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The Role of Farmer Personal Characteristics in the Adoption of Localized Irrigation Technology (LIT): Exploratory and Econometric Analysis

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Abstract

In Morocco, one of the most important and effective ways to combat the water crisis is to increase irrigation efficiency through the use of water-efficient irrigation technologies. Among the existing irrigation technologies, LIT has the highest efficiency rate (up to 90-95% irrigation efficiency). However, the adoption of this technology is low and continues at a slow pace.

The main objective of this study is to identify and understand the role of individual variables in the adoption of localized irrigation technology (LIT) by farmers in the Draa-Tafilalt region. The results of the analysis of data collected by questionnaire from 400 farmers in the Draa-Tafilalt region showed that the variables "Self-Efficacy", "Attitude" and "Education Level" had a positive and significant effect on the probability of LIT adoption at the 1% significance level. On the other hand, the variables "Age" and "Experience" had a negative and significant effect on the probability of adopting LIT at the 1% significance level. While the effect of the "personal innovation" variable on LIT adoption in the Draa-Tafilalt region was non-significant.

The results of this work are of obvious practical and operational significance, as they provide information on the individual factors that condition the successful adoption of LIT by farmers. The results obtained can serve as a guide for action that leads to practical responses to the problems of irrigation water management and valuation in the study area. Our results are therefore beneficial not only to equipment suppliers and consultants but also to public officials responsible for supporting the integration of innovations in agriculture.

Keywords: Adoption, Localized irrigation technology, Logit, Draa-Tafilalt region.
JEL Classification : C51; O13; O31; O33; Q25.
Paper type: Empirical research

1. Introduction

Today, the adoption of innovations in agriculture has attracted a great deal of interest from development economists because the majority of people in developing countries derive their livelihoods from agricultural production. In Morocco, agriculture is one of the most important economic sectors and accounts for a significant percentage of production and employment. It is considered the lever of the national economy. In addition to its contribution to GDP of 13% (Between 2008 and 2018, the weight of GDPA in GDP varied between 12% and 14% with an average of 12.8%), agriculture provides a contribution of nearly 38% to total employment and nearly 73.7% to employment in rural areas and generates more than 65% of rural household income. It is a key sector for the country's economic and social development, given the rural population that depends directly on it, its strategic dimension in terms of food security, and finally its contribution to regulating the balance of trade (18% of overall exports). Despite this strategic importance and given the resources available, Moroccan agriculture is still far from its real potential. According to the report of the High Commission for Planning (Agriculture 2030: What Futures for Morocco?), productivity at the farm level and the performance of the sector are insufficient and the agricultural trade balance is clearly in deficit. This is mainly due to the constraints[1] (including water scarcity) facing the sector, which hamper its development and its role as a catalyst of the national economy. The adoption of water-efficient irrigation technologies (including in particular LIT) is proving to be an unavoidable option to accompany efforts to adapt to climate change coupled with water scarcity and promote sustainable agriculture with high added value. However, the adoption of this technology is conditioned by a number of economic, institutional and social factors that can negatively or positively influence farmers' choice to adopt LIT.

In Morocco, although the switch to LIT has often been proposed as a solution to the problem of water scarcity and despite financial incentives to accelerate LIT adoption. The adoption of this technology is low and continues at a slow pace. The areas currently equipped with this technology represent only a negligible part of the potential[2]. It is therefore important to identify the reasons why LIT is not being adopted to the extent expected. In the literature reviewed several individual, economic, technological and institutional variables were identified as determinants of LIT adoption. In this study we will limit ourselves to the role of individual variables in the adoption of LIT. This study is therefore deficient in addressing the following research question: **To what extent do individual variables influence LIT adoption in the Draa-Tafilalt region?**

The following six sections will help to answer this research question. Thus, the second section presents a review of the literature on the choice of individual variables explaining the adoption of LIT and the related hypotheses. The third section is devoted to the methodology and data. The fourth section deals with the results. The fifth section is reserved for discussion of the results obtained. The final section is devoted to the conclusion and perspectives.

2. Literature review

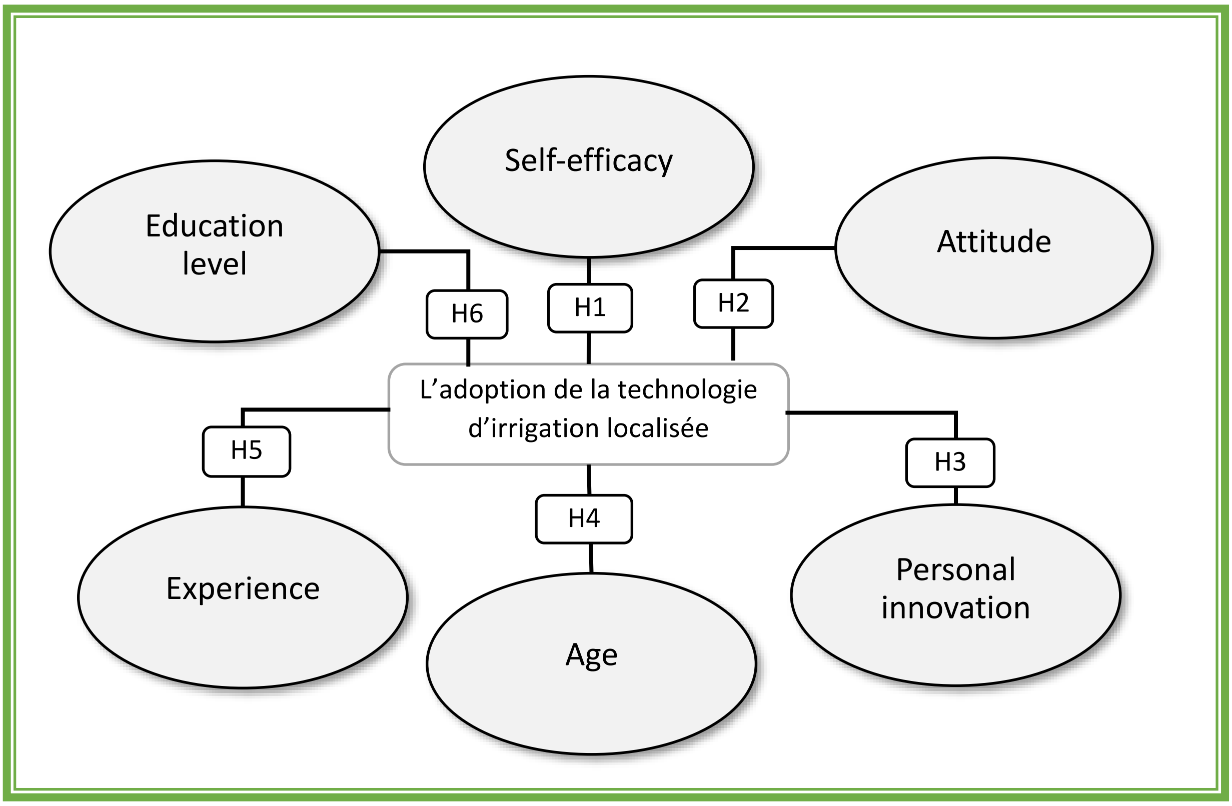
In this study individual factors refer to the driving role that may play the farmer's beliefs and personal characteristics in the adoption of LIT. These factors are seen as facilitators or barriers to the adoption of this technology. In this study and drawing on UTAUT (Venkatesh & al., 2003), the Technology Acceptance Model (Davis, 1986), Social Cognitive Theory (bandura,

[1] These include archaic land tenure structures, lack of human resources, low investment capacity, weak professional organization, insufficient supervision and, above all, climatic dependence materialized by the spatial and temporal irregularity of rainfall.

