason for non-adoption. These are the main reasons why they did not adopt the new technology.

Table 2. *Results of Stated Preferences on the Reasons for not Adopting a WST*

Reasons for not adopting a WST	**Lack of (or costly) capital**	**Land tenure**	**Difficulties in subsidy access**	**Lack of technology knowledge**	**Old orchards ***	**Water availability ****
	(1)	(2)	(3)	(4)	(5)	(6)
N = 72 non-adoptors	70 %	56 %	42 %	28 %	14 %	8 %

* Farmers say this technique would not be suitable for older plantations, because they would have developed their root system based on gravity irrigation.
** Farmers say that water is plentiful, whereas introducing WSTs is not justified.

The results indicate that the adoption of more efficient water-saving techniques and practices depends primarily on farmers' financial capacity to invest. Acquiring new irrigation technologies involves significant financial outlay, which poses a substantial challenge for farmers. In fact, 70% of respondents cited a lack of liquidity or high investment costs as the primary obstacles to adoption. In the Mitidja region, most farmers frequently encounter credit constraints. Access to agricultural credit represents a major hurdle for agricultural investments in the study area. Our survey reveals that only 27% of all farmers surveyed have access to agricultural credit. Moreover, for those who are renting land, there is an additional financial burden in the form of rent payments, further limiting their investment capacity.

Farmers whose land tenure is unstable and insecure, meaning their right to the land is not secure, face significant obstacles when it comes to making long-term investments necessary for technology adoption. Our survey findings reveal that 58% of farms operate on a rental basis, while only 42% are owned by their cultivators (assignees of EAC and EAI). For farmers with uncertain land tenure, the risk of eviction looms, making it impractical for them to invest in anything with long-term benefits or fixed assets on the land. This uncertainty hampers their ability to adopt new technologies that require sustained investment and commitment.

In response to the financing challenges that may discourage farmers from adopting irrigation technologies, public authorities have implemented an investment incentive policy. This intervention involves a range of economic measures aimed at reducing the costs of necessary investments. The most significant measure employed in this incentive framework is the subsidy offered to farmers for their investments. By providing financial support through subsidies, the authorities aim to encourage farmers to adopt water-saving irrigation technologies and overcome the hurdles posed by high initial investment costs. This policy seeks to promote sustainable agricultural practices and enhance water efficiency, benefiting both farmers and the environment.

However, the challenges in accessing subsidies explain the relatively low adoption rate. In fact, 42% of farmers state that obtaining equipment subsidies is difficult. The more farmers face difficulties in accessing these subsidies, the less likely they are to adopt WST. Moreover, a significant number of farmers in the irrigated perimeter of West Mitidja report that they have not applied for subsidies due to unfavorable administrative conditions. These conditions include bureaucratic processes, slow review of applications, and difficulty in accessing credit. Another hindrance is the requirement that all recipients of an EAC must sign off on subsidy or credit applications, while many EACs are embroiled in long-lasting conflicts. This disagreement among EAC members makes it challenging to apply for subsidies or obtain credit. Survey results indicate that the majority of farms in the region are EACs, accounting for 84% of the sample, with 62.5% being internally divided EACs and 21% being in a union. In contrast, individual and private farms constitute a minority, making up only 16% of the sample. As a result, subsidies are not accessible to all operators, particularly tenants, and assignees entangled in conflicts within the EACs. Among the selected sample, only 22% of WST adopters received the grant. This further highlights the difficulties farmers face in obtaining subsidies and how it affects their decisions regarding technology adoption.

Equipment subsidies have demonstrated their effectiveness in expediting the adoption of new irrigation technologies, provided specific conditions related to farmers' characteristics and the nature of the technologies are met. However, when it comes to technologies like drip irrigation, which entail higher risk and complexity, subsidies alone might not suffice to drive adoption. In such cases, coupling subsidies with other supportive measures becomes essential. One such complementary instrument is guided assistance and extension services for irrigation. By offering guided assistance and extension services, farmers receive additional support and training, which proves valuable in managing the complexities of adopting technologies like drip irrigation. This combination of equipment subsidies and guidance aids in enhancing the adoption rate and promoting sustainable water-saving practices in agriculture.