[2] In 2018, the total equipped area is estimated at 540000 ha (Ministry of Agriculture and Maritime Fisheries, 2019) compared to a total UAA of nearly 8.7 million hectares.

1977), Triandis' Theory of Interpersonal Behavior (1980), and the context of the study area, and in order to construct our conceptual research model (Figure 1) we selected six individual variables: "Self-efficacy", "Attitude", "Personal Innovation", "Age", "Experience" and "Education Level ". In the remainder of this section, we will present the six individual variables selected in this study and the related hypotheses.

Figure 1: The conceptual model that traces the influential relationships between the dependent variable "LIT adoption" and the six individual variables



Source: *Authors*

2.1 Self-efficacy

This variable is inspired by Cognitive Social Theory (bandura, 1977). Self-efficacy, which reflects a person's confidence to perform a particular behavior. It is defined as a set of beliefs about a person's ability to perform a behavior. Little research has been done on the effects of self-efficacy on farmers' behaviors (Momvandi & al., 2018; Amin & al., 2013).

In their study which aims at identifying factors affecting the use of pressure irrigation technologies by farmers, Momvandi & al. (2018) considers that self-efficacy is a person's belief in his or her innate ability to achieve goals. Momvandi & al (2018) examined the relationship between self-efficacy and the use of pressure irrigation technologies by farmers and states that there is a positive and significant relationship between these two variables.

The study by Amin et al (2013), revealed that the influence of the self-efficacy variable on farmers' behavior differs from one country to another. Thus, contrary to the Chinese context where self-efficacy has no effect, in Bangladesh, self-efficacy plays an important role in farmers' intention to use ICTs such as the microfinance platform. Self-efficacy is seen as an intrinsic motivating factor that could help the local farmer to adopt a technology or information system. In this study, self-efficacy refers to the perception of the farmer's ability to adopt localized irrigation technology to do his work. Therefore, the hypothesis formulated for this factor is as follows:

H1	*self-efficacy positively influences the probability of adoption of LIT by farmers.*

2.2 Attitude

This variable is based on the Technology Acceptance Model (Davis, 1986) and Triandis' Theory of Interpersonal Behavior (1980). Attitude, explains the positive or negative evaluation of performing a particular behavior. It refers to an individual's judgement about the consequences of his or her behavior (fishbein & Ajzen, 1975). If this individual believes that a behavior will result in positive consequences, his or her attitudes will be favorable. It is thus formed by the set of beliefs about the consequences of carrying out a behavior. These beliefs reflect the individual's subjective probability of performing the behavior.

For the adoption of an agricultural innovation, the farmer is first informed of its existence. Then, he develops an attitude towards it, and then decides to adopt or reject it. In principle, a farmer with a favorable attitude towards an innovation should first adopt it and then use it. The adoption of an agricultural technology by a farmer is therefore conditioned by his or her attitude. In the literature reviewed, several research works have demonstrated this close relationship between the adoption of agricultural technologies and the attitude of the adopter (Momvandi & al., 2018; D. Zhou & al., 2017; Afshar & Zarafshani, 2010 ; Glanz et al. ,2008 ; Deyi Zhou & Abdullah ,2017 ; Aluisio & al.,2017 ; Far, S.T., & Rezaei-Moghaddam, K,2017).

In its study aimed at identifying factors affecting the use of pressurized irrigation technologies by farmers Momvandi & al. (2018) considers that attitude refers to a set of emotions, beliefs and behaviors towards a particular object, person, thing or event and is always considered an important factor in guiding human behavior. The study by Momvandi & al (2018) found that attitude has the greatest impact on the use of pressure irrigation technology by farmers. The same result has been proven by D. Zhou & al (2017) with regard to farmers' acceptance of solar water pump technology. In their studies, (Afshar & Zarafshani (2010)); Glanz & al. (2008) cited by Momvandi & al. (2018) examined the relationship between attitude and use of irrigation technologies by farmers. They found a positive and significant relationship between these two variables. For Far, S.T., & Rezaei-Moghaddam, K. (2017), behavioral attitude is the most important determinant of the willingness of agricultural consultants to use precision farming technologies. Aluisio et al (2017) in their study showed that farmers' attitude has a positive effect on the adoption and use of Integrated Production (IP) technologies by common bean growers in the central region of Brazil. Given this research, which showed a positive relationship between attitude and technology adoption in agriculture, the following hypothesis should be tested:

H2	*Farmer attitude positively influences the probability of adoption of LIT*

2.3 Personal Innovation

According to Agarwal & prasad (1998), personal innovation refers to an individual's willingness to try a new technology. According to these two authors, the variable "personal innovation" positively influences the adoption of technologies. In the literature, little research has been done to analyze the relationship between the variable "personal innovation" and technology adoption in agriculture (Far, S.T., & Rezaei-Moghaddam, K. (2017) ;Amin & al., 2013).

The study by Far, S.T., & Rezaei-Moghaddam, K. (2017), showed that individual innovation is among the factors that influence the behavioral intention of agricultural consultants to use precision agriculture technologies. On the other hand, the study by Amin & al. (2013), revealed no significant direct effect of the variable "personal innovation" on farmers' intention to use ICT compatible products and services such as the microfinance platform. In this research work we consider that the variable "personal innovation" can positively affect farmers' decisions to adopt LIT. We propose the following hypothesis:

H3	*Personal innovation positively influences the probability of adoption of LIT*

2.4 Age

The age factor is considered one of the decisive factors in the decision to adopt agricultural technologies (Feder & Umali, 1993; Abdulai & Huffman, 2005; Wang & al., 2015). The influence of the "age of the farmer" factor on the technology adoption decision does not lend itself to an easy explanation. However, it has been established in previous research that age is either negatively correlated with adoption or is not significant in farmers' adoption decisions. Empirically, and in the sense that the motivation to try and then adopt a technology decreases with age, age has been shown to be an important explanatory factor that negatively influences the adoption decision of irrigation technologies (Chuchird & al., 2017; Bagheri & Ghorbani, 2011; Abdulai & Huffman, 2005; Wang & al., 2015; B. Zhang & al., 2018). In this sense, Kapemba and Nganda (2018) showed in their study on the adoption of agricultural mechanization by farmers in Kimpese City in Central Kongo that the probability of adoption of agricultural mechanization is negatively influenced by the age of the household head. Thus, younger farmers show more intention to adopt agricultural mechanization than older farmers. This relationship is explained by Mauceri and colleagues (2005) & Adesina & Zinnah (1993) who argue that as farmers age, there is an increase in risk aversion and a decrease in interest in long-term investment in the farm.

On the other hand, the Salhi. S & al (2012) study aimed at identifying the determinants of the adoption of drip irrigation system by Algerian farmers showed that contrary to what is stated in the literature, age is not a determinant in the use of drip irrigation technique. Similarly, the study of Collas (2018) on the adoption of new agricultural practices led to the same result.

Among the variables that can hinder the adoption of a new agricultural technology is resistance to technological change (Debbabi, 2014) and the risk that the farmer faces when using a new technology (Adéoti et al., 2002). These two variables are positively correlated with the age of the adopter and through which the age factor positively or negatively influences farmers' choices. According to Feder (1982) "the adoption of new technologies requires a certain level of risk associated with the decision to choose technologies. Younger producers are inclined to take more risk than older producers". Given this discussion, the following hypothesis should be tested:

H4	*Age of the farmer negatively influences the probability of adoption of LIT*

2.5 The Experience

A farmer's farming experience can be measured by the number of years that the farmer has worked in agriculture. Previous studies have indicated that to the extent that farmers learn by doing (Adhikari & al., 2009), more experience can lead to greater knowledge of technology use and less uncertainty about farm investments (Feder 1982). In this sense, some studies have shown that the role of experience on technology adoption is positive (Asghar & Ghorbani (2011); Alam 2015; Baffoe-Asare & al., 2013; Gedikoglu & al., 2011; Sauer & Zilberman, 2009), that is to say the higher the farmer's experience, the more motivated he is to adopt new technologies.

Although some studies have shown that experience in agriculture influences farmers' technology adoption behavior (Hisali & al., 2011; Seekao & Pharino, 2016; Alam 2015; Baffoe-Asare & al, 2013; Gedikoglu & al., 2011; Sauer & Zilberman, 2009), Farmer experience has an ambiguous impact on technology adoption (Kebede & al., 1990; Knowler & Bradshaw, 2007; Prokopy & al., 2008; Rubas, 2004).

This ambiguity is explained by Kebede & al. (1990) who point out that the farmer's experience plays a distinct role according to the risk perceived by the farmer. Farming experience facilitates the adoption of technologies that reduce the perceived risk (such as more pesticides and fertilizers), but may have the opposite effect on the adoption of innovations that increase the perceived risk. Soule et al (2000) argue that experienced farmers know their production context better and can take more risks. In contrast, older, more experienced farmers have a shorter planning horizon that does not push them to change current technology. This finding is confirmed by Kalantari & al (2010) who have shown that young Iranian farmers, meaning the less experienced ones, are more willing to accept new irrigation technologies than older farmers. The same result is obtained by Abdulai & al. (2011) among vegetable farmers in Ghana and by Koundouri & al. (2006) among olive farmers in Greece. Based on this discussion, we propose the following hypothesis:

H5	*Farmer's experience negatively influences the probability of adoption of LIT*

2.6 Education Level

In previous studies on the adoption of agricultural technologies, the education level of the farmer has been assumed to have a positive effect on the farmers' decision to adopt a new agricultural technology, especially information and management-intensive technologies (Waller & al., 1998; Caswell & al., 2001). A farmer's education level increases his or her ability to obtain, process and use information relevant to the adoption of a new technology (Strauss et al., 1991; Feder & al.,. 1985; Mignouna & al., 2011; Feder & Slade, 1984; Lavison 2013; Namara & al., 2013).

The education level of the operator is generally recognized as being conducive to the adoption of human capital-intensive innovations (Abdulai & Huffman, 2005; Barham & al., 2004; Feder & Umali, 1993; Foltz & Chang, 2002; Kebede & al., 1990; Sauer & Zilberman, 2009; Wu & Babcock, 1998).

Several studies have shown that the education level of farmers plays an important role in the adoption of irrigation technologies (B.Zhang & al., 2018; Alam, 2015; Cremades & al., 2015; Fernandez-Cornejo & al., 2005; Saha & Schwart, 1994; Mwangi & Kariuki, 2015; Feder & al., 1985; Kemp, 1997; Saviotti, 2001). These authors have shown that better educated farmers are often in a better position to understand and appreciate the benefits of adopting irrigation technologies. This finding is consistent with the idea that education is important to help farmers make decisions regarding the adoption of new innovations and technologies (Abdulai & Huffman, 2005; Abdulai & al., 2011).

In Iran, Asghar and Ghorbani (2011) showed that the adoption of micro-irrigation was positively influenced by the higher education level of farmers and consequently, adopters were more educated than non-adopters. The same result is obtained by Huffman (1977) for whom higher farmer education encourages adoption of innovations and by Namara & al. (2007) who obtained the same result in India: more educated legume and oilseed producers were more likely to adopt drip and micro-sprinkler irrigation as more water efficient technologies. In general, farmers with higher education levels are expected to be better informed about the availability and performance of different irrigation technologies (Abdulai & al., 2011).

In Morocco, localized irrigation technology is still in its infancy, particularly in the study area. It is therefore reasonable to believe that farmers who intend to adopt localized irrigation technology will have higher levels of education than non-adopters.

In this study and even if some works do not find significant relationships between education and adoption (Grieshop & al., 1988; Khanna, 2001; Banerjee & al., 2008; Samiee & al., 2009; Ishak & Afrizon, 2011; Knowler & Bradshaw, 2007), it can be considered that the education level of the farmer could positively or negatively influence technology adoption. Therefore, we will test the following hypothesis:

H6	The higher the education level, the higher the probability of adoption of LIT.

3. Methodology and data

3.1 Survey: Design, administration and validity

Given the nature of our problem and in order to be able to test the hypotheses built around our conceptual model, we have adopted the hypothetical-deductive approach in this work, which is in line with a "positivist" perspective, and the quantitative method by means of a face-to-face survey as our research strategy. The development of the survey and the choice of measures for each variable was based on the research hypotheses underlying our conceptual model and the literature review.

The dependent variable in our conceptual model is whether or not farmers adopt the localized irrigation technology. This is a dichotomous or binary choice variable. In our case the dependent variable or variable to be explained is coded as follows: 1 if the farmer adopts the localized irrigation technology; 0 if he does not adopt it.

In this study the explanatory variables that determine the adoption of the localized irrigation technology are: Self-efficacy, Attitude, Personal Innovation, Age, Experience, and Education.

To measure the independent variables, Self-Efficacy, Attitude and Personal Innovation, we chose to use the subjective or perceived method. The following table presents the variables of the model as well as the way they are operationalized.

Table 1: the variables of the model as well as the way they are operationalized

Variables	Coding	Measure
Adoption	Adop	1 if the farmer adopts the localized irrigation technology; 0 if he does not adopt it
Explanatory variables		
Self-efficacy	A_eff 1	I could use LIT even if there was no one around to tell me what to do.
	A_eff 2	I could use LIT if I could call someone to help me in case I get stuck.
	A_eff 3	I would be able to use the LIT if I saw a colleague using it before I tried it myself.
	A_eff 4	I would be able to use the LIT if someone shows me how to use it first.
Attitude	Att 1	Localized Irrigation Technology Solves Water Crisis
	Att 2	Localized Irrigation Technology Improves Irrigation Efficiency
	Att 3	Localized Irrigation Technology Makes Profits
	Att 4	Localized irrigation technology allows for the expansion of the area under irrigation.
	Att 5	Localized Irrigation Technology Makes New Crops More Profitable
	Att 6	Localized Irrigation Technology Makes Agriculture More Interesting
Personal Innovation	Ino_Per 1	I am receptive to new agricultural technologies such as LIT
	Ino_Per 2	I do not trust new agricultural technologies such as LIT until the majority of neighbors have adopted them
	Ino_Per 3	I am generally hesitant to try new agricultural technologies such as LIT
Age	Age	Age in years
Experience	Experience	Number of years in agriculture
The level of education	Ni_in	1 if Never attended school 2 if Primary level 3 if Secondary level 4 if Superior level

Source: *Authors*

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It is important to note that the choice of a face-to-face interview with our survey was not made by chance. This method is considered to be the most effective in terms of the quantity and quality of the information collected. Also, the specificity of our research object which generally concerns the perceptions and attitudes of farmers regarding the use of localized irrigation technology, on the one hand, and the specificities of the population studied (farmers) which is generally uneducated, on the other hand, obliged us to choose this mode of administration which allows us to be close to the farmer interviewed and to rule out the possibility of using other modes of administration of the survey which require an average level of education.