One of the main obstacles hindering the adoption of new WSTs is the lack of skills and knowledge among irrigators, with 28% of them citing this as a reason. It is crucial to highlight a common concern among all farmers, which is the inadequate agricultural supervision and extension services in the irrigated perimeter of Mitidja West. Survey results indicate that access to extension institutions remains extremely limited for the surveyed farmers, with only about 9% receiving visits from extension agents. The study reveals that farmers in the region have minimal contact with support and extension structures and have not benefited significantly from the services provided by agricultural extension agents from municipal extension agencies. This deficiency in interactions with public agricultural advisory and research organizations poses a significant obstacle to the effective dissemination of WST. Despite the proximity of several technical institutes—such as the National Institute of Soil, Irrigation and Drainage (INSID), National Institute of Agronomic Research of Algeria (INRAA), Technical Institute for Field Crops (ITGC), Technical Institute of Fruit Arboriculture and Vine (ITAFV)—public intervention in terms of extension services in Mitidja is lacking. Extension and advisory programs primarily rely on mass methods, such as technical demonstrations in agricultural chambers, distribution of technical brochures, radio and television spots, and telephone messages, as observed in the case of the National Office of Irrigation and Drainage (ONID), for instance. However, these methods have proven to have a limited impact. Additionally, there is a lack of coordination between institutions responsible for disseminating research results in a productive environment, further hindering the adoption of WST among farmers.

A fraction of 14% of farmers express concerns that new WSTs might not be suitable for old orchard plantations due to the well-established root systems developed under gravity irrigation. The dissemination of new WSTs remains limited to specific crops cultivated by relatively affluent farmers who are well-integrated into the local market, especially for fruits and vegetables. However, for trees in older orchards traditionally irrigated using furrows, their extensive root systems, which have adapted to seek deeper groundwater, might not be compatible with drip or sprinkling techniques. Consequently, these farmers believe that transitioning to drip irrigation could result in lower yields for such orchards. This statement highlights the need for a comprehensive analysis to explore the causal relationship between changes in irrigation technique and potential declines in yield. It is crucial to recognize that localized irrigation techniques are most effective for new plantations, and there might be a mismatch between the root magnitude of mature orchards and the requirements of a drip irrigation system. Hence, when considering the adoption of WST, special attention must be given to the specific characteristics and age of the orchards to ensure the suitability and effectiveness of the chosen irrigation technology.

It is reasonable to assume that a farmer who does not require the reduced input usage offered by drip irrigation would select reason—water availability. However, the remarkably low number of farmers choosing this option indicates that the resource conservation needs of both adopters and non-adopters are quite similar. This suggests that factors such as credit availability, access to information, and land tenure constraints significantly influence farmers' adoption decisions, hindering their ability to make investments aimed at resource conservation.

Finally, the main obstacles to the adoption of new WSTs, as reported by farmers, are twofold: 56% of them face challenges with the land ownership system, while 42% encounter difficulties in accessing subsidies. However, the most significant hindrance, according to 70% of farmers, lies in financing and investment costs, which they consider the main deterrent to adoption.

4.2 Comparison of the Two Approaches: Revealed Preferences vs. Stated Preferences

The empirical findings of Belaidi et al. (2022) were derived from the estimation of rational choice models, which aimed to elucidate individual decisions regarding the adoption of new WSTs. The models employed included the logit model, used for binary choices of WST adoption, the tobit model, applied to censored values of the WST area, and the poisson model, used for counting data of the WST area. These models were used to study the determinants of WST adoption among the same sample of farmers. Our dataset allowed for an examination of several variables related to agronomic and socio-economic characteristics at the farm level to understand the process of irrigation technology selection by farmers. The main outcomes of the rational choice models highlighted that capital constraints (including access to credit, fixed investment costs, and subsidies), as well as the cost of water extraction, social networks of irrigators, sources of information, and certain aspects of human capital (such as age and level of education), were the primary determinants influencing the choice, rate, and intensity of WST adoption in the study area.

The direct (revealed) preferences approach offers distinct methodological advantages as it avoids assuming that the researcher possesses more knowledge than the farmers being interviewed. By combining revealed preference analysis with direct revelation, credit and information constraints are validated as the primary factors behind non-adoption. Additionally, direct revelation also highlighted land tenure as a reason for non-adoption, potentially indicating a mismeasurement of this variable in the dataset used in rational choice models.