In the framework of this research work, once the questionnaire was established, the validity of the survey and its content was verified in two stages:

The first step is the validity of its content which was determined by consulting two professors from the Hassan II Agronomic and Veterinary Institute, a professor at the FLESSM[3] and an expert irrigation engineer at the ROADO[4] who evaluated the relevance and objectivity of each element of the survey and the duration of the questionnaire: a response time between 20 and 30 minutes was set.

The pre-test with farmers is the second step in this process of validity of the survey. Thus, once the survey is redesigned, we found it useful to pre-test it. For this study, 20 farmers from the province of Midelt[5], were interviewed during this pre-test, which was called a pilot study. First, permission was sought from local authorities to conduct interviews with 20 farmers. After receiving permission, 20 farmers were then randomly selected according to their availability, 5 of whom were adopters of the localized irrigation technology. This was important in the research process because it helped us identify vague questions and unclear instructions. It also helped us to capture important comments and suggestions from farmers, to discover appropriate vocabulary, commonly used terms, and to identify the meaning given to words. This helped us to improve the efficiency of our survey. It should be noted that at the time of the interviews we found that conducting interviews with farmers in the local language using a French-language survey was very difficult to manage and could even be a source of dissatisfaction for the farmer. Therefore, we decided to use a survey in Arabic, the language mainly used by farmers in the study area.

After presenting and explaining how the content of our survey was constructed, as well as the validation and the mode of administration retained for the collection of data. In the rest of this section, we will present the sample size and the sampling technique.

3.2 Sample size and sampling technique

The study targeted farms in the Drâa-Tafilalet region. For a total population of approximately 95,643 farms in the Drâa-Tafilalet region, and based on Cochran's formula, a minimum sample size of 383 is calculated for a 95% confidence level ($z = 1.96$) and a precision margin of error of 5%. For the estimated proportion (p) of the population with the characteristic studied in this research, i.e. the adoption or not of the LIT, and in the absence of absolute knowledge on the proportion of adopting farmers, we used $p = 0.5$, which corresponds to the worst case, i.e. the largest dispersion, and which maximizes the minimum sample size.

For the selection of 400 farmers from the Draa-Tafilalet region, and given the absence of a complete list of farms in the Draa Tafilalt region from which to draw a random sample, and in order to obtain a fair representation of farmers from each of the provinces, the sampling technique proportional to the size of the population of the province was used (Table 2). Then,

[3] Faculty of Legal, Economic and Social Sciences of Marrakech

[4] regional office of agricultural development of Ouarzazate

[5] This is because it is a province that is part of the main study area and the closest to us

farmers in each of the five provinces were randomly selected based on their availability and willingness to participate in the interviews.

Table 2: The number of farmers surveyed by province according to the sampling technique proportional to the population size of the province

Provinces	**Number of Farms (Population)**	**Percentage (%)**	**Number of Farms (Sample)**
Errachidia	18 588	19,43	78
Ouarzazate	17 978	18,80	75
Midelt	17 968	18,79	75
Zagora	20051	20,96	84
Tinghir	21058	22,02	88
Region :Drâa - Tafilalet	**95 643**	**100**	**400**

Source : *Author's calculation based on data from the 2016 General Census of Agriculture*

3.3 Data analysis strategy and model

In order to be able to test the hypotheses built around our conceptual model, the processing of the data collected in this study necessarily goes through two stages. The first exploratory step consists of using exploratory factor analysis to determine the measurement scales. Thus, first, a correlation analysis between the items of each of the three variables measured by several items is performed. Then, the test of the reliability of the items (Cronbach's Alpha) and the principal component factor analysis with the orthogonal rotation of Varimax type were carried out. The results of these analyses are interpreted according to the criteria and acceptance thresholds presented in the following table.

Table 3: Criteria used to perform the exploratory factorial analysis

Nature of the decision	Criteria used
Internal consistency	α> 0,6
Kaiser-Meyer-Olkin Index (KMO)	≥ 0,5
Bartlett Sphericity Test	≤ 0,1
Extraction mode	Principal Component Analysis
Number of factors to be retained	Own values >1
Rotation	Varimax
Communality (Extraction)	≥ 0,4
Saturations	Correlation ≥ 0,5

Source: *Authors*

The second step is confirmatory. In this stage we performed the confirmatory analysis that allowed us to analyze the relationships between the variables of the model studied. To this end, we used the binary logistic regression model to test the research hypotheses and identify the variables that most influence the adoption of localized irrigation technology in the study area. This model is written as follows:

$$\textbf{Log (Pi/1-Pi)} = \beta 0 + \beta i \text{ individual determinants} + \varepsilon$$

Where

βi (i = 1,2,3,4,5,6) are the coefficients attached to the individual determinants of adoption of the localized irrigation technology namely Self-efficacy, Attitude, Personal Innovation, Age, Experience and Education level. ε is the error term.

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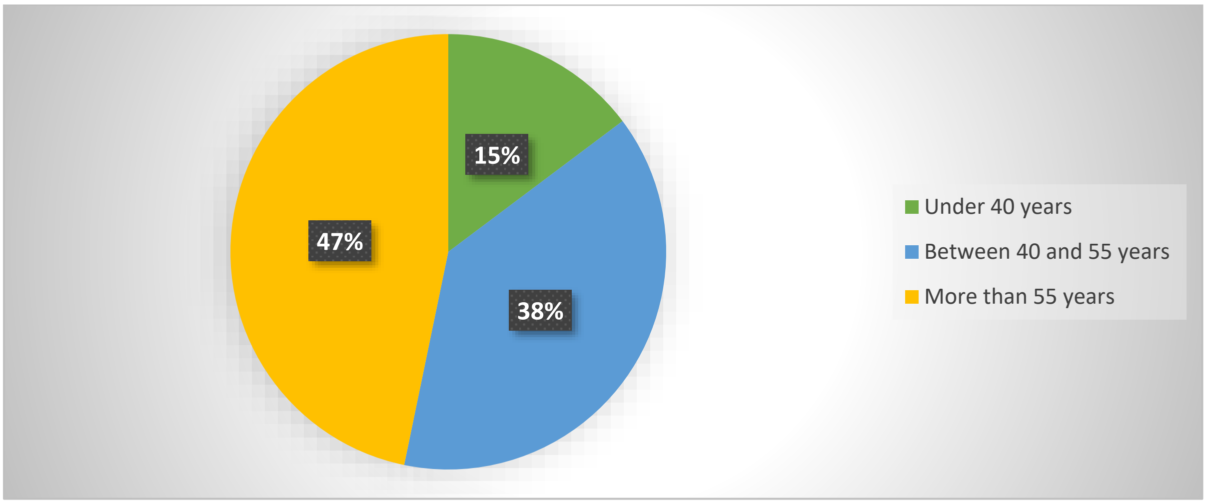
4. Results and discussions

4.1 Descriptive statistics and comparative analysis of LIT adopters and non-adopters

4.1.1 Age of the Farmer and Adoption of LIT

The Age of the farmer is a continuous variable measured in years. It varies between 32 and 72 years with an average of 53 years. For presentation purposes this variable has been grouped into three bands. The results presented in the following graph show that the first group includes farmers with a maximum age of 40 years. This bracket represents 14.8%(59) of the farmers surveyed. The second group is made up of farmers between 40 and 55 years of age. This group represents 38.5%(154) of the farmers surveyed. The last bracket is that of farmers over 55 years of age, which includes 187 farmers.

Graph 1: Distribution of surveyed farmers according to their age



Source: *Results of our study*

The comparative analysis between the ages of the adopters and non-adopters of LIT in the table below revealed that the average age of the adopters (47 years) is much lower than the average age of the non-adopters (56 years) of LIT. More than 77% of the LIT adopters are younger than 55 years of age. On the other hand, 61% of the non-adopters surveyed are over 55 years old. This shows that the adoption of LIT is closely related to the age of the farmers and that older farmers tend not to adopt LIT. This variable may therefore be a significant determinant of LIT adoption decision making.

Table 4: Distribution of surveyed farmers by age and by group (LIT adopters and non-adopters)

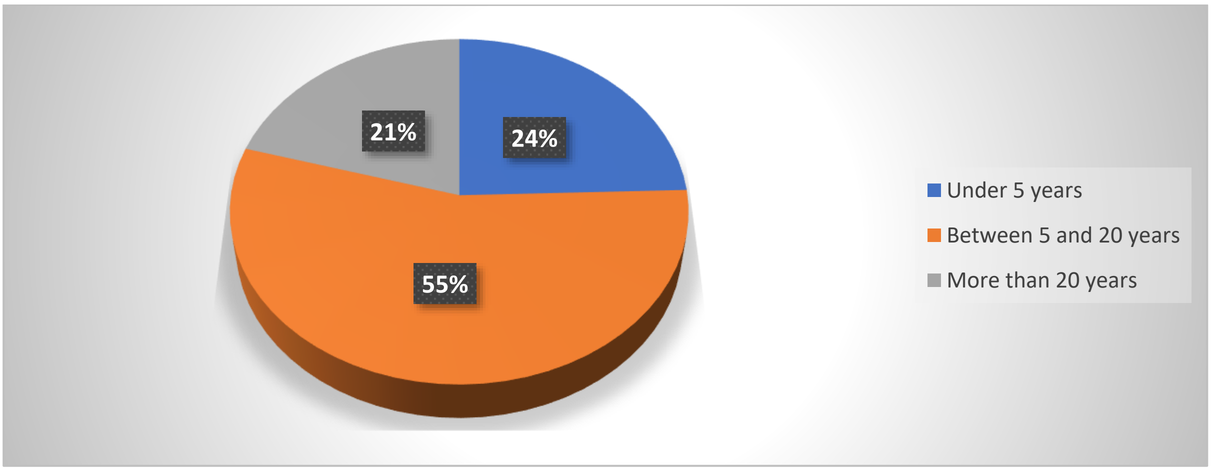
Age	Non-Adopting LIT			Adopting LIT			Total		
	Mean	Number	%	Mean	Number	%	Mean	Number	%
Under 40 years	56	26	10,3	47	33	22,3	52,6	59	14,8
Between 40 and 55 years		72	28,6		82	55,4		154	38,5
More than 55 years		154	61,1		33	22,3		187	46,8
							Standard deviation	**Min**	**Max**
							10,8	32	72

Source: *Results of our study*

4.1.2 The Farmer's Experience and Adoption of LIT

The Farmer's Experience is a continuous variable measured in years. As shown in the following graph, this variable is grouped into three slices: the first slice includes farmers with a maximum of 5 years' experience. This bracket represents 24.5% (98) of the farmers studied. The second group is made up of farmers with experience between 5 and 20 years. This group represents more than half of our sample, or 55% (220). The last tranche is that of farmers with more than 20 years of experience, which includes 82 farmers. The Experience of the farmers in our sample ranges from 1 to 52 years with an average of 14 years.

Graph 2: Distribution of the farmers studied according to their Experience



Source: *Results of our study*

The following table presents the results of the comparative analysis between the experiences of adopters and non-adopters. These results revealed that the average experience of adopters (10 years) is significantly lower than the average experience of our sample (14 years) and the average experience of non-adopters (17 years) with this technology. More than 38% of LIT adopters have less than 5 years' experience. In contrast, only 17% of the non-adopters studied have less than 5 years' experience. This shows that the adoption of LIT is closely related to the farmer's experience and that the most experienced farmer tends not to adopt LIT. This variable may therefore be a significant determinant for LIT adoption decision making.

Table 5: Distribution of the farmers studied according to their Experience and by group (adopting or not adopting LIT)

Experience	Non-Adopting LIT			Adopting LIT			Total		
	Mean	Number	%	Mean	Number	%	Mean	Number	%
Under 5 years	17	42	16,7	10	56	37,8	14,2	98	24,5
Between 5 and 20 years		147	58,3		73	49,3		220	55,0
More than 20 years		63	25,0		19	12,8		82	20,5
							Standard deviation	Min	Max
							10,7	1	52

Source: *Results of our study*

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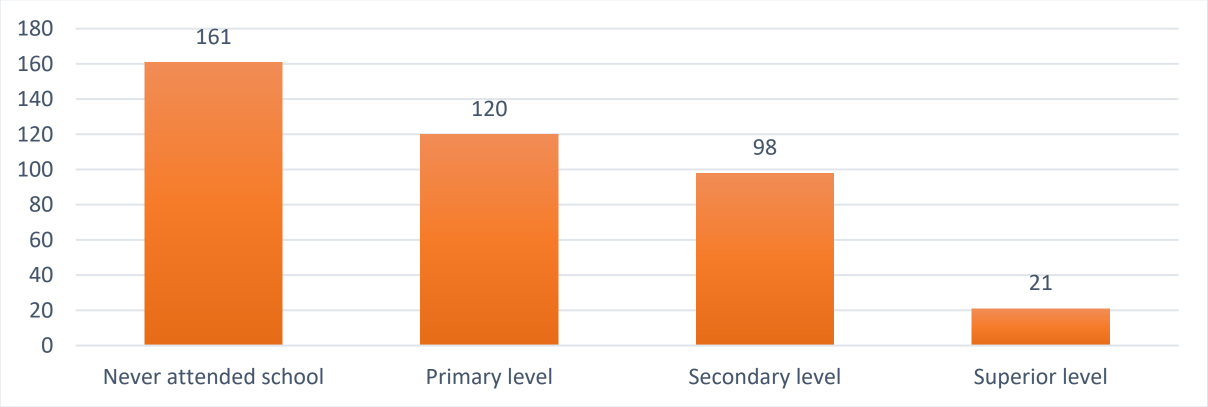
4.1.3 Farmer Education and Adoption of LIT

With regard to the farmer's education level and adoption of LIT, the statistical analysis presented in the following graph reveals that the majority of farmers in our sample (70%) have a primary education level (30%) or never attended school (40%). This shows the low education level of the farmers surveyed. On the other hand, farmers with secondary or higher levels of education represent less than 30% of the sample.