It is important to acknowledge that the particular concerns about land tenure insecurity expressed by those who cited it as a reason for non-adoption may not be adequately reflected in the available measures of tenure insecurity. This is because the social capital and trust necessary for secure land contracts cannot be easily quantified by an external observer. Interestingly, some of the farmers who adopted the new irrigation technologies were operating on farms that they did not own. This implies that certain issues related to moral hazards in land contracts were successfully resolved on these farms, enabling them to adopt the technologies despite not being landowners.

The findings from the direct revelation approach strongly support the following econometric conclusions: farmers are driven to adopt water-saving technologies due to the costs associated with resource usage.; a significant number of farmers in the region likely preferred drip irrigation technologies because of their resource-conserving qualities; the econometric analysis provides robust evidence that farmers are indeed adopting these technologies with resource conservation in mind; and interestingly, the farmers themselves are well aware of the resource-saving benefits when making their adoption decisions.

In the region, all farmers experienced a ‘new drilling cost’ shock, which led them to prioritize water conservation technologies. However, this preference for water-saving techniques resulted in only a minority of farmers actually adopting this technology, as they encountered various other constraints that hindered widespread adoption.

The direct revelation method demonstrates that equipment subsidies can effectively accelerate the adoption of new irrigation technologies, provided that certain eligibility conditions are met. Additionally, the results of this approach confirm that the adoption of water-saving technologies is a substantial investment, requiring significant financial capacity from farmers. Moreover, the direct revelation approach highlights that potential gains in productivity through technology adoption strongly influence farmers' choices. Furthermore, this method reveals other obstacles, such as the complexity of more efficient water-saving technologies, which depend on farmers' initial levels of training and improve over time through interactions with irrigation equipment suppliers and fellow farmers in association networks. Access to better information on technologies and the required skills can significantly impact individual technological choices. Additionally, the aging of orchards and the abundance of water, which may not justify the use of water-saving technologies, are also factors that come to light through this approach.

5.0 Conclusion

By trying to provide a better understanding of the adoption process of new irrigation technologies in the rural community of Mitidja Plain, this study utilized a stated preference approach to uncover the actual motivations and barriers faced by local actors toward the adoption of these technologies. The research was conducted within the irrigated perimeter of West Mitidja (Tranche 1), situated in the Province of Blida, Algeria. A structured questionnaire was administered to a representative sample of 136 farms, selected using a random sampling procedure, to collect relevant data.

The findings revealed that the decision to adopt new irrigation technologies, namely drip or sprinkler, was primarily influenced by economic factors such as water savings, increased productivity, and cost reductions in production factors. Additionally, risks associated with specific diseases played a minor role in this choice. On the other hand, the decision to stick with gravity irrigation was mostly driven by economic considerations such as financial constraints, land tenure, access to subsidies, and the lack of irrigation advice. Furthermore, the aging of orchards and water availability also factored into this choice, albeit to a lesser extent. The stated preferences approach validated that credit constraints, land tenure, access to subsidies, and information were the key factors contributing to the non-adoption of new technologies. It reinforced the econometric conclusion that the costs of resources were the driving force behind farmers' decisions to adopt resource-conserving technologies.

These results have significant implications for public authorities, particularly the managers of irrigated perimeters. When considering the use of economic instruments to encourage farmers to adopt radical innovations like drip and sprinkling technologies, which entail a major shift in practices, adoption dynamics respond more to a cost-benefit analysis for the irrigators. While investment costs remain a major obstacle, alternative approaches to the current subsidy system could address some of its current limitations. Public authorities could ease eligibility conditions, streamline administrative processes to obtain subsidies, and increase subsidy rates while ensuring verification of product purchase and use. Farmers could also benefit from interest-free loans covering the full cost of water-saving technologies, managed by existing financial institutions, or receive conditional cash transfers to expedite adoption. Furthermore, inadequate efforts in terms of training and support advice for irrigators on irrigation equipment could lead to suboptimal public policies. The establishment and maintenance of on-farm and local demonstrations, showcasing the benefits of promoted water-saving technologies, and involving the active participation of farmers, would enhance awareness and knowledge about these technologies.

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