Graph 3: Distribution of farmers surveyed by education level



Source: *Results of our study*

The results of the association between the education level of the farmers in our sample and their use of LIT, shown in the table below, show that the farmers who do not adopt LIT are mostly those who never attended school (50% of non-adopters). On the other hand, 40% of the adopting farmers have attained secondary or higher education compared to only 24% of the non-adopters of LIT. According to these results, the education level of farmers can have a significant influence on their choice to adopt LIT. Thus, it appears that farmers with secondary or higher education tend to adopt LIT and that farmers with primary education or who never attended school tend not to adopt LIT.

Table 6: Distribution of surveyed farmers by educational level and by group (adopting or not adopting LIT)

Education level	Non-Adopting LIT		Adopting LIT		Total	
	Number	%	Number	%	Number	%
Never attended school	125	49,6	36	24,3	161	40,3
Primary level	67	26,6	53	35,8	120	30,0
Secondary level	52	20,6	46	31,1	98	24,5
Superior level	8	3,2	13	8,8	21	5,3

Source: *Results of our study*

4.1.4 Farmer Self-Efficacy and Adoption of LIT

In this research work, self-efficacy refers to the perception of a farmer's ability to adopt LIT to do his or her job. To measure this variable, specific category scale questions were chosen. The self-efficacy variable is measured using four Items. These items provide information on the farmer's self-efficacy in relation to the use of LIT. The results of the statistical analyses indicated in the following table show that the mean of the farmers' responses is (M= 3.36) with a standard deviation (σ= 0.85) on a 5-point scale. The comparative analysis between LIT adopters and non-adopters in relation to self-efficacy (Table below) revealed that the average response score of LIT adopters (M= 3.85) is higher than the average response score of non-adopters (M= 3.08) and the average response of farmers. This means that overall LIT adoption is closely related to farmer self-efficacy. The direction of this relationship which appears positive and the intensity of the influence of this variable on LIT adoption can only be asserted when estimating the parameters of our logit model.

Table 7: Mean score of self-efficacy items by group (adopting or non-adopting LIT)

self-efficacy	**Non-Adopting LIT**	**Adopting LIT**	**Total**
Mean Score	3,08	3,85	3,36

Source: *Results of our study*

4.1.5 Farmer Attitude and Adoption of LIT

In this research work, we consider that the adoption of LIT by a farmer is conditioned by his attitude. To measure this variable, specific category scale questions were chosen. The variable "Attitude" is measured using six items. Practically, we asked each farmer to express his or her greater or lesser agreement with the six assertions made to him or her, which gives us information on their Attitude towards the use of LIT. The results presented in the following table show that the mean of the farmers' answers is (M= 3.38) with a standard deviation (σ= 0.94) on a 5-point scale. The comparative analysis between LIT adopters and non-adopters of LIT in relation to their Attitude revealed that the Mean Score of LIT adopters' responses of (M= 4.05) is much higher than the Mean Score of non-adopters (M= 2.98) and the average of farmers' responses. This means that overall adoption of LIT is closely related to the farmer's Attitude towards adopting the technology.

Table 8: Mean Score for Attitude Variable Measurement Items by Group (Adopting or non-Adopting LIT)

Attitude	**Non-Adopting LIT**	**Adopting LIT**	**Total**
Mean Score	2,98	4,05	3,38

Source: *Results of our study*

4.1.6 Farmer's Personal Innovation and Adoption of LIT

In this research work, personal innovation refers to the farmer's willingness to try LIT. In order to measure this variable, specific category scale questions were chosen. The variable "personal innovation" is measured using three items. The three statements tell us about the farmer's willingness to try the LIT. According to the following table, the mean of the farmers' answers is (M= 3.46) with a standard deviation (σ= 0.68) on a 5-point scale. Regarding the comparative analysis between LIT adopters and non-adopters in relation to personal innovation, the results showed that the Mean Score of LIT adopters' responses of (M= 3.54) is higher than the Mean Score of non-adopters (M= 3.41) and the average of farmers' responses. This means that overall LIT adoption is positively related to the farmer's personal innovation. This variable may therefore be a significant determinant for LIT adoption decision making in the study area.

Table 9: Mean Score for Personal Innovation Measurement Items by Group (LIT Adopters and Non-adopters)

Personal Innovation	**Non-Adopting LIT**	**Adopting LIT**	**Total**
Mean Score	3,41	3,54	3,46

Source: *Results of our study*

4.2 PCA and Item Reliability Results

4.2.1 PCA and reliability of self-efficacy items

The variable "Self-efficacy" is measured using four Items.

Table 10: Correlation matrix for self-efficacy items

Items	A_eff 1	A_eff 2	A_eff 3	A_eff 4
A_eff 1	1,000			
A_eff 2	0,605	1,000		
A_eff 3	0,490	0,571	1,000	
A_eff 4	0,532	**0,451**	**0,652**	1,000

Source: *Author's calculation with SPSS*

The results indicate that the correlations between the items measuring "Self-efficacy" are positive. Analysis of the correlation coefficients between the 4 items, taken in pairs, shows a mean correlation between these items (between 0.451 and 0.652), which means the average uniqueness of this scale of measurement.

The results of the item reliability test (Cronbach's Alpha) and the results of the principal component analysis applied to the "Self-efficacy" variable are shown in the following table.

Table 11: Results of the factor analysis applied to the "Self-efficacy" scale

Items	**Factorial contributions**	**Quality of representation (Communality)**	**Cronbach's Alpha in case of deletion of the element**	**Cronbach's Alpha of the scale**
A_eff 1	0,804	0,647	0,791	0,830
A_eff 2	0,806	0,649	0,789	
A_eff 3	0,837	0,700	0,772	
A_eff 4	0,809	0,655	0,789	
N	**Own value**	**Variance explained**	**Bartlett test**	**KMO test**
400	2,651	66,278	0,000	0,735

Source: *Author's calculation with SPSS*

These results show a good level of reliability and internal consistency (α from Cronbach =0.830) of the measurement scale. The KMO index of this measurement scale is 0.735 (higher than the required threshold of 0.5), and Bartlett's test is significant (the data are factorizable) which confirms the possibility of performing a PCA on the 4 items measuring the "Self-efficacy" variable.

The PCA of these 4 items shows a single factorial axis according to Kaiser's criterion (Own value equal to 2.651> 1) in which the items explain 66.278% of the variance. The quality of the representation (the communalities) of the items is greater than 0.4 (between 0.647 and 0.700) for all items. All items have good factorial contributions greater than 0.5 (between 0.804 and 0.837). We therefore conclude for the reliability and unidimensionality of the self-efficacy scale. This ensures that the results of the questionnaire are reproducible if it is administered several times to the same sample (Igalens & Roussel, 1999). No item deletion improves the reliability of the "self-efficacy" measurement variable.

4.2.2 PCA and reliability of the items in the "Attitude" variable

The variable "Attitude" is measured from six Items.

Table 12 : Correlation Matrix of Attitude Variable Items

Items	Att 1	Att 2	Att 3	Att 4	Att 5	Att 6
Att 1	1,000					
Att 2	0,541	1,000				
Att 3	**0,725**	0,420	1,000			
Att 4	0,471	0,391	0,591	1,000		
Att 5	0,476	0,449	0,493	0,446	1,000	
Att 6	0,427	0,567	0,317	**0,235**	0,447	1,000

Source: *Author's calculation with SPSS*

The above correlation matrix suggests a positive correlation between the six items measuring the "Attitude" variable (between 0.235 and 0.725). The correlation coefficients between the six items, taken in pairs, are average except for the correlation between Att 4 and Att 6, which is relatively low (0.235). This result reveals the average uniqueness of this measurement scale.

The results of the item reliability test (Cronbach's Alpha) and the results of the principal component analysis applied to the "Attitude" variable are shown in the table below.

Table 13: Results of the factor analysis applied to the "Attitude" variable scale

Items	Factorial contributions	Quality of representation (Communality)	Cronbach's Alpha in case of deletion of the element	Cronbach's Alpha of the scale
Att 1	0,829	0,687	0,794	0,840
Att 2	0,748	0,560	0,811	
Att 3	0,807	0,651	0,800	
Att 4	0,698	0,488	0,825	
Att 5	0,736	0,542	0,815	
Att 6	0,650	0,422	0,833	
N	**Own value**	**Variance explained**	**Bartlett test**	**KMO test**
400	3,350	55,832	0,000	0,799

Source: *Author's calculation with SPSS*

These results show a good level of reliability and internal consistency (α from Cronbach =0.840) of the measurement scale. No item deletion improves the reliability of the measurement variable "Attitude". The results presented in the table above show that the KMO test (0.799) and the Bartelett test (Significant) allow us to conclude that a principal component analysis can be applied. Examination of the Own value provides information on the number of factors to be retained: a single factorial axis according to Kaiser's criterion (Own value equal to 3.350> 1) in which the items explain 55.832% of the total variance of the scale, while the quality of the representation (the communalities) of the items is greater than 0.4 (between 0.422 and 0.687) for all items. All items have factor contributions greater than 0.5 (between 0.650 and 0.829). We therefore conclude for the reliability and unidimensionality of the "Attitude" measurement scale.

4.2.3 PCA and reliability of items in the "Personal Innovation" variable

The "Personal Innovation" variable is measured by three items.

Table 14: Correlation Matrix of Personal Innovation Variable Items

Items	Ino_Per 1	Ino_Per 2	Ino_Per 3
Ino_Per 1	1,000		
Ino_Per 2	0,826	1,000	
Ino_Per 3	0,514	0,569	1,000

Source: *Author's calculation with SPSS*

The above correlation matrix suggests a strong positive correlation between the three items measuring the Personal Innovation variable (between 0.514 and 0.826).
The results of the item reliability test (Cronbach's Alpha) and the results of the principal component analysis applied to the "Personal Innovation" variable are shown in the following table.

Table 15: Results of the factor analysis applied to the "Personal Innovation" variable scale

Items	Factorial contributions	Quality of representation (Communality)	Cronbach's Alpha in case of deletion of the element	Cronbach's Alpha of the scale
Ino_Per 1	0,907	0,823	0,717	0,833
Ino_Per 2	0,927	0,860	0,639	
Ino_Per 3	0,775	0,600	0,890	
N	**Own value**	**Variance explained**	**Bartlett test**	**KMO test**
400	2,283	76,100	0,000	0,654

Source: *Author's calculation with SPSS*

The KMO index of this scale is 0.654 (above the required threshold of 0.5), and Bartlett's test is significant (the data are factorizable) which confirms the possibility of performing a PCA on the 3 items measuring the "Personal Innovation" variable. The PCA of these 3 items shows a single factorial axis according to Kaiser's criterion (Own value equal to 2.283> 1) in which the items explain 76.10% of the variance. The quality of the representation of the items is higher than 0.4 (between 0.600 and 0.860). All items have good factorial contributions greater than 0.5 (between 0.775 and 0.927). The results also show a good level of reliability and internal consistency (α from Cronbach =0.833) of the scale for the "Personal Innovation" variable. The value of α from Cronbach can be slightly improved by removing the item Ino_Per 3 " I am generally hesitant to try new agricultural technologies such as LIT ". However, the choice is made to keep this item because the internal consistency of the scale is already good.

4.3 Estimation Results of the Explanatory Model of Individual LIT Adoption Variables

By regressing the six individual determinants on the dependent variable "LIT adoption", we obtained the results shown in the following tables.

In terms of explanatory power, using the Nagelkerke R Square test, which is the adjusted version of the Cox & Snell test shown in the following table, we find that the individual determinants explain 61.2% of the total variance of LIT adoption by farmers in the Draa-Tafilalt region.

Table 16: Explanatory power of the model

Log of likelihood -2	R^2 of Cox and Snell	R2 of Nagelkerke
289,339	0,448	0,612

Source: *Author's calculation with SPSS*

This result is supported by the improvement in the overall percentage of classification shown in the following table. The individual order variables alone allow for the correct classification of 86.5% of farmers between LIT adopters and non-adopters. This result confirms the idea that "individual determinants significantly influence farmers' adoption of LIT technology".

Table 17: Model classification table after the introduction of the explanatory variables

Observed		Forecast		
		Adoption		Correct percentage
		No LIT Adopter	LIT Adopter	
Adoption	No LIT Adopter	232	20	92,1
	LIT Adopter	34	114	77
Overall percentage				**86,5**

Source: *Author's calculation with SPSS*

The binary logistic regression result in the table below indicates that all of the individual variables in this study, with the exception of the "personal innovation" variable, have a significant effect on the probability of adopting LIT at the 1% significance level.

Table 18: Binary logistic regression results for individual variables

Variables		B	E.S	Wald	ddl	Sig.	Exp(B)
Step 1	Age	-0,049	0,015	9,935	1	0,002	0,953
	Experience	-0,091	0,018	25,715	1	0.000	0,913
	Education level	0,414	0,154	7,239	1	0,007	1,513
	Self-efficacy	1,054	0,222	22,48	1	0.000	2,869
	Attitude	1,438	0,197	53,167	1	0.000	4,211
	Personal innovation	-0,077	0,235	0,106	1	**0,744**	0,926
	Constant	-6,156	1,415	18,926	1	0	0,002

Source: *Author's calculation with SPSS*

According to these results, the variables "Self-efficacy", "Attitude", and "Education level" had a positive and significant effect on the probability of adopting LIT at the 1% significance level. On the other hand, the variables "Age" and "Experience" had a negative and significant effect on the probability of adopting LIT at the 1% significance level. While the effect of the "Personal Innovation" variable on LIT adoption in the Draa-Tafilalt region was not significant.

Therefore, and based on the results of the binary logit regression to estimate the explanatory model of the individual variables of adoption of localized irrigation technology with the input method of the explanatory variables, "Enter" under SPSS 25, the hypotheses H1, H2, H4, H5 and H6 are confirmed. However, hypothesis H3 is rejected. Based on the results of the table above, the individual determinants model, which will predict the adoption of LIT in the Draa-Tafilalt region, is written as follows:

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Log (P/1-P) = **1.054***(Self-Efficacy) +**1.438***(Attitude)-**0.077***(Personal Innovation) +**0.414***(Education level) **-0.049***(Age) -0.091*(Experience)**-6.156**

5. Discussion of results

The purpose of this section is to discuss the results obtained from the econometric analyses and compare them with those of previous studies.

The results of the estimation of the explanatory model of the individual variables of adoption of LIT showed that the variable "Personal innovation" did not show significant. On the other hand, individual variables such as "Age", "Experience", "Education level", "Self-Efficacy" and "Attitude" showed a significant influence on the probability of LIT adoption in the Draa-Tafilalt Region. The significance of these variables confirms a result already highlighted by the literature referenced to explain individual decisions to adopt new technologies in agriculture. However, contrary to the conclusions of some studies on LIT adoption such as the Salhi. S & al (2012) study aimed at identifying the determinants of the adoption of drip irrigation by Algerian farmers and which showed that age is not a determinant in the use of LIT, our analysis highlights a significant negative influence of "age" on the probability of LIT adoption (B= -0.049): younger farmers show more intention to adopt LIT than older ones. This negative influence of age confirms the results of studies referenced in the literature (Chuchird et al., 2017; Bagheri & Ghorbani, 2011; Abdulai & Huffman, 2005; Wang et al., 2015; B. Zhang & al., 2018). The latter had come to the following conclusion: The age factor is considered one of the decisive factors in the decision to adopt agricultural technologies. Explanations given in the literature for this result is that as farmers age, there is an increase in risk aversion and a decrease in interest in long-term investment (Mauceri and colleagues, 2005; Adesina & Zinnah, 1993).

On the other hand, the variable "Experience", measured by the number of years farmers have been working in agriculture and often correlated with the age of the farmer, also has a negative influence on the probability of LIT adoption in the Draa-Tafilalt Region (B= -0.085) at the 1% significance level. This means that the greater the farmer's experience, the lower the probability of adoption of LIT by the farmer. These results are consistent with our research hypothesis and the work of Kalantari & al. (2010) which showed that young Iranian farmers, that is to say the less experienced, are more willing to accept new irrigation technologies than older farmers. The same result is obtained by Abdulai et al (2011) among vegetable farmers in Ghana and by Koundouri et al (2006) among olive farmers in Greece. These findings were explained by the fact that the more experienced farmers, that is to say the older ones, have a shorter planning horizon that does not push them to adopt a new technology. The negative influence of "The Experience" on the adoption of LIT by farmers in the Draa-Tafilalt Region is in contradiction with the results revealed by Asghar & Ghorbani (2011); Alam (2015); Baffoe-Asare & al. (2013); Gedikoglu & al. (2011); Sauer & Zilberman (2009) who showed that the role of experience on technology adoption is positive.

The variable "self-efficacy" also plays a very important role in the adoption of LIT in the Draa-Tafilalt region. The variable "self-efficacy", which refers to the perception of the farmer's ability to adopt localized irrigation technology to do his work, has a positive and significant effect on the probability of LIT adoption at the 1% significance level (B= 1,226). The results of the estimation of the explanatory model of the individual LIT adoption variables confirmed our research hypothesis and the earlier findings of Momvandi & al.(2018) in their study on factors affecting the use of pressure irrigation technologies and revealed the existence of a positive and significant relationship between self-efficacy and the use of pressure irrigation technologies. The result found in this research work indicates that the set of farmer beliefs regarding their ability to adopt LIT increases the likelihood of LIT adoption.

The variable "Attitude" is based on the Technology Acceptance Model (Davis, 1986) and Triandis' Theory of Interpersonal Behavior (1980). It explains the positive or negative evaluation of exercising a particular behavior. It refers to the farmer's judgment of the consequences of his or her LIT adoption behavior. In principle, a farmer with a favorable attitude towards LIT should adopt it. In this research work, we considered that the adoption of LIT by a farmer is conditioned by his attitude. In this analysis, as in the Technology Acceptance Model (Davis, 1986), the "Attitude" variable has a positive and significant effect on the probability of LIT adoption at the 1% significance level (B= 1.438). Work on the adoption of new irrigation technologies, notably that of (Momvandi & al., 2018; Afshar & Zarafshani, 2010, Glanz & al., 2008; D. Zhou & al. 2017 reached the same conclusions. The study by Momvandi & al. (2018) found that attitude has the greatest impact on farmers' use of pressure irrigation technology. The same result was proven by D. Zhou & al. (2017) with regard to farmers' acceptance of solar water pump technology. Also, in their studies, Afshar & Zarafshani (2010); Glanz & al. (2008) have shown this positive and significant influence of attitude on the adoption of irrigation technologies. In our study context, this result means that the more the farmer judges that LIT can solve the water crisis, improve irrigation efficiency, make profits or enable new and more profitable crops, the more likely he is to adopt it.

Regarding the role of the variable " Education Level " in the adoption of LIT in the Draa-Tafillalt region, contrary to some works that reported an insignificant or negative effect of education level on the rate of technology adoption in agriculture (Grieshop & al., 1988; Khanna, 2001; Ishak & Afrizon, 2011), our study showed the importance of this variable in the adoption of LIT. The results of the estimation of the explanatory model of the individual LIT adoption variables showed that "Education level" has a positive and significant influence on the probability of LIT adoption at the 1% significance level (B= 0.414). This means that "Education level" is therefore important in constructing farmers' decision on whether or not to adopt LIT. Among other things, it helps to understand and appreciate the benefits of adopting this technology. This is consistent with the idea that education is important in helping farmers make decisions regarding the adoption of new innovations and technologies (Abdulai & Huffman, 2005; Abdulai et al., 2011). Indeed, this result corroborates Asghar and Ghorbani (2011) who showed that in Iran, the higher education level of farmers positively influences the adoption of micro-irrigation and consequently, adopters are more educated than non-adopters. The same result was obtained in India by Namara & al (2007). In the study region, LIT is still in its infancy. It is therefore reasonable to find that farmers who adopt LIT have higher education levels than non-adopters.

6. Conclusion and perspective

The main objective of this study is to understand the role of farmers' beliefs and characteristics in the adoption of LIT by farmers in the Draa-Tafilalt region. The results of the data analysis revealed that the variables "Self-Efficacy", "Attitude" and "Education Level" had a positive and significant effect on the likelihood of LIT adoption. On the other hand, the variables "Age" and "Experience" had a negative and significant effect on the likelihood of adopting LIT. While the effect of the "personal innovation" variable on LIT adoption in the Draa-Tafilalt region was found to be non-significant. These individual variables explain 61.2% of the total variance in LIT adoption by farmers in the Draa-Tafilalt Region.

Although this study focuses on the adoption of LIT, which is considered a radical innovation, the process is based on the introduction of a new method of irrigation involving technical and material means with the objective of improving productivity through the efficient use of water. Other studies on the adoption of different types of innovations: product, process, organizational or marketing innovation would also be important to carry out. They will provide a comprehensive understanding of the determinants of agricultural innovation adoption for the development of an integrative predictive model of innovation adoption in Moroccan agriculture.

